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AUTOMATED EMERGENCY CALL SYSTEM BASED ON SOUND INCIDENT RECOGNITION

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Abstract. *An automated emergency call system based on the recognition of sound incidents has significant advantages over a video surveillance system. The review focuses on systems that use microphones to quickly respond to an emergency. The material of this research work is based on an analysis of publications on the topics of sound recognition, the use of WSN. Also, the program has been developed, which allows convenient and practical positioning microphones on the cards.*

The practical significance of the work is obvious. The results of the study can be used to create an automated emergency call system based on the recognition of sound incidents.

The objectives of the research work are: obtaining new results that are important for the implementation of the emergency call system based on the recognition of sound incidents; mastering the principles of sound recognition using neural networks.

Keywords: *emergency call, acoustic surveillance, Wireless sensor network, sampling, neural networks.*

1. Introduction

Why do we need an automated emergency call system based on the recognition of sound incidents? With the development of society, crime also develops. More and more, there is a need to protect people from attacks on their lives and property. The system allows you to identify violators in case of emergency.

The development of computer technology and artificial intelligence systems has led to the fact that now more and more information is analyzed automatically. Sound has many more advantages than even a good camcorder. The microphone does not have to be within line of sight, it does not have dead zones. Moreover, a good microphone is much cheaper than a good camera. In case of sound observation for many situations, just a simple analysis of the sound level and spectrum is enough, while video requires non-trivial computer vision algorithms.

The sound surveillance system is convenient because it does not take much time. If the system detects the sound of an emergency (screaming, shot, sudden braking), all information is sent to the police and to the company's servers for analysis, to reduce the number of false positives, for example, from firecrackers.

Acoustic sensors located at the intersection can provide accurate information about the number, speed of passing cars, collisions, accidents, etc.

Using microphones as surveillance will allow you to respond to emergencies much faster than using cameras.

2. Analytical review of the literature

The emergency call system is used to automatically alert emergency services of any incidents and provide timely medical assistance to victims. The use of an emergency call

system based on the recognition of sound incidents can significantly reduce the level of injuries during incidents.

The system recognizes the sound of an emergency. Then she scans all available GSM networks and selects a channel for sending SMS messages about the incident. The system automatically contacts the emergency call center and provides information on the location of the received sound.

To obtain more accurate data, it is advisable to use WSN. Wireless sensor network (WSN) is a distributed, self-organizing network of many sensors (sensors) and actuators, interconnected via a radio channel [1]. According to work M. Brandstein and D. Ward "Microphone arrays: signal processing techniques and applications"[2], multi-microphone recordings enable to exploit spatial diversity, allowing to localize target sound sources and/or to cancel out interfering sound sources coming from certain directions.

A wireless sensor network (BSN) consists of sensor nodes that are tightly deployed, where each node has a sensor, processor, transmitter, and receiver. These nodes are inexpensive low-power and multi-functional devices for performing various probing tasks. Sensor nodes are deployed throughout the area to monitor certain events (for example, temperature) in real conditions. BSN mainly operate in an open and uncontrolled area. They are expected to play an important role in various areas, for example, military surveillance, forest fire monitoring, building security monitoring and process control. Most applications require a more accurate localization process for nodes in order to obtain their coordinates within the network. [3].

To write a program most practical disposing the microphones on the map, we used a scientific article. Alexander Bertrand clarifies in his work: in the case of signal estimation (also referred to as signal enhancement), the goal is to estimate a desired signal (e.g., a speech signal), while suppressing background noise and/or removing reverberant components. This usually relies on fusion of the recorded signals at different nodes, requiring transmission of audio signals. In the case of parameter estimation, the goal is to extract certain parameters from the recorded audio signal(s), such as the location or identity of speakers, the acoustic properties of a room, or speech features. In this case, the nodes may only exchange parameter vectors or energy measurements at a slow time-scale compared to the sampling rate of the microphones [4].

As for the sound recognition system itself. Theoretically, machine speech recognition, that is, its automatic presentation in the form of text, is an extreme degree of compression of the speech signal. Each sound has a complex wave structure, including various frequencies and vibrations. Sound is an air vibration, the frequency of which lies in the range of frequencies perceived by man. Sound vibrations lie in the range of 16-20000 Hz [5].

But how to turn sound waves into numbers? Sound waves are one-dimensional. At each moment in time, they have one value, depending on the amplitude of the wave. In order to turn a sound wave into numbers, we record the values of the wave amplitude at equally spaced points. This process is called sampling. We read the data thousands of times per second and write down the numbers corresponding to the amplitude of the sound wave at that moment in time. Uncompressed .wav audio files are obtained [6].

Thanks to Kotelnikov's theorem[7], we know that for a perfect reconstruction of the original sound wave, it's enough to use a sampling frequency twice the highest frequency of the recorded sound [6].

The formulation of the Kotelnikov theorem: if an analog signal has a compact (limited in width) spectrum, then it can be uniquely and losslessly reconstructed from its discrete samples taken with a frequency strictly exceeding twice the upper frequency [7].

The physical meaning of the theorem can be explained in the following words: if you need to transmit a certain signal, then it is not necessary to transmit it in its entirety. You can transmit its instant impulses.

To create a system that will learn from its mistakes, you need to use neural networks. In essence, a neural network is a learning system. It acts in accordance with not only a given algorithm and formulas, but also based on experience. Neural networks are models of biological neural networks of the brain in which neurons are imitated by relatively simple, often of the same type, elements (artificial neurons) [8]. A neural network is a collection of neurons that make up the layers. In each layer, neurons are not interconnected, but are connected with neurons of the previous and next layers. Information comes from the first to the second layer, from the second to the third, etc. To train a neural network, a large amount of information is needed: the more layers and neurons on each layer, the less errors and the higher the reliability of the network. However, if you build too large a network, you may encounter a decrease in productivity and an increase in the complexity of the model [9].

Le N.V. and Panchenko D.P. in their article on speech recognition based on artificial neural networks described a speech recognition model based on artificial neural networks[10].

3. Object, subject and methods of research

The object of this study is an emergency call system.

Subject of research: a method for creating an automated emergency call system based on recognition of sound incidents.

In the process of writing a research paper, we used research methods such as: analysis and generalization of specialized literature, publications in periodicals devoted to BSN, neural networks; creating a working program, capable, given the air resistance, the range of microphones, to place them on the map. A general description was also given of the emergency call system.

4. Work results

The first thing we managed to achieve was the creation of a program that would place the microphones on the card in the most practical way. Considering factors that can affect sound distortion. Such as air resistance, the reflection of sound from buildings, the attenuation of sound when propagating on the ground, and so on.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Drawing.Drawing2D;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
```

```
namespace SoundArea
{
   public partial class Form1 : Form
   {
      Graphics gr;
      Bitmap bitm;
      bool fl = true;
      public Random rnd = new Random();
      List<Figure> figuresList = new List<Figure>();
      public Form1()
      {
         InitializeComponent();
         textBox1.Text = "100";
      }
      public void ProceduralPixelCircleDraw(Graphics graphics, Pen pen, Rectangle
rect, Bitmap bm)
      {
         Point Center = new Point(rect.X + rect.Width / 2, rect.Y + rect.Height / 2);
         int R = rect.Width / 2;
         for (int x = -R; x <= R; x++)
         {
            bool flag = true;
            int y = (int)(Math.Sqrt(R * R - x * x));
            if (x + Center.X > 0 && y + Center.Y > 0 && x + Center.X < bm.Width
&& y + Center.Y < bm.Height)
            {
               int x_r = x + Center.X;
               int y_r = y + Center.Y;
               int xn = x_r, xk = Center.X;
               if (x_r > Center.X)
               {
                  xn = Center.X;
                  xk = x_r;
               }
               for (int a = xn; (a < xk) && flag; a++)
               {
                  int b = ((a - Center.X) * (y_r - Center.Y) / (x_r - Center.X)) +
Center.Y;
                  if (bm.GetPixel(a, Math.Abs(b)).R == 0 && bm.GetPixel(a,
Math.Abs(b)).B == 0 && bm.GetPixel(a, Math.Abs(b)).G == 0)
                     flag = false;
               }
               if (flag)
                  bm.SetPixel(x + Center.X, y + Center.Y, pen.Color);
            }
         }
```

```
                for (int x = R; x >= -R; x--)
                {
                    bool flag = true;
                    int y = (int)(Math.Sqrt(R * R - x * x));
                    if (x + Center.X > 0 && y + Center.Y > 0 && x + Center.X < bm.Width
&& y - Center.Y < bm.Height)
                    {
                        int x_r = x + Center.X;
                        int y_r = Math.Abs(y - Center.Y);
                        int xn = x_r, xk = Center.X;
                        if (x_r < Center.X)
                        {
                            xn = Center.X;
                            xk = x_r;
                        }
                        for (int a = xn; a > xk && flag; a--)
                        {
                            int b = ((a - Center.X) * (y_r - Center.Y) / (x_r - Center.X)) +
Center.Y;
                            if (bm.GetPixel(a, Math.Abs(b)).R == 0 && bm.GetPixel(a,
Math.Abs(b)).B == 0 && bm.GetPixel(a, Math.Abs(b)).G == 0)
                                flag = false;
                        }
                        if (flag)
                            bm.SetPixel(x + Center.X, Math.Abs(y - Center.Y), pen.Color);
                    }
                }
                for (int y = -R; y <= R; y++)
                {
                    bool flag = true;
                    int x = (int)(Math.Sqrt(R * R - y * y));
                    if (x + Center.X > 0 && y + Center.Y > 0 && x + Center.X < bm.Width
&& y + Center.Y < bm.Height)
                    {
                        int y_r = y + Center.Y;
                        int x_r = x + Center.X;
                        int yn = y_r, yk = Center.Y;
                        if (y_r > Center.Y)
                        {
                            yn = Center.Y;
                            yk = y_r;
                        }
                        for (int b = yn; b < yk && flag; b++)
                        {
                            int a = (b - Center.Y) * (x_r - Center.X) / (y_r - Center.Y) +
Center.X;
```

```
                    if (bm.GetPixel(a, Math.Abs(b)).R == 0 && bm.GetPixel(a, Math.Abs(b)).B == 0 && bm.GetPixel(a, Math.Abs(b)).G == 0)
                        flag = false;
                }
                if (bm.GetPixel(x + Center.X, y + Center.Y).R != 0 && bm.GetPixel(x + Center.X, y + Center.Y).B != 0 && bm.GetPixel(x + Center.X, y + Center.Y).G != 0)
                    if (flag)
                        bm.SetPixel(x + Center.X, y + Center.Y, pen.Color);
            }
        }
        for (int y = R; y >= -R; y--)
        {
            bool flag = true;
            int x = (int)(Math.Sqrt(R * R - y * y));
            if (x + Center.X > 0 && y + Center.Y > 0 && x + Center.X < bm.Width && y + Center.Y < bm.Height)
            {
                int y_r = y + Center.Y;
                int x_r = Math.Abs(x - Center.X);
                int yn = y_r, yk = Center.Y;
                if (y_r < Center.Y)
                {
                    yn = Center.Y;
                    yk = y_r;
                }
                for (int b = yn; b > yk && flag; b--)
                {
                    int a = (b - Center.Y) * (x_r - Center.X) / (y_r - Center.Y) + Center.X;
                    if (bm.GetPixel(a, Math.Abs(b)).R == 0 && bm.GetPixel(a, Math.Abs(b)).B == 0 && bm.GetPixel(a, Math.Abs(b)).G == 0)
                        flag = false;
                }
                if (flag)
                    bm.SetPixel(Math.Abs(x - Center.X), y + Center.Y, pen.Color);
            }
        }
    }
    private void ProceduralCircleDraw(float startingAngle, float step, Graphics graphics, Pen pen, Rectangle rect)
    {
        float nextAngle = startingAngle + step;
        Figure Arc = new Figure() { FillColor = pen.Color };
        Arc.Path.AddArc(rect, startingAngle, nextAngle);
        bool flag = false;
        for (int i = 0; i < figuresList.Count; i++)
```

```
            {
                if (figuresList.Count == 0)
                    break;
                var r = Arc.Region;
                var rWithFigure = r;
                r.Intersect(figuresList[i].Region);
                if (r == null)
                {
                    flag = true;
                } }
            if (flag)
            {
                ProceduralCircleDraw(nextAngle, step, graphics, pen, rect);
            }
            else
            {
                if (nextAngle >= 360)
                {
                    return;
                }
                else
                {
                    graphics.DrawArc(pen, rect, startingAngle, nextAngle);
                    //System.Threading.Thread.Sleep(1);
                    ProceduralCircleDraw(nextAngle, step, graphics, pen, rect);
                }
            }
        }
        private void DrawProceduralSoundArea(int xPoint, int yPoint, Graphics graphics, double decibel, double attenuationCoefficient)
        {
            int attenuationCount = (int)(decibel * attenuationCoefficient);
            int colorCounter = (int)(255 / attenuationCount);
            float widthCounter = 5 / attenuationCount;
            Pen gradientPen = new Pen(Color.Red, 2);
            for (int i = 0; decibel - i * attenuationCoefficient > 0; i++)
            {
                int red = 255 - (i * colorCounter / 2);
                if (red < 0)
                    red -= red;
                int blue = 0 + (i * colorCounter / 2);
                if (blue > 255)
                    blue -= blue - 255;
                gradientPen.Color = Color.FromArgb(255, red, 0, blue);
                gradientPen.Width -= i * widthCounter;
                int range = 10 * (i + 1);
```

```
                Rectangle rect = new Rectangle(xPoint - range / 2, yPoint - range / 2, range, range);
                ProceduralCircleDraw(0, 15, graphics, gradientPen, rect);
                decibel -= i * attenuationCoefficient;
            }
        }
        private void DrawProceduralSoundArea(int xPoint, int yPoint, Graphics graphics, double decibel, double attenuationCoefficient, Bitmap bm)
        {
            int attenuationCount = (int)(decibel * attenuationCoefficient);
            int colorCounter = (int)(255 / attenuationCount);
            float widthCounter = 5 / attenuationCount;
            Pen gradientPen = new Pen(Color.Red, 2);
            for (int i = 0; decibel - i * attenuationCoefficient > 0; i++)
            {
                int red = 255 - (i * colorCounter / 2);
                if (red < 0)
                    red -= red;
                int blue = 0 + (i * colorCounter / 2);
                if (blue > 255)
                    blue -= blue - 255;
                gradientPen.Color = Color.FromArgb(255, red, 0, blue);
                gradientPen.Width -= i * widthCounter;
                int range = 10 * (i + 1);
                Rectangle rect = new Rectangle((int)(xPoint - range / 2), (int)(yPoint - range / 2), range, range);
                ProceduralPixelCircleDraw(graphics, gradientPen, rect, bm);
                decibel -= i * attenuationCoefficient;
            }
        }
        private void DrawGradientSoundArea(int xPoint, int yPoint, Graphics graphics, double decibel, double attenuationCoefficient)
        {
            int count = (int)(decibel / attenuationCoefficient);
            GraphicsPath path = new GraphicsPath();
            Rectangle rect = new Rectangle(xPoint - count / 2, yPoint - count / 2, count, count);
            path.AddEllipse(rect);
            Color[] surroundColors = { Color.Blue };
            PathGradientBrush gradientBrush = new PathGradientBrush(path)
            {
                CenterColor = Color.Red,
                SurroundColors = surroundColors
            };
            graphics.FillEllipse(gradientBrush, rect);
        }
```

```
private void Form1_MouseDown(object sender, MouseEventArgs e)
{
    int x = e.X;
    int y = e.Y;
    Graphics graphics = CreateGraphics();
    if (e.Button == MouseButtons.Left)
        DrawProceduralSoundArea(x, y, graphics, 100, 0.226);
    else if (e.Button == MouseButtons.Right)
    {
        AddFigure(x, y);
    }
}
public void AddFigure(int xPoint, int yPoint)
{
    var figure = new Figure() { FillColor = Color.Black };
    int figureWidth = rnd.Next(50, 200);
    int figureHeight = rnd.Next(50, 200);
    figure.Path.AddRectangle(new Rectangle(xPoint - figureWidth / 2, yPoint - figureHeight / 2, figureWidth, figureHeight));
    figure.DrawFigure(CreateGraphics());
    figuresList.Add(figure);
}
public void pictureBox1_Paint(object sender, PaintEventArgs e)
{
    Bitmap bm = new Bitmap(pictureBox1.Width, pictureBox1.Height);
    pictureBox1.Image = (Image)(bm);
    Graphics gr = CreateGraphics();
    gr = e.Graphics;
    gr = Graphics.FromImage(pictureBox1.Image);
    gr.FillRectangle(new SolidBrush(Color.Black), 50, 50, 50, 50);
}
private void pictureBox1_MouseDown(object sender, MouseEventArgs e)
{
    int Decibel = Convert.ToInt32(textBox1.Text);
    int x = e.X;
    int y = e.Y;
    if (fl)
    {
        gr = CreateGraphics();
        bitm = new Bitmap(pictureBox1.Width, pictureBox1.Height);
        fl = false;
        for (int i = 1; i < bitm.Width; i++)
            for (int j = 1; j < bitm.Height; j++)
                bitm.SetPixel(i, j, Color.White);
    }
    pictureBox1.Image = (Image)(bitm);
```

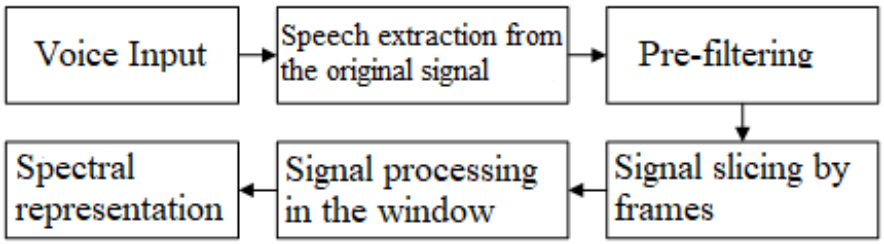
```
            gr = Graphics.FromImage(pictureBox1.Image);
            if (e.Button == MouseButtons.Left)
                DrawProceduralSoundArea(x, y, gr, Decibel, 0.226, bitm);
            else
                gr.FillRectangle(new SolidBrush(Color.Black), x - 25, y - 25, 50, 50);
        }
        private void label1_Click(object sender, EventArgs e)
        {

        }
        private void toolStripButton1_Click(object sender, EventArgs e)
        {
            OpenFileDialog open = new OpenFileDialog();
            open.InitialDirectory = "C://";
            open.Filter = "Image file(*.jpg)|*.jpg|(*.png)|*.png|All Files(*.*)|*.*";
            open.FilterIndex = 1;
            if (open.ShowDialog() == DialogResult.OK)
            {
                string picpath = open.FileName.ToString();
                pictureBox1.ImageLocation = picpath;
            }
        }
        private void toolStripButton2_Click(object sender, EventArgs e)
        {
            SaveFileDialog save = new SaveFileDialog();
            save.FileName = "Image";
            save.DefaultExt = ".jpg";
            save.Filter = "Image (*.jpg)|*.jpg";
            save.InitialDirectory                                                    =
Environment.GetFolderPath(Environment.SpecialFolder.LocalApplicationData);
            save.RestoreDirectory = true;
            if (save.ShowDialog() == DialogResult.OK)
            {
                string filename = save.FileName;
                bitm.Save(filename, System.Drawing.Imaging.ImageFormat.Jpeg);
            }
        }
    }

    class Figure
    {
        public GraphicsPath Path = new GraphicsPath();
        public Color FillColor;
        public PointF Center
        {
            get
```

```
            {
                var rect = Path.GetBounds();
                return new PointF(rect.X + rect.Width / 2, rect.Y + rect.Height / 2);
            }
        }
        public Region Region
        {
            get { return new Region(Path); }
        }
        public void DrawFigure (Graphics graphics)
        {
            Random rnd = new Random();
            SolidBrush figureBrush = new SolidBrush(FillColor);
            graphics.FillPath(figureBrush, Path);
        }
    }
}
```

The practical arrangement of microphones will allow you to create the most effective emergency call system. Since there will be no areas that are not covered by the range of the microphones. Accordingly, the accuracy of the data is improved and the sound incident recognition system is improved.

We examined a method for recognizing sounds using neural networks. It is clear that the creation of an accurate neural network requires a lot of time and a large set of sounds. It will take more than one month, and not even one year, to create a system that will determine the sound of an emergency with almost no errors. Nevertheless, neural networks will help to improve this system, taking into account the experience of previous errors.

Picture 1 shows a diagram of the preprocessing of speech signals.

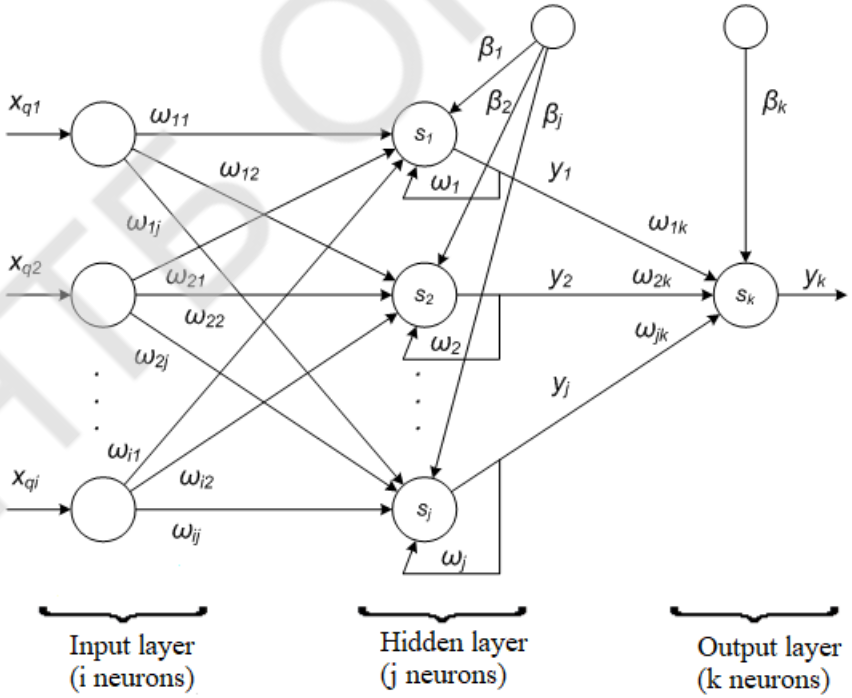


Picture 1. The scheme of preliminary processing of speech signals

After processing the audio data received, we get an array of signal segments. Each segment corresponds to a set of numbers characterizing the amplitude spectra of the signal. To prepare for the calculation for the output signal of the neural network, it is necessary to write all sets of numbers in the table, the line of which is the set of numbers of each frame.

Table 1. Description of a set of features of a speech signal

Frame	1st value	2nd value	…	ith value
1st frame	x_{11}	x_{12}	…	x_{1i}
2nd frame	x_{21}	x_{22}	…	x_{2i}
…	…	…	…	…
Nth frame	x_{N1}	x_{N2}	…	x_{Ni}



Picture 2. Single feedback neural network structure

- i – the number of values of one set of numbers
- N – number of sets of numbers (signal frame after slicing)
- x_{qi} - ith input value qth of a set of numbers;

- y_j – output j[th] neuron layer;
- ω_{ij} – coupling weight connecting i[th] neuron to j[th] neuron;
- ω_j – feedback weight j[th] neuron;
- β_j – displacement j[th] neuron layer.
- The number of input and output neurons is known. Each of the input neurons corresponds to one set of numbers. And on the output layer there is only one neuron, the output of which corresponds to the desired signal recognition value.

To calculate the output of a neural network, you must perform the following steps:

1. Initiate all contexts of all hidden layer neurons.
2. Submit the first set of numbers to the input of the neural network. Calculate the outputs of the hidden layer for it.

$y_j = f\left(\sum_{i=1}^{I} \omega_{ij} x_{1i} + \beta_j + \omega_j x_j\right)$[10],

where $f(x)$ - non-linear activation function $y_j = \frac{1}{1+\beta^{-aS_j}}$[10].

3. If the current set of numbers is not the last, then go to step 5, otherwise go to step
4. Record the outputs of hidden layer neurons to contexts where $x_j = y_j$. Go to step 2 for the next set of numbers.
5. Calculate the output neuron output layer.

Neural network learning algorithm: iterative adjustment of the weight matrix is necessary, gradually reducing the error in the output vectors.[10]

5. Conclusion

All of the above gives us the opportunity to draw the following conclusions. An automated emergency call system based on the recognition of sound incidents is quite a practical solution to many of the problems inherent in video surveillance. Such as the speed of response to an incident, the absence of "dead zones" in microphones. There are a sufficient number of difficulties that can be encountered when creating a sound recognition system using neutron networks. For example, a huge amount of information is necessary, since it is impossible to achieve high accuracy of the operation of artificial neural networks on a sufficiently small amount of data. There are a lot of sounds in our world. You cannot teach a system to analyze everything reliably in a couple of days. The first presented version of neural network-based speech recognition contained an error rate of about 25%, and only after 3 years the result was improved and already accounted for 8% of errors.

But despite the rather complicated implementation, with the help of an automated emergency call system based on the recognition of sound incidents, we get the opportunity to secure our city, our property, and our life.

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AN APPLICATION FOR DEMONSTRATING AND COMPARING SORTING AND RETRIEVAL ALGORITHMS

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Abstract. *The use and information and communication of their technology and in education is constantly increasing, including - when teaching professional disciplines in high school. The study of algorithms for sorting and searching data is provided by many educational programs of the specialties of the field of knowledge "Information Technologies". Using the process of presenting these sections of the information and communication means learning how a demonstration is application allows to better understand the essence of each algorithm, cf. ivnyaty them on specific examples.*

The purpose of the work is to develop a program (application) in the visual programming environment, which would allow students studying the algorithms for sorting and searching data , to observe the process and to analyze the advantages and disadvantages of a number of methods to better understand the principles of their work.

The object of study - algorithms for sorting and searching data . The subject of the study is demonstration of a number of algorithms and their comparison.

The first section looks at some algorithms and sorts and retrieves data, and analyzes existing software systems. The second section is performed to develop object-oriented model of a software system means s visual design and UML notation functional model BPWin. The third section provides a user guide and an example of how the software system model is developed.

Key words: *algorithms, sorting, search, composition of the algorithm, computerization, application, uml modeling, functional modeling, functional meling, functional melening.*

I. Introduction

New information technologies occupy the most important place not only in specialized but also in everyday spheres of life. Computers are used in business, management, trade, training and many other areas of human activity. Postiyno growing use and iformatsiyno and communication s technologies and in education , including - in the teaching of professional disciplines of Higher ground school.

The study of algorithms for sorting and searching data is provided by many educational programs of the specialties of the field of knowledge "Information Technologies". Use during the presentation of these sections of the information and communication means learning how a demonstration is application allows to better understand the essence of each algorithm to equalize them with specific examples.

The task was to create a program (application) to demonstrate and compare algorithms for sorting and finding data in order to better understand the principles of their operation.

The object of study - algorithms for sorting and searching data . The subject of the study is demonstration of a number of algorithms and their comparison.

The purpose of the work is to develop a program (application) in the visual programming environment, which would allow students who study sorting and data retrieval algorithms to observe the process and to analyze the advantages and disadvantages of a number of methods. In order to achieve this goal, it is necessary to select algorithms for analysis, to carry out information system design (application) and to carry out its computer implementation.

II Analysis of data collection and search algorithms

Although in the dictionaries the word "sorting" (sorting) is defined as the process of separation of objects by species or variety, programmers have traditionally used it in a very narrow sense, designating them as the rearrangement of objects in which they are arranged in ascending or descending order. This process should probably would not call that sorting and ordering (ordering), but the use of the word would lead to confusion because of congestion word meaning "order." In the following we will use the word "sorting" in the narrow sense: "arrangement in order" [1].

The task of sorting is to find the following permutation of records p (1) p (2) ... p (N) with indexes {1,2, ..., N}, after which the keys would be arranged in descending order:

$$Kp(1) \le Kp(2) \le ... \le Kp(N), \quad (1.1)$$

where Kp (i) is the ith key,

N is the number of entries.

Typically, sorting methods are divided into two classes: internal, when all records are stored in fast RAM, and external, when all records are not in it. Internal sorting

methods provide more flexibility in building data structures and accessing them, while external methods provide the desired result in “spartan” conditions of limited resources.

A fairly good general algorithm spends time sorting N records in proportion to N log N; this requires about log N "passes" according to the data. This is the minimum time if the entries are arranged in random order and sorting is done by pairwise comparison of the keys. If you double the number of records, then the time, all else being equal, increases slightly more than twice. On the other hand, if the keys are known to be random variables with some continuous distribution, then sorting can be performed on average in O (N) steps.

There is a basic list of sorting algorithms:

a) sorting by insertion method. The elements are viewed one at a time, and each new element is inserted into a corresponding place among the previously ordered elements;

b) exchange sorting. If the two elements are not in order, they are interchanged. This process is repeated until the items are ordered;

c) sorting by choice. First, the smallest (or largest) element is selected and in any way separated from the others, then the smallest (largest) is selected from the rest, etc .;

d) sorting by calculation. Each element is compared to all the others; the final position of the element is determined after counting the number of smaller keys;

e) special sorting. It is well suited to the five elements specified in the task, but is not easy to summarize if the elements are larger;

e) a new sorting supermethod. These are substantially advanced known methods.

There are many different sorting algorithms [2], co wives has its advantages and disadvantages, as he is better in some other configuration data and equipment.

In developing our application program we will use the following algorithms: bubble sorting; sorting inserts; sorting by choice; merger sorting; quick sorting; shaker sorting; gnome sorting; sorting Shell; binary sorting; sequential search; binary search.

Merge sort is a sorting algorithm that sorts lists (or other data structures that can only be accessed sequentially, such as streams) [3-4]. Initially, the task is broken down into several smaller tasks. Then these problems are solved by recursive call or directly if their size is small enough. Finally, their solutions are combined, and the solution of the original problem is obtained. The complexity of the algorithm is determined by the formula O (n * log (n)) , where O (n) is a function of the time complexity of the algorithm; n is the number of input data (array elements).

Quick Sort works recursively , repeating the following steps:

a) select the key index and divide the array into two parts. This can be done in different ways, but in this work the array is split in half;

b) transfer all key elements over the right side of the array, and all items less key - to the left. Now the key element is in the correct position - it is larger than any element on the left and less than any element on the right;

c) repeat the first two steps until the array is completely sorted.

Shuffle sorting, or shaker sorting, or Cocktail sort, is a kind of bubble sorting [5]. The boundaries of the working part of the array (ie the part of the array where the movement occurs) are set at the last exchange location at each iteration. The array is viewed alternately from right to left and from left to right. The best case for this sort is the sorted array, the run time is determined by the formula O (n). The worst case for this sorting is the array sorted in reverse order, the running time is determined by the formula.

Gnome sorting is based on the technique used by the ordinary Dutch garden gnome. This is the method by which the garden gnome sorts a line of flower pots. In the other looks at the next and previous garden pots: if they are in the correct order, he steps one pot forward, otherwise he swaps them and steps one pot back. Boundary Conditions: If there is no previous pot, it steps forward; if there is no such pot, he is done.

Sort of a Shell named after American scientist Donald Shell. At its core, this algorithm is an advanced “ Sort Insert ” algorithm . The meaning of the algorithm is to compare not only the elements standing next to each other, but also at some distance. Originally selected for a rock - a gap through which will compare array elements on each iteration [6] . For the first iteration, the step is defined as the result of dividing the number of elements of the array by 2, then the step is divided by 2. That is, it gradually shrinks , and when equal to one , the last comparisons will occur , and the array will be sorted. The best case for this sort - sorted array, Mr. ayhirshyy case for this sort - sorted second backwards array.

The pyramidal sorting method [7] , invented by D. Williams ohm , is an improvement of traditional tree groups. The general idea behind pyramid sorting is that the pyramid is first constructed from the elements of the source array, and then the elements are sorted. We take the last element of the array as the current one. Replace the top (smallest) element of the array and the current one. We sift the current element (it is now the upper one) through the elemental pyramid. Then we take the penultimate element, etc.

Besides sorting, even at dniyeyu and the major processing procedures are structured information search. The search task has attracted a great deal of attention from scientists (programmers) since the dawn of the computer age. Since the 1950s, the problem of finding elements with a certain property in a given set has begun to be solved [8].

Sequential search is the search for the desired entry in a non-sorted list [9] . From, the entire list is viewed before the record is found. It's the simplest m of search algorithms , not very efficient, but it works on a random list.

B inarnyy (or the method of dividing in half) search data can be Apply of Old to the sorted set of elements whose placement is made in the adjacent memory. The essence of this method is as follows: the search begins with the middle element. When comparing a target with an average sorted list item, one of three results is possible: a value equal to, a target value less than a list item, or a target value greater than a list item. In the first, and best of all, the search is complete. In the other two cases, we can drop half of the list. If the target is greater than the middle element, we know that if it is in the list, then it is after that middle element. This is enough to allow us to drop half of the list by comparison.

In this work, the algorithms for sorting and searching data are characterized by the time of work and the number of iterations spent. For a better understanding of their work, you first need to read a summary of each of them in the application program, as well as begin the study from easier to learn algorithms to more complex. Since the amount of memory consumed by the algorithm is not so important for understanding it and described in the help, it will not be further considered in this work.

Next, we will analyze the existing software systems to solve the problem . An application (application) for demonstrating the work of sorting and data retrieval algorithms is created to facilitate understanding of how these algorithms work for the target audience (1st year students).

There are now quite a few websites that demonstrate the sorting and searching of data. Let's look at some of them.

The article "Algorithms and data structures for beginners: sorting" on the site "Tproger" [10] deals with bubble sorting, sorting by inserts, sorting by choice, sorting by merging, quick sorting and swap method for permutation of elements (Fig. 1.1).

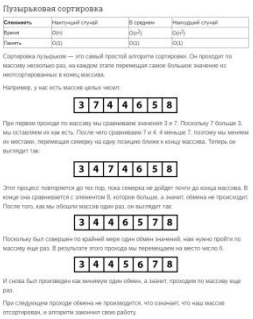

Figure 1.1 - Consideration of bubble sorting on the Tproger site

Also on the site are examples of code in C ++ to implement these algorithms. The main disadvantages include: lack of animation and an example of the operation of each of the algorithms for only one arbitrarily filled array.

Another article "Visualization of Sorting Algorithms" on the same site [11] provides the user with an already animated sorting process, but in turn does not have an example code and also allows the user to enter their own array of data to consider for example the best and worst cases (Fig. 1.2).

An excellent example is the article "Insert Sorting" on the habr website [12]. It includes the advantages of the previous two articles, but it has its own major drawback - only the algorithm for sorting inserts and improving them is considered (Fig. 1.3).

The article is about sorting choices on the same site, which has similar drawbacks [13].

Another example of demonstrating sorting algorithms is the article "Sorting in GIFs: 8 Most Popular Algorithms" on the proglib website [14].

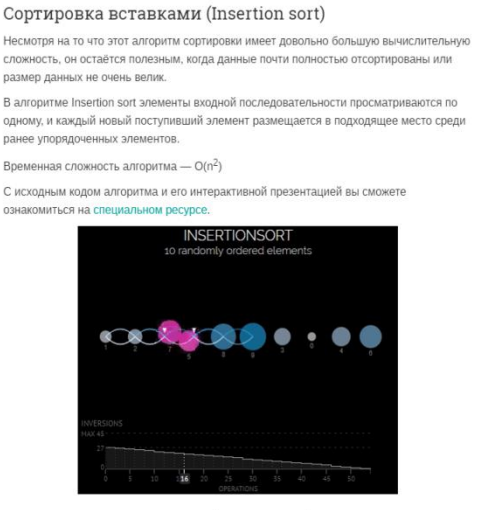

Figure 1.2 - Another example of bubble sorting on the Tproger site

Its disadvantages: lack of accuracy of the algorithm description, and work with a single preset array. An example of a quick sorting demo from this site is shown in fig. 1.4.

An interesting example of a demonstration of sorting algorithms is presented in the article "Sorting all the times and peoples" on the habr website [15]. This example is implemented in Excel using macros. An example of work in Fig. 1.5.

The obvious drawback is information overload. But the main drawback of all the examples above, except the last one, is the need for a permanent Internet connection. Therefore, the created application will focus on simplicity and autonomy. Borland Delphi 7 is chosen as the programming language. It will be a great advantage to add multiple interface languages to reach a larger audience.

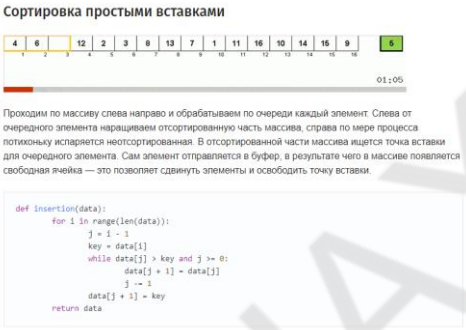

Figure 1.3 - Consideration of sorting with simple inserts on habr site

Figure 1.4 - An example of a quick sort demo on proglib

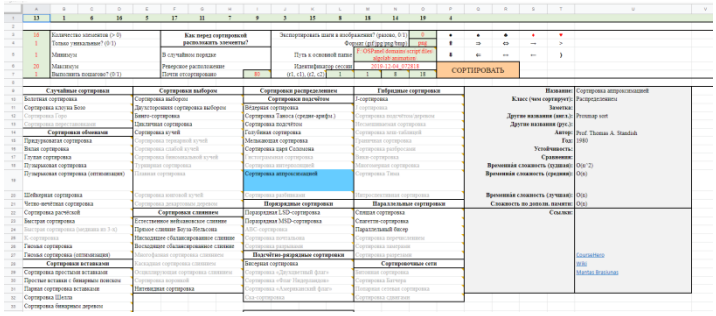

Figure 1.5 - Demonstration of sorting in Excel

III. Design of an application program for demonstration of the algorithms of data sharing and search

In just display will reflect and be only the number of iterations (step algorithm) as real time algorithm too fig s, and the user does not have time to understand the principle along with his work. To solve this problem we must add the delay in following each step of the algorithm, which in turn significantly increase the count time.

Working time is:

$$T = t_i + t_d * N, \quad (2.1)$$

where T is the total running time of the algorithm;

t_i is the time of one iteration;

t_d - delay time;

N is the number of iterations.

When comparing the algorithms, such a problem will not occur, because the size of the array will increase many times, and thus the time of work should be the same. Therefore, the delay can be removed. Then the running time shown will be real.

For a better understanding of user interaction with the application will make the UML- diagram Use Case (Eng. Use case diagram), showing the relationship between actors and precedents, and is part of the model precedent [16].

The following options are available to the actor: working with algorithm demonstration, comparing algorithms and customizing the interface. Working with demonstration algorithms includes : selecting a sort algorithm and / or search algorithm, populating an array, and viewing results. When using the search algorithm, you must specify the desired item.

When comparing algorithms, the user is required to choose the fill option (best and worst case, or random fill) and specify the size of the array that would then analyze the results (by run time and by number of iterations).

Setting up the interface is to choose the language of the software (there are three options: Russian, Ukrainian and English), and if necessary, get help on each of the algorithms for sorting and searching, as well as the whole program as a whole. The diagram of the variants of use is shown in fig. 2.1.

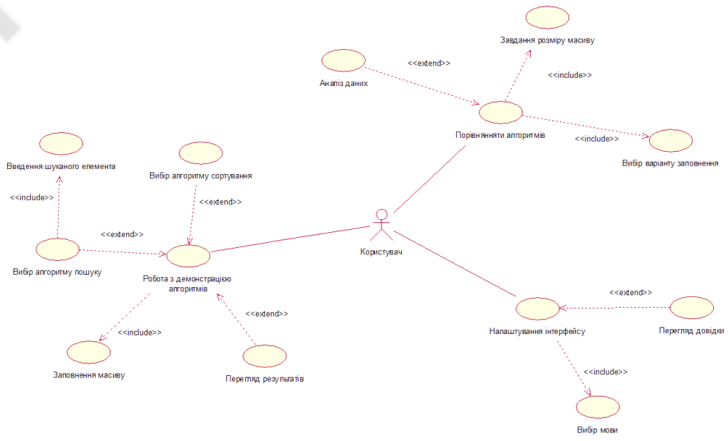

Figure 2.1 - Diagram of use cases

The purpose of the class diagram is a graphical representation of static structures declarative system elements and element s behavior [17]. The constructed diagram of classes is shown in fig. 2.2.

Algorithm Demonstration and Algorithm Comparison classes depend on the Interface class. Communication power of zero or more to one.

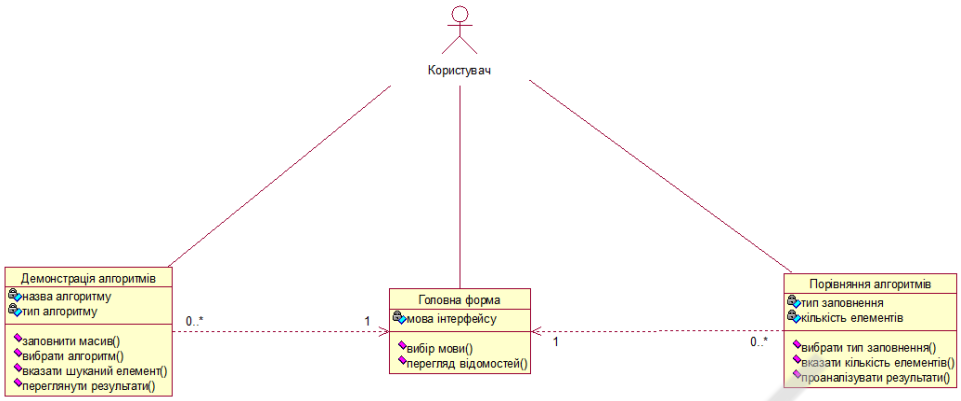

Figure 2.2 - Class diagram

The cooperative diagram [18-19] , which shows the messaging sequence , is presented in Fig. 2.3.

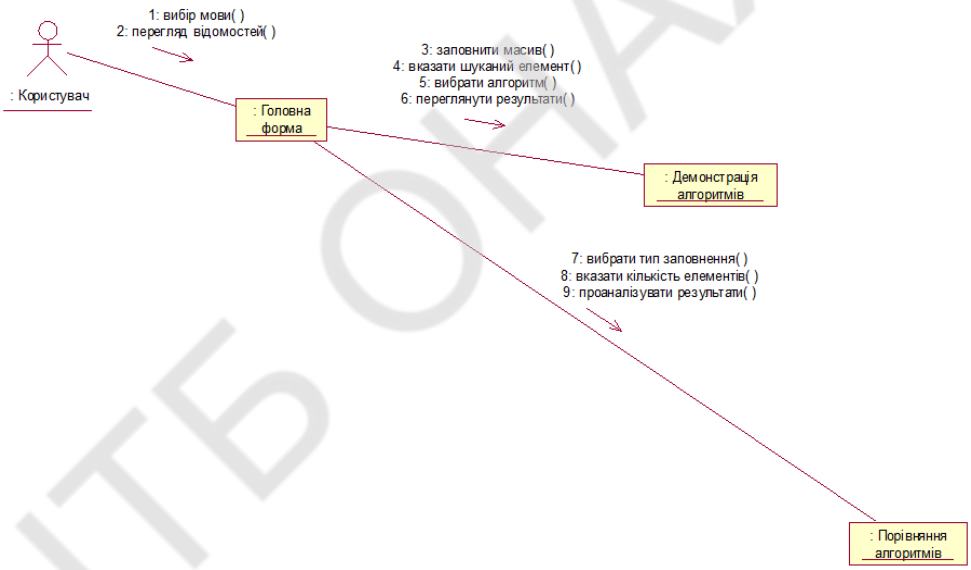

Figure 2.3 - Diagram of cooperation

The component diagram is shown in fig. 2. 4.

In order not to overload the component diagram with unnecessary information, it did not have all the files with Delphi configurations and basic settings. Since the certificate and the application and information on the algorithms loaded with .txt files a total of 36 pieces, for simplification of the diagram were three components Images: «Sort.txt», «Search.txt» and «Program.txt».

Then give functional in a model b system in BPWin notation . The first level of the model in BPWin notation, which shows all input (left) and output (right) information flows, as well as mechanisms (bottom) and governing factors (top) is shown in Fig. 2. 5 .

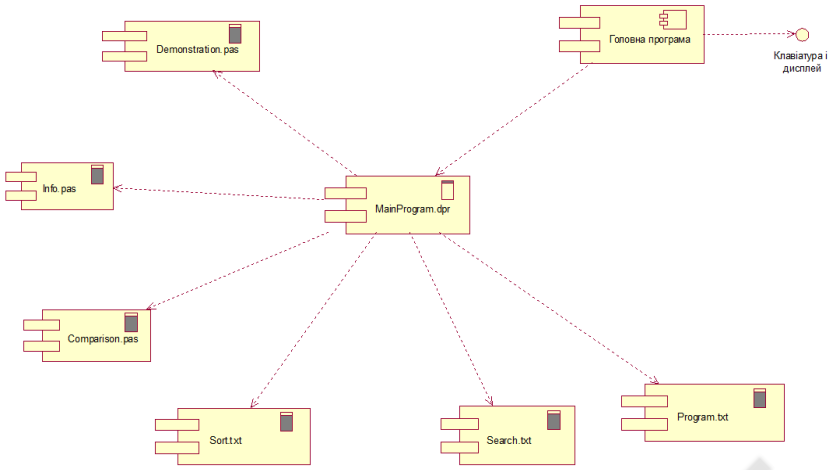

Figure 2. 4 - Component diagram

The second level of the model reflects the three main parts of the software product divided by functional and visual representation on the working forms of the application (Fig. 2.6).

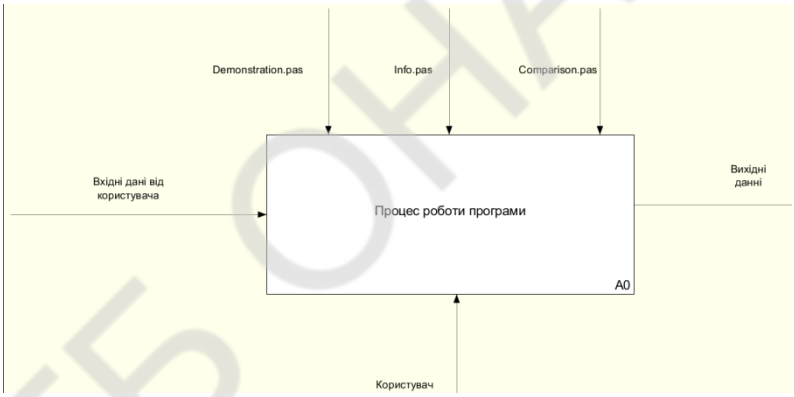

Figure 2. 5 - The first level of the model in BPWin notation

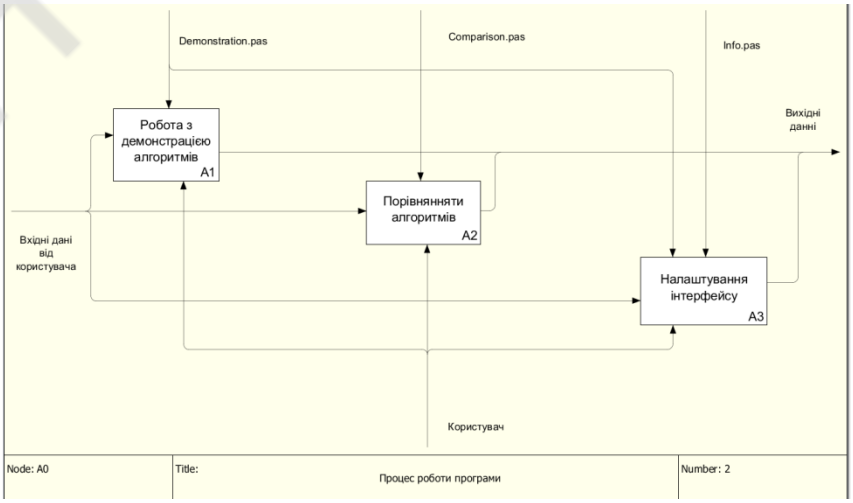

Figure 2. 6 - The second level of the model in BPWin notation

IV. Computer implementation of the software

The scope of the software product is to use it to consolidate knowledge about the principles of sorting algorithms and data retrieval in first year students [20] .

When implementing and using the software, requirements for the functional characteristics, system reliability, hardware parameters, information and software compatibility must be taken into account.

Initially, the main form of the program is developed, which will demonstrate the work of algorithms for sorting and searching data. The form in development is shown in fig. 3.1.

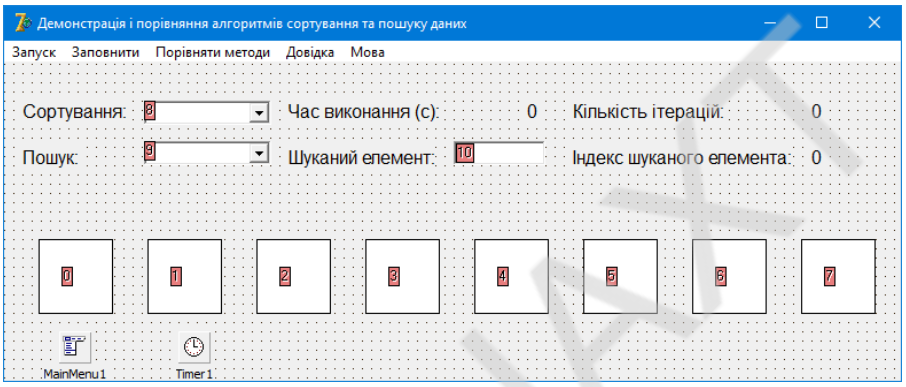

Figure 3.1 - Main form in development

In this form, the user will be able to select sort and search algorithms from the drop-down lists (ComboBox) and set an item to search in an array (Edit field) [21]. Array elements are represented by constituent objects (Edit and Shape). The run time, the number of iterations, and the index of the desired item are output to the appropriate Label component. The transition between forms, interface setup and array filling are represented by the corresponding items in the main menu of the program (MainMenu) [22] . The timer provides the calculation of the running time of the algorithms [23]. In Fig. 3.2 presents the second form of the program - help.

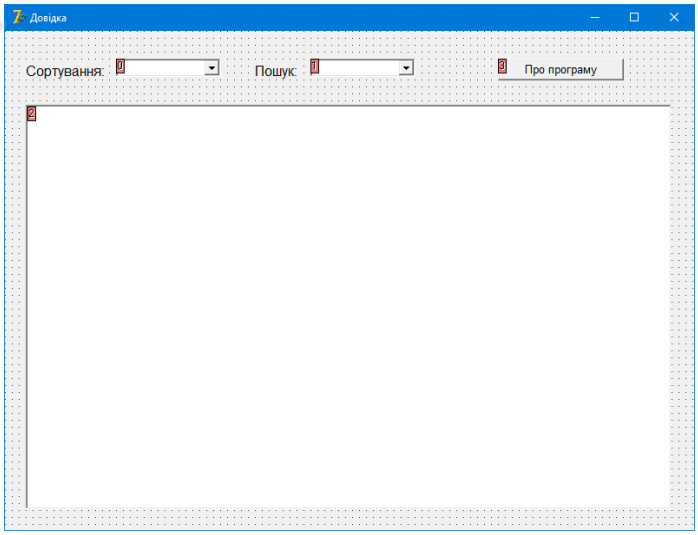

Figure 3.2 - Help window

Similarly, the first form the user can choose the algorithm that it is interested in, and get brief information about it in the Memo. In the same field information about the program is displayed when you press the (Button) button "About". The largest third form for comparing sorting algorithms by run time and the number of iterations spent is presented in Figs. 3.3.

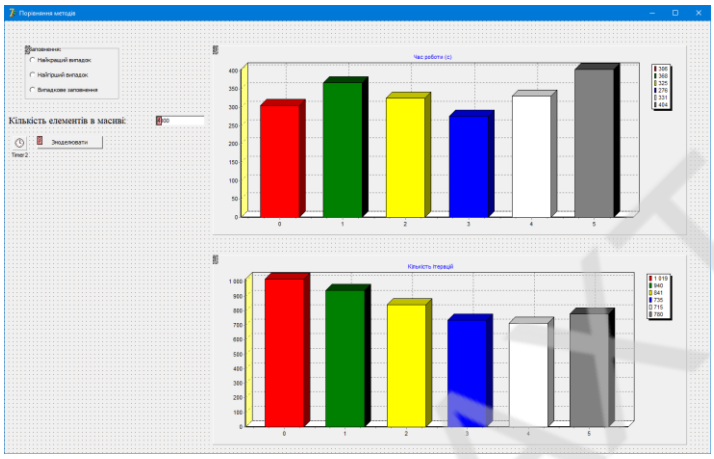

Figure 3.3 - Method Comparison Form

In this form, the user will enter the size of the array (Edit), select the type of fill (RadioGroup) and run the simulation (Button) [24]. Timer provides timing of algorithms and number of iterations. Chart-type elements are used to construct bar charts, to better compare method performance, [25] .

An example of a demonstration of the bubble sorting algorithm program is shown in Fig. 3.4-3.7.

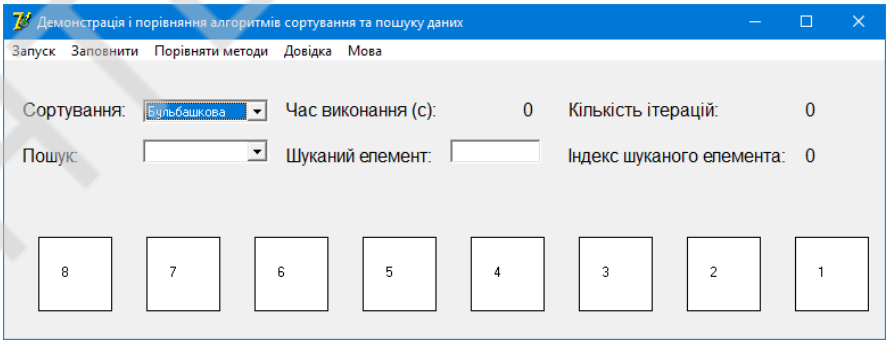

Figure 3.4 - Initial data input

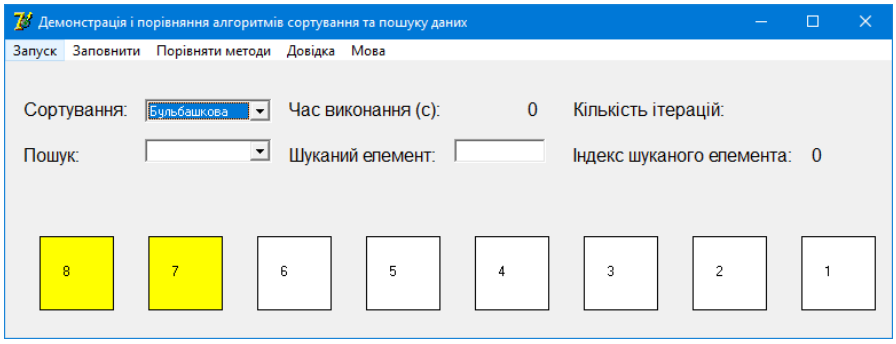

Figure 3.5 - IR procedure verification at x neighboring values

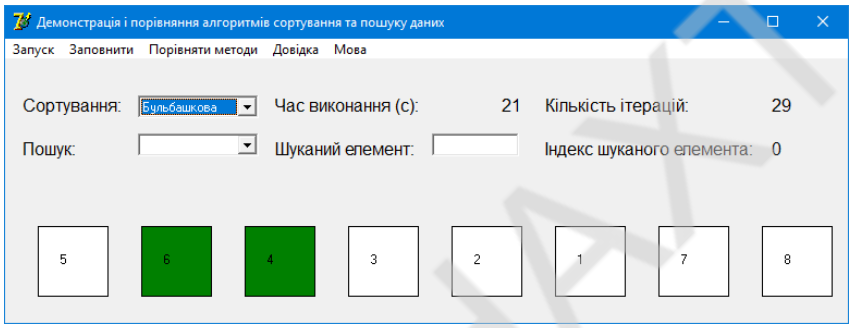

Figure 3.6 - Procedure yard permutation of x Neighbor

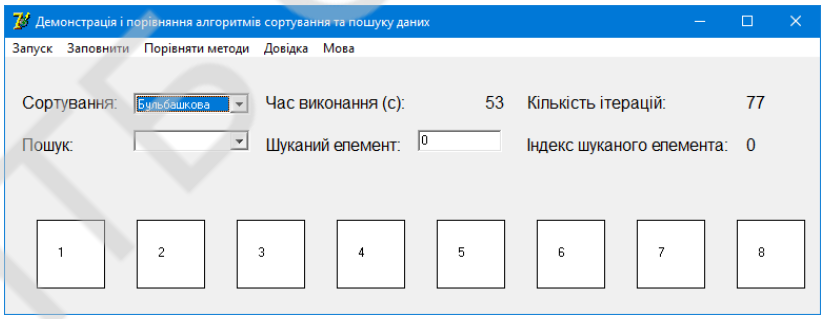

Figure 3.7 - Results of algorithm execution

An example of working with help is the output of information about the sequential search algorithm (Fig. 3.8).

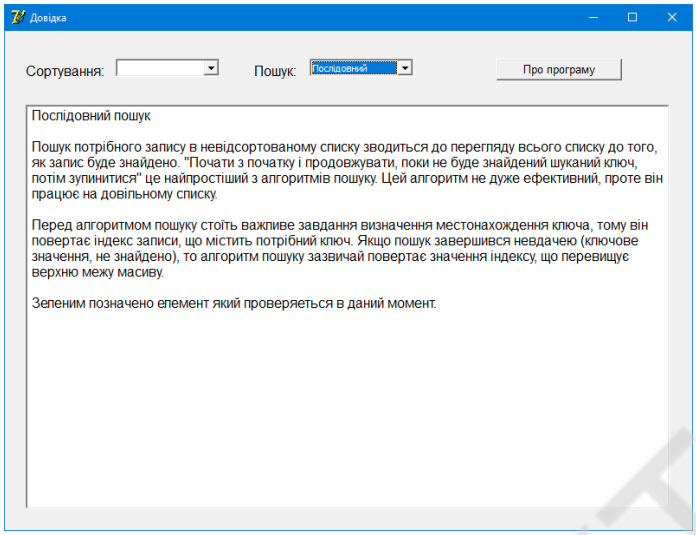

Figure 3.8 - "Serial Search" help information

An example of comparing sorting algorithms in a program by randomly filling an array of 25,000 elements is shown in Fig. 3.9-3.10.

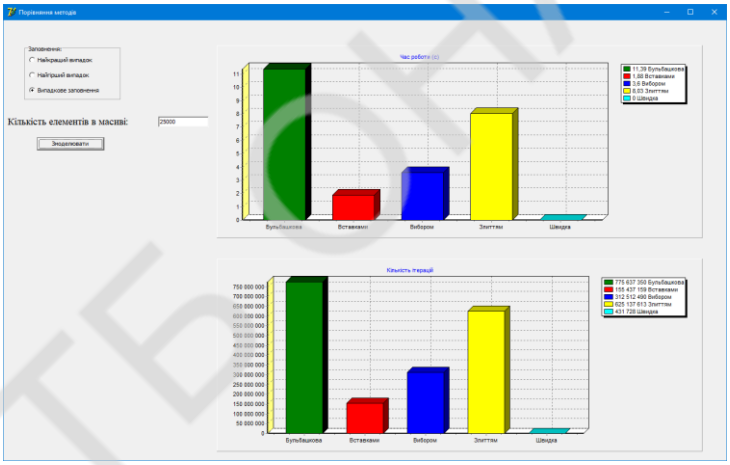

Figure 3. 9 - The process of comparing algorithms

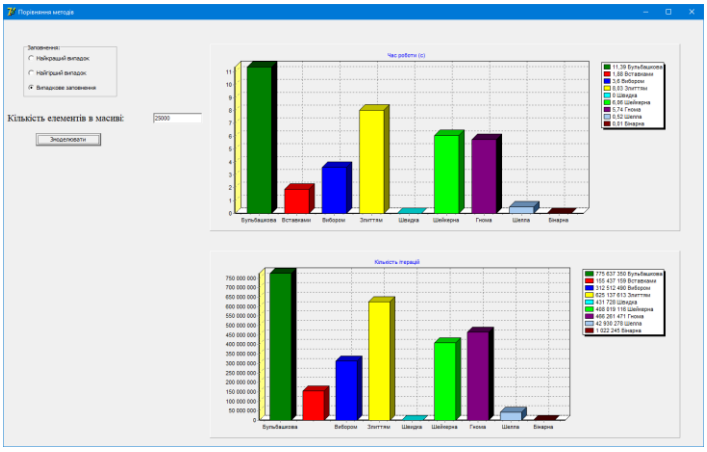

Figure 3.1 0 - Comparison results

An example of changes in the main form when choosing English (Figure 3.1 1):

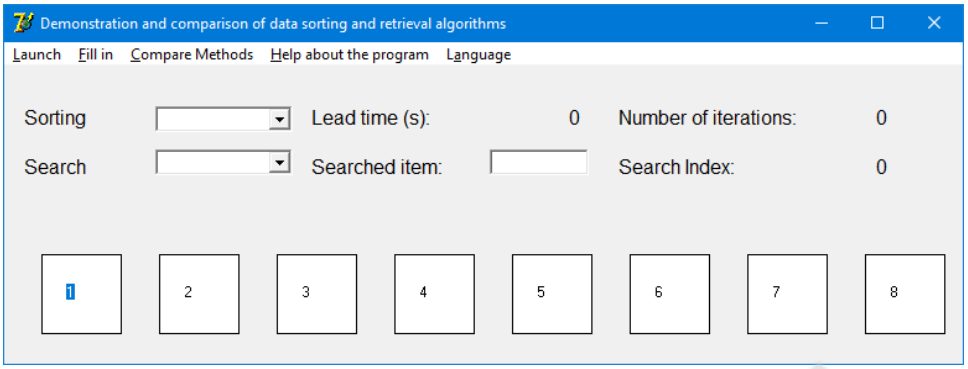

Figure 3.1 1 - The main form of the program in English

Consider the typical sequence of work with the developed application. When you start the program, you open the main form, which houses the main menu of the program , responsible for all the basic functions of the program, array elements and fields for initial values. First of all, you must select the interface language (the fifth item in the main menu). Available and parameters: a) Ukrainian language; b) Russian; c) English.

To demonstrate how the algorithm works, you need to fill in an array and select the sorting and / or search algorithms you are interested in. The array can be filled automatically - the second point Maine st available three options: the best and worst case, random fill. You can manually fill an array with arbitrary integers, select one of the array elements with the mouse and enter the desired value.

After filling in, the desired algorithm is sorted and / or searched from the appropriate list. Available algorithms: bubble sorting; sorting inserts; sorting by choice; merger sorting; quick sorting; shaker sorting; gnome sorting; sorting Shell; binary sorting; sequential search; binary search. If a search algorithm is selected , you must specify the search item in the box to the right of the list of sorting algorithms.

To start the demo, select the first item in the main menu of the application. I n case and elected binary search as the initial data presented are not sorted second by not reducing the array, the program sorts his own "fast" sorting. Time , spent it , will not be taken into account when calculating the algorithm binary search. This is necessary , because binary search can only work with sorted arrays.

Upon completion, the application outputs the running time of the algorithms, the number of iterations, and the index of the search item if the search algorithm was used. If the array does not contain the desired element, the index of the searched element will be null.

To compare sorting algorithms, select the third menu item. A new form will open in which to select from the list one of the possible options for filling and enter the size of the array in the appropriate field. Then the work process is started - pressing the "Model" button. The operation time of the algorithms depends on the computing power of the computer, and when working with large arrays can take quite a long time.

V. Conclusions

The paper analyzes a number of algorithms for sorting and searching data, existing software systems for solving this task. We have designed an application to demonstrate

sorting and data retrieval algorithms using UML and BPWin. The developed information model has received software implementation in Borland Delphi 7 environment.

The created application allows to demonstrate work of a number of algorithms of sorting and search of the data, and also to make their comparison by the criteria "Hours of work" and "Number of iterations". So is the application could be an additional element of information and communication means training in presenting relevant disciplines - for example, "Algorithms and Data Structures" for specialty 124 "System Analysis".

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INFORMATION SYSTEM FOR WORKING WITH EDUCATION PROGRAMS AND HIGHER EDUCATION STANDARDS

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Abstract. *Higher education standard is a set of norms that establish the main purpose and objectives of education, requirements for the content of education, the level of training of specialists, determine the way to diagnose the quality of higher education. Each institution of higher education, on the basis of an approved standard, develops, for each specialty, an educational (vocational, educational or scientific) program that can be approved or modified annually. Creating educational programs based on existing standards, comparing and improving them is a creative process, but the need to constantly update materials and conduct quality assessments requires the involvement of information systems and technologies.*

The purpose of the work is to develop in a system of visual programming (application) that would allow to work with the standards of higher education and educational programs, the list of competences and subjects, and program results of training. The system should be able to import all available data, make changes to any partition, while working with XLS-format data.

The object of study is higher education standards and educational programs. The subject of the study is the automation of the processing of these documents.

The first section looks at existing approaches to working with higher education programs and standards. The second section develops an object-oriented model of the software system using UML visual design tools. The third section provides a user guide and an example of a developed model system software.

Key words: *standard of higher education, education professional program, competences, software learning results, subject matters, information system, list of literature, higher education institution, unified modeling language, object-pascal*

I. Introduction

Modern education requires considerable accumulation of funds and resources, and most importantly - a competent management approach, strategic planning, control and transparent financing. The number of higher education institutions that need automated systems to operate is steadily increasing. The developed database will serve as an example of what skills are needed for a student to successfully master the discipline. Students should have a level of training based on the competencies of the bachelor's specialization in some areas, namely: training professionals who will have the skills to develop methods and tools of system analysis to solve complex problems, regardless of field of activity, and also be able to apply them directly in work.

Higher education standard is a set of norms that establish the main purpose and objectives of education, requirements for the content of education, the level of training of specialists, determine the way to diagnose the quality of higher education. Each institution of higher education, on the basis of an approved standard, develops, for each specialty, an educational (vocational, educational or scientific) program that can be approved or modified annually.

Creating educational programs based on existing standards, comparing and improving them is, of course, a creative process, but the need to constantly update materials and conduct quality assessments requires the involvement of information systems and technologies. The purpose of the work is to develop in a system of visual programming (application) that would allow to work with the standards of higher education and educational programs, the list of competences and subjects, and program results of training. The system should be able to import all available data, make changes to any partition, while working with XLS-format data.

II Current approaches to work with educational programs and higher education standards

By 2016, the standard of higher education [1] consisted of two parts - "Educational and qualification characteristics" (EQC) and "Educational and Professional Program" (EPP). Educational qualification characteristic of a graduate of a higher education institution (EQC) was an industry normative document, which summarizes the content of higher education, ie reflects the goals of higher education and vocational training,

determines the place of a specialist in the structure of branches of the state's economy and requirements for its competence, other social competences and qualities. Five types of competences were envisaged: social-personal, general-scientific, instrumental, general-professional, specialized-professional. Skills were divided into subject-practical, subject-mental, sign-practical and sign-mental, typical tasks of activity - professional, social-production and social-everyday life. The educational-professional program was an industry normative document, which defines the normative term and content of training, normative forms of state attestation, establishes requirements for the content, volume and level of education and professional training of a specialist of the relevant educational and qualification level of a certain area. Also, the educational and professional program contained a recommended list of subjects and a list of competences on educational and qualification characteristics that are formed in each discipline.

According to the new rules adopted by the Ministry of Education and Science of Ukraine [2], the Higher Education Standard now defines the following requirements:

– the amount of ECTS credits required to obtain an appropriate higher education degree;

– list of competences of the graduate;

– the normative content of training for higher education applicants, formulated in terms of learning outcomes;

– forms of attestation of applicants for higher education;

– requirements for the availability of internal quality assurance system for higher education;

– requirements for professional standards (if any).

That is, it does not now contain a breakdown of the educational and vocational program and educational qualification characteristics, it has only two types of competences (general and special, or professional), regulatory content in the form of a list of knowledge and skills, as well as two annexes: the correspondence matrix of national framework descriptors qualifications (knowledge - ability - communication - responsibility) of each competence; Matrix of correspondence of programmatic learning outcomes (ie list of knowledge and skills) to the list of competences [3].

Each higher education institution, based on the approved standard for each specialty, develops an educational (vocational or educational-scientific) program that contains general competencies, special competences, program learning outcomes, educational components (list of disciplines of the curriculum), structural and logical scheme and Matrix of correspondence of competencies and program learning outcomes (PLO) to program components (ie disciplines). The program results of study in the educational program should, as a rule, ensure at least 50% of the competencies of the HES. The number of competences and PLO may be greater than or equal to its HES counterparts. As a rule, a vocational program is drawn up in a higher education institution and may be approved or modified annually.

Higher education institution independently determines the list and content of components [4], in accordance with subparagraph 17 of the first article of Article 1 of the Law of Ukraine on Higher Education [5].

Ukrainian higher education institutions use the competent approach [6] recommended by the European TUNING project [7]. This approach proposes to describe

the learning outcomes of the competencies that a graduate must possess, that is, the result is the degree of the graduate's willingness to demonstrate relevant competencies [6].

In general, the TUNING project [7] proposes to shift the emphasis of the educational process to teachers, when the result is largely influenced by the combination of the areas of interest and experience of the teaching staff, to the students, so that the key knowledge, skills and skills that the student must master during their studies, determine the content of the curriculum.

The search for common principles and recommendations for the process of creating educational programs in European countries revealed that the autonomy of European universities does not imply the existence of uniform standards that would be available on the Ministry of Education's website [8-9]. Each university creates its own programs, taking into account local, national and pan-European needs. For example, there is a "Single European System of Electronic Competences 16234-1" [10], which contains a guide to 40 competences applied in the workplace in information and communication technologies (ICT), using a common language for competences, skills, knowledge and skills .

In [11] the experience of Russian universities on the integration of professional and educational standards in the design of higher education education programs in the field of information and communication technologies is analyzed. A number of aspects of current versions of educational standards have been identified that present a challenge for combining professional standards in the development of basic educational programs. Methodical recommendations on updating the FSES HE and selection of professional standards, developed by leading Russian universities as a result of implementation of international and domestic projects, are presented. The analysis of conformity of generalized labor functions and their components from the professional standards of general and professional competencies with the FSES HE in the direction of preparation "Fundamental Informatics and Information Technologies".

In [12] the analysis of conformity of the educational process with the requirements of educational standards on the example of the Faculty of Economics and Management is given, but attention is paid not to the structure and content of the educational programs, but to the staffing of the educational process.

[13] presents an analysis of the experience of upgrading undergraduate programs using the TUNING methodology. The algorithm of reforming curricula in the subject area of information technologies in accordance with the TUNING methodology is explained. Comparisons are made between existing Russian and European standards in the field of ICT education, including the European e-Competence System, with a focus on relevant competences, and some guidelines for the preparation of educational programs are provided.

Research [14] addresses the issues of applying a competent approach in higher education in formulating the requirements of state educational standards for the quality of education. For the quantitative characterization of the quality of training, groups of criteria (indicators) and their weight coefficients are defined. An indicative methodology for assessing the quality of education is proposed, which involves surveys of expert teachers and expert employers.

But all the above studies were carried out without the use of information systems, and their results cannot be easily developed in other fields. Most automated system projects (eg, [15]) are aimed at analyzing the quality of student learning and differ in the

method of processing the collected material without analyzing the content of educational programs.

The analysis of available sources of information revealed that at present there is no computer system that allows to solve complex problems related to the processing of educational standards and educational programs. One of the systems [16-18] allows to enter, store and process most of the information. It provides the ability for users of three levels: the system administrator (admin) changes the basic data, the main user (main user) generates and corrects EQC and EPP, the ordinary user (user) receives the information in the right form (each of them has access to all information, only the possibility of changing it is closed). The system works with the databases Competence Classes, Production Functions, Types of Typical Activity Tasks, Activity Task Classes, Types of Skills, and Skills Formation Levels. In EQC mode, Tables “Competencies”, “Typical Activity Tasks”, “Skills for providing typical activity tasks”, “Skills for providing selected competence” are created. In the mode of work with the EPP the tables "Names of disciplines", "Names of disciplines", "Names of blocks of content modules", "Names of content modules", "List of content modules for providing each skill", "List of blocks of content modules for state certification are processed ».

This system does not have a clear division of data into standard ones (ie the "Higher Education Standard") and created in a higher education institution ("Educational Program"), does not allow the assessment of compliance with the EPP standard and is generally based on an outdated list of competences.

III Design of specialized software

The task was to create a software system that would allow to work with the list of formed competencies in both subjects and program results of training. The system should be able to import all available data, make changes to any partition, while working with XLS-format data:

– provide the information available in one application (for ease of use);

– to establish the reference of each item of the EPP to the EQC (which competence of the EPP provides the competence of the EQC, etc.);

– to work with EQC - to study the matrix of correspondence of program results of training to competencies;

– work with the EPP - to create a matrix of correspondence of programmatic learning outcomes to competencies, as well as to determine which programmatic learning outcomes are appropriate for each discipline;

– to work with EPP - to get a list of competences that a student receives in each discipline;

– conduct a simple analysis of the compliance of the EPP with the EQC and the presence of unsecured competencies;

– to calculate how seriously these or other PLO and competencies are analyzed by analyzing the educational components (credits);

– to calculate student success in terms of competences and program outputs;

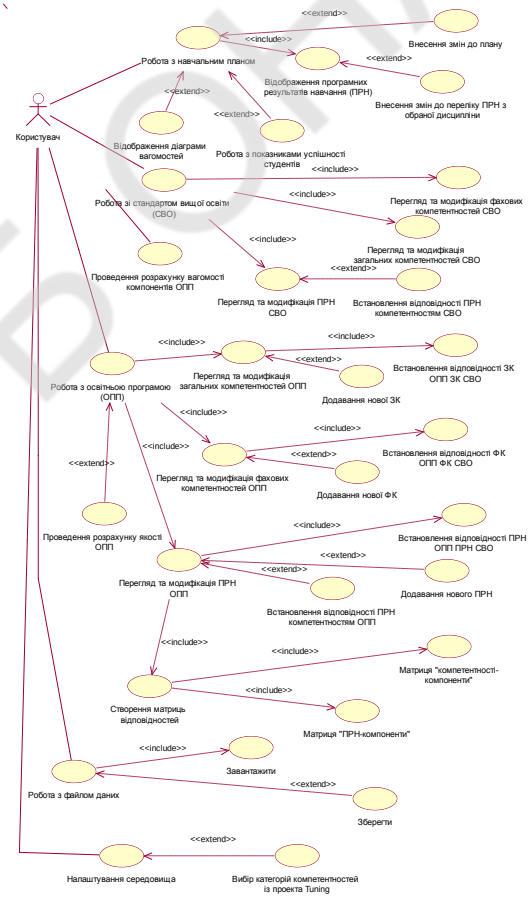
Using such a system will make it easier to work with educational and methodological documents at the departments when preparing materials for licensing and accreditation.

The information model of the system was created by the Unified Modeling Language (UML). Visual modeling using UML is a step-by-step descent from the most general conceptual model of the system to the logical and then to the physical model, and the model is a collection of so-called diagrams [19-20]. System features are presented in the use case diagram (use case diagram), which reflects the conceptual model of the system (drawing 3.1).

One user of the system (teacher or other employee) is envisaged. He has the basic precedents of "Work with the curriculum", "Work with the standard of higher education", "Work with the educational program", "Calculate the weight of components of the EPP", "Work with data file" and "Setting up the environment".

"Work with the curriculum" requires mandatory ("include" ratio) "Display program learning results" and not necessarily (ratio "extend") "Making changes to the plan", "Making changes to the list of program learning outcomes from the selected disciplines "," Working with student performance indicators "," Displaying the chart of weights ".

"Working with the higher education standard" requires (include "ratio") "Review and modification of professional competencies of the higher education standard", "Review and modification of the general competencies of the higher education standard", "Review and modification of program results of higher education standard training" and not necessarily (the "extend" ratio) "Matching programmatic learning outcomes to the competencies of the higher education standard."

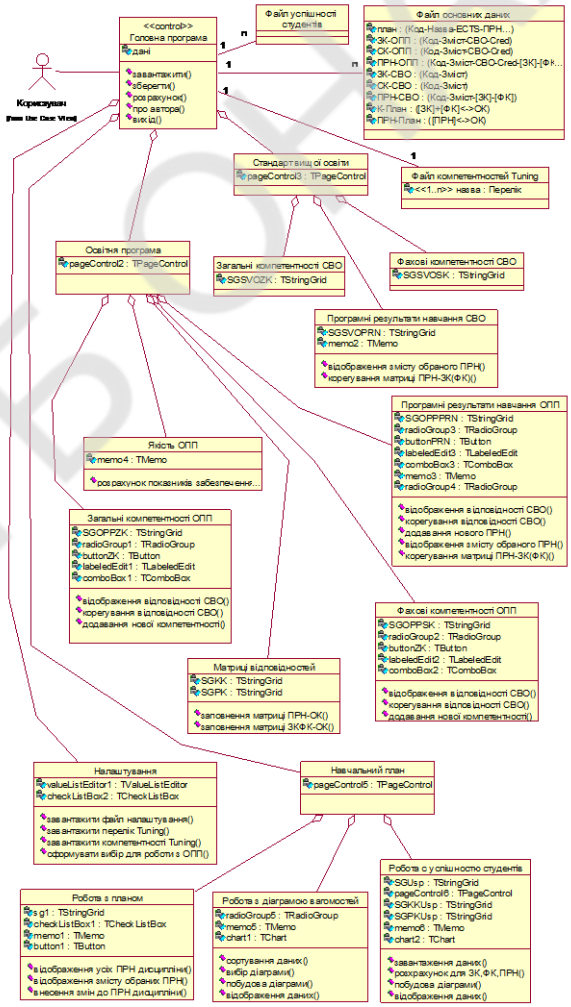


Drawing 3.1 – Use case diagram

"Working with the educational program" requires ("include" relation) "Review and modification of the general competences of the educational and professional program", "Establishment of conformity of the general competences of the educational and

professional program of the general competencies of the higher education standard", "Review and modification of professional competences EPP", "Establishing the correspondence of professional competences of the educational and professional program to the professional competences of the higher education standard", "Review and modification of the program results of educational training professional program", "Establishment of compliance of program results of training of educational and professional program of program results of training of the standard of higher education", "Creation of matrices of correspondence" (matrix "competence-components", matrix "PLO-components") and not obligatory (relation "extend") "Adding a new general competence", "Adding a new professional competence", "Adding a new program learning result ", " Establishment of conformity of program results of training to the competences of educational and professional program", "Carrying out the quality calculation of educational and professional program".

The structure of the system in terms of object-oriented design is shown in the class diagram (drawing 2.2). The structure is not too complex: the user is associated with a management class ("Main Program"), which contains (aggregation ratio) classes for working with a higher education standard, a vocational program and curriculum, as well as classes - data files.



Drawing 3.2 – Class diagram

XLS is selected as the output format. It allows you to make any changes to the data without using the system, and also removes the requirements for installing additional

software. One file is one specialty (educational program). Each letter carries its functional load (name is irrelevant, sequence is required):

– Syllabus - a list of disciplines of the syllabus (code, title, volume in ECTS credits);

– GC-EPP - a list of general competencies in the educational and professional program (code, content, compliance with the standard, the estimated amount in ECTS credits);

– SC-OPP - a list of special competences in the educational and professional program (code, content, compliance with the standard, the calculated amount in ECTS credits);

– PLO-EPP - a list of program results of training in the educational and professional program (code, content, compliance with the standard, the calculated amount in ECTS credits, compliance with the competences of the EPP);

– GC-EQC - a list of general competences in the higher education standard (code, content);

– SC- EQC - list of special competences in the higher education standard (code, content);

– PLO- EQC - a list of programmatic learning outcomes in the higher education standard (code, content, compliance with the competences of the higher education standard);

– C-Plan - conformity of competences of the educational and professional program to its components (disciplines of the curriculum);

– PLO -Plan - correspondence of program results of training of educational and professional program to its components (disciplines of the curriculum).

Only the first seven sheets should be loaded; the last two are to be created by the system and then stored in a file upon user request.

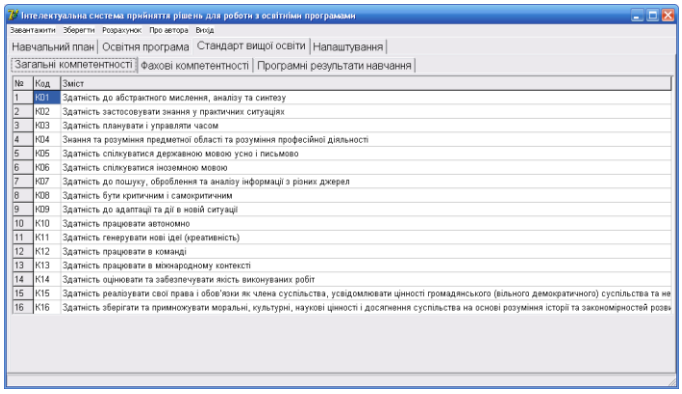
As an example, the standard of bachelor's training in specialty 124 "System Analysis" and the educational and professional program "Intelligent Decision Making Systems" were used.

IV Computer implementation of specialized software

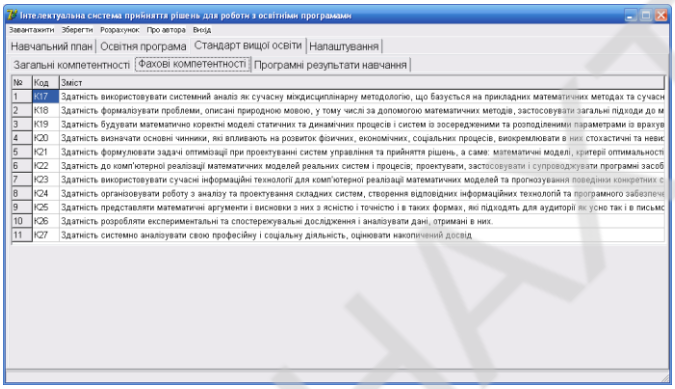
The developed information model of the software system for work with educational programs and standards of higher education was implemented in the Object Pascal environment [21-22].

The application form contains four main tabs: "Curriculum", "Education Program", "Higher Education Standard" and "Settings".

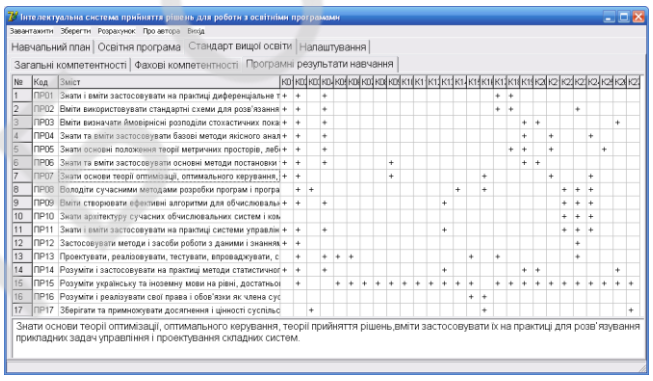
Working with the standard of higher education (drawing 3.1-3.3) allows to review the general competences, special competences and program results of training in the form of a correspondence matrix [3]. The user is given the opportunity to make changes to the text, but it is assumed that the standard is approved and unchanged.



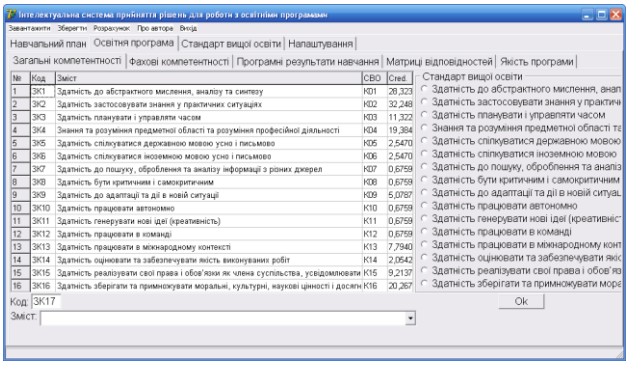
Drawing 3.1 – Working with EQC: general competencies



Drawing 3.2 – Working with EQC: professional competencies



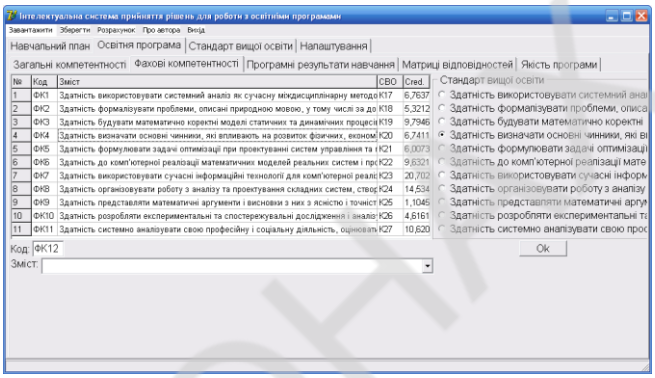
Drawing 3.3 – Working with EQC: programmatic learning outcomes



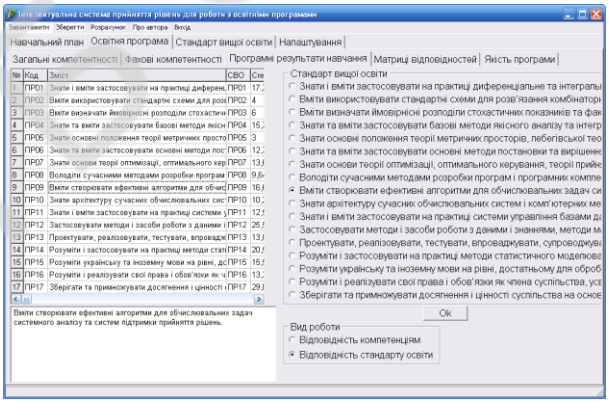
Drawing 3.4 – Working with EQC: general competencies

Working with the educational program (drawing 3.4-11) also allows you to review general competencies, special competences and programmatic learning outcomes, including in the form of a compliance matrix. The user can make changes to the text, set the compliance of each item of the educational program with the item of the higher education standard (if such conformity is envisaged), and also add new data (new lines). The new code is calculated automatically, but the user can change it. A new line can be added from a helper file.

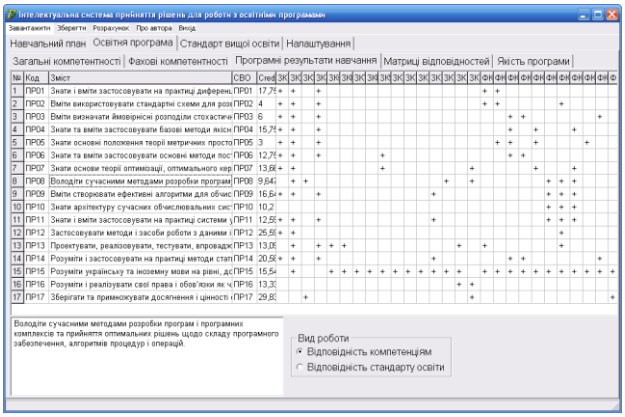
It also provides a Compliance Matrix for Components and a Software Matrix for Software Learning Outcomes, which can be adjusted using the mouse and keyboard. The user, when working with the software learning outcomes, has the choice to work with a window of competence or a window of conformity with the standard of education, as in the case of general and professional competencies.



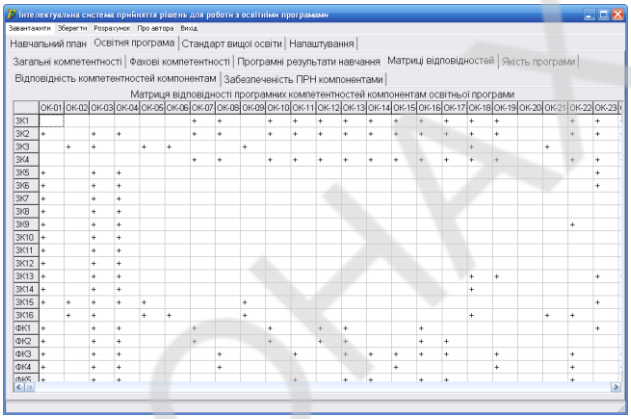
Drawing 3.5 – Working with EPP: special (professional) competencies



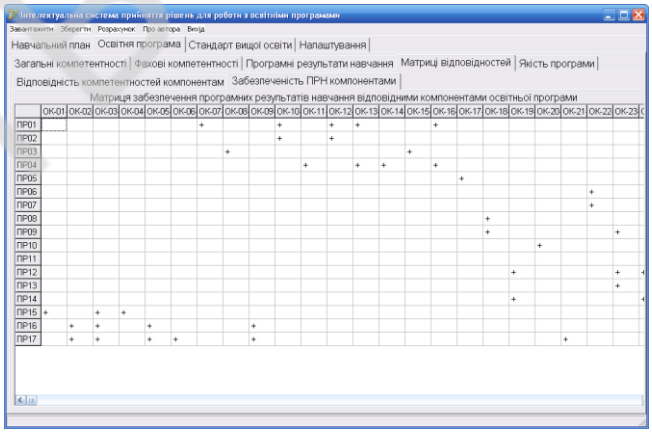
Drawing 3.6 – Working with EPP: programmatic learning outcomes (EQC compliance)



Drawing 3.7 – Working with EPP: programmatic learning outcomes (competence-relevant)

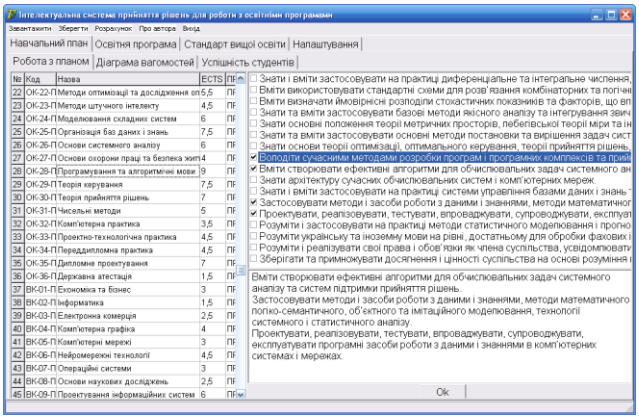


Drawing 3.8 – Working with EPP: compliance matrix of components



Drawing 3.9 – Working with EPP: a matrix of software results learning components

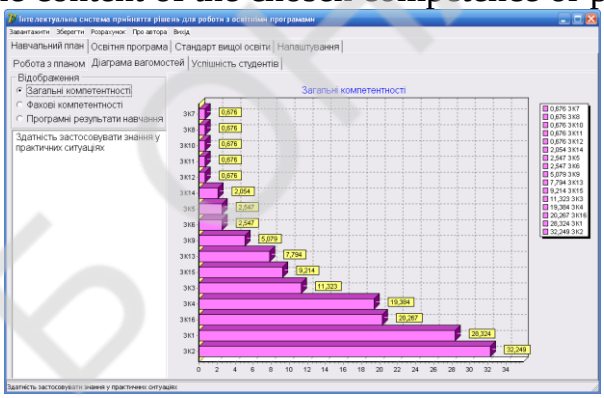
Working with the curriculum involves establishing the relevance of each discipline to the program results on the basis of its study (one-to-many ratio, up to 10 positions). The bottom right of the window displays all the program results of the chosen discipline. If the user needs to change the selection, he must confirm it by pressing the "Ok" button (drawing 3.10).



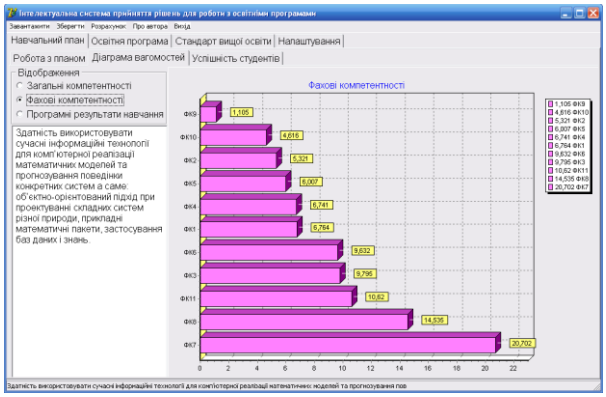
Drawing 3.10 – Work with the curriculum

The peculiarity of the developed system is the ability to work with the weights of each competence or learning outcome. When selecting the Calculation menu item, the system fills in the credits cell to which ECTS credits each competency or program result is based on the available data from the correspondence matrix. The user has the opportunity to review the weight of each general competence (drawing 3.11), professional competence (drawing 3.12) and program output (drawing 3.13).

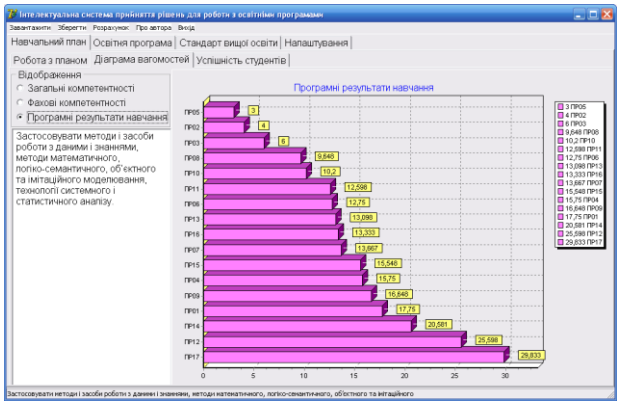
The columns of the charts show the values (indicators) of weights in ECTS credits, on the left in the text box - the content of the chosen competence or program output.



Drawing 3.11 – Working with kettlebells: general competencies



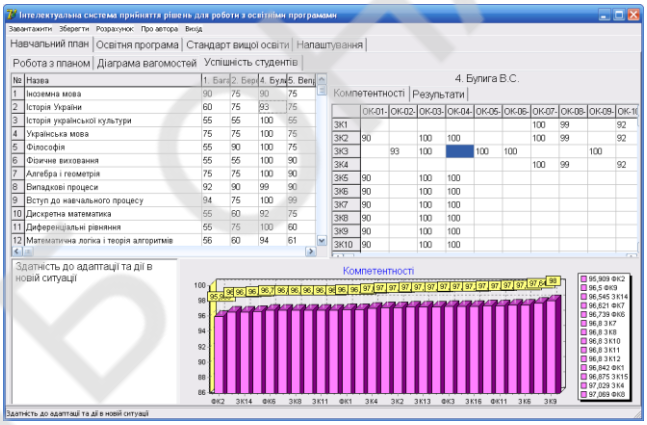
Drawing 3.12 – Dealing with weights: professional competencies



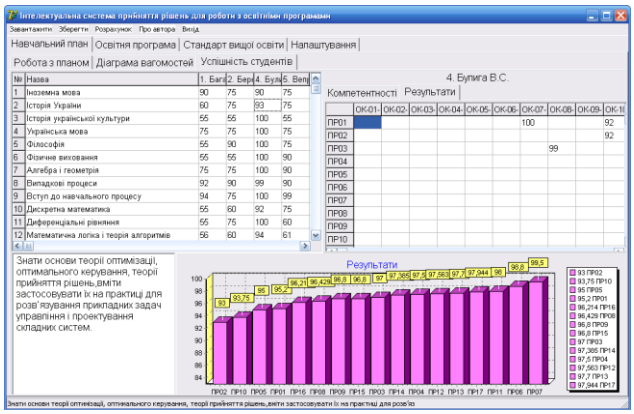
Drawing 3.13 – Working with weights: program outputs

Another feature of the system is the ability to analyze the student's or entire group's performance in terms of the competencies or program outputs they have learned. The "group1.xls" input file contains student grades (in columns) x for each discipline of the syllabus (in rows). If for some reason the student has not studied this or that discipline, it is set to "zero" and the line will not be taken into account in the calculations.

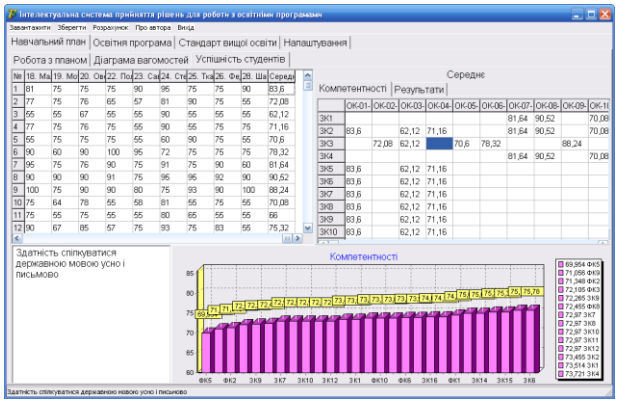
In drawing 3.14-3.15 presents examples of calculating student success by competencies and program results of study, respectively, in drawing 18-19 is the same for the student group average.



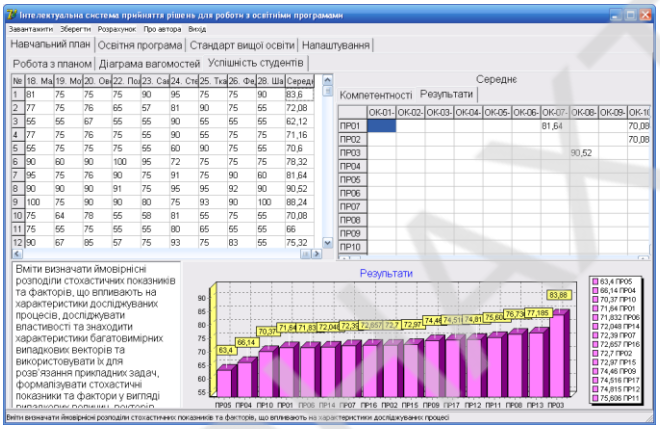
Drawing 3.14 – Work with student's competencies by competencies



Drawing 3.15 – Work with student's success on program results of study



Drawing 3.16 – Working with the success of the group by competence



Drawing 3.17 – Work with the success of the group on the program results of training

Conclusions

The structure of higher education standards and educational and professional programs was analyzed, the information model of the software system for work with educational programs and higher education standards was created, and its program implementation was carried out. Examples of the work of the system with the standard of preparation of the bachelor in specialty 124 "System analysis" and educational and professional program "Intelligent decision-making systems" are given.

Using the developed application will make it easier to work with teaching documents at the departments when preparing materials for licensing and accreditation.

Prospects for further research include filling the database with real data on the disciplines of student choice, introducing a comparison of educational programs of different specialties of one institution of higher education and one specialty of different institutions of higher education, as well as the creation of a holistic model of quality assessment of EPP, taking into account the compliance with the EQC and the results of success.

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AUTOMATION OF PROCESS CONTROL FOR POSITIONING PISTON ACTUATORS

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Abstract. *The paper considers a control model for positioning piston actuators, briefly discusses the issues of existing analogues, the advantages of pneumatic and hydraulic drives. The main goal of the work is autonomous accurate positioning of piston mechanisms and the development of a prototype for a practical experiment, as well as for practical work. Advantages of using pneumatic drives:*

1. Long service life.

2. Reliability, warranty.

3. High speed start-up, operation, response to operator signals.

4. Simplicity of design for easy maintenance.

5. Production efficiency (low cost of the work environment along with the absence of taps).

6. Fire safety. This makes pneumatic actuators common in the chemical or mining industry.

Keywords: *piston mechanisms, pneumatic drives, hydraulic drives, efficiency.*

Introduction

PR drives include an engine, control system, gears, braking devices, feedback sensors and communications. Communications are needed to transfer energy to the drives and transmit control signals, as well as to provide feedback.

The choice of drive type depends on the functionality of the PR. The main factors determining the choice of drive type are: purpose and operating conditions, load capacity and the required dynamic characteristics of the structure, as well as the type of control system.

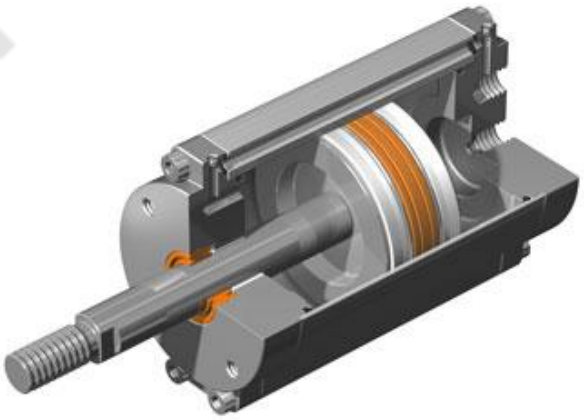
The drive of any kind has the general requirements:

- minimum overall dimensions at high energy performance, providing great importance to the ratio of output power to mass;
- the ability to work in automatic control and regulation, providing optimal laws of acceleration and braking with a minimum of transient processes;
- performance, i.e. implementation of actuator movements with high speeds and low positioning error;
- low mass of drive elements with high efficiency of the entire structure;
- reliability and durability of structural elements;
- ease of installation, repair, maintenance, readjustment and noiseless operation.

Depending on the type of energy used, the drives are divided into hydraulic, pneumatic, electric and combined (for example, electro-hydraulic, hydropneumatic, etc.)

Pneumatic drives are used in 20 ... 30% (according to other estimates in 40-50%) of commercially available PR. They are used for light and medium (with a carrying capacity of up to 20 kg) PR with the number of degrees of mobility 2 ... 3. The positioning error in these drives does not exceed ± 0.1 mm. The speed of the driven link of the drive with linear movement is up to 1000 mm / s, with an angular - up to 60 rpm. They have a simple design, low cost and quite reliable in operation.

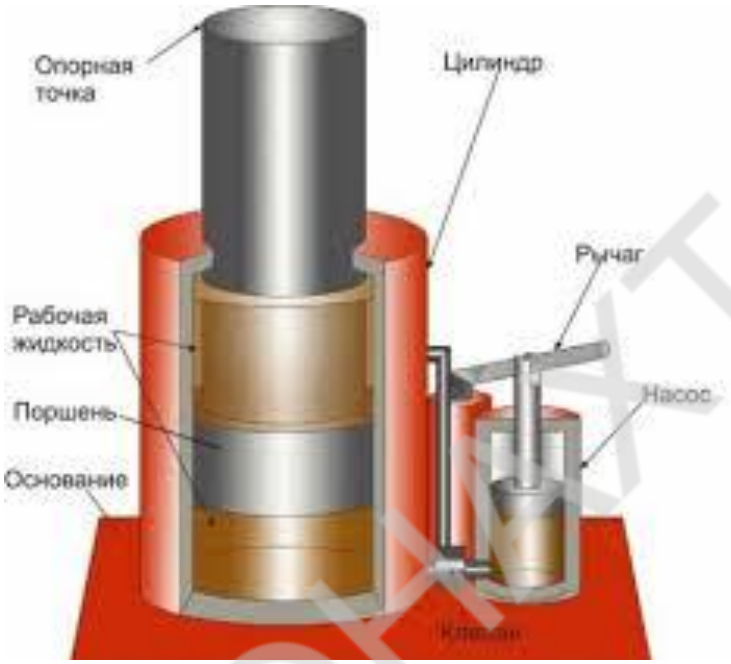
Due to the low adjusting ability, they are not used much in positional and contour modes of operation, and they have cyclic control as the simplest version of positional (two points are set - the beginning and end of the movement).



Hydraulic drives are used in 30% of commercially available medium and heavy PR with the number of degrees of mobility 3 ... 4. The positioning error in these drives does not exceed ± 0.5 mm with a linear speed of up to 0.8 ... 1200 mm / s. These drives have a complex structure, high cost of manufacture and operation. The hydraulic drive has good adjusting ability, and it is used in PR with positional and contour operation.

Electric drives are used in 40 ... 50% of mass-produced PR with an average load capacity and the number of degrees of mobility 3 ... 6. The positioning accuracy of the electric drive reaches values up to ± 0.05 mm. They are used both in positional and in contour operation modes.

The advantages of electric drives are higher efficiency, efficiency, ease of assembly and good adjusting properties.



As a rule, synchronous, stepper and DC motors are used in electric drives. Asynchronous motors are used less frequently, which is associated with the complexity of speed control.

Analytical analysis of the literature

We have considered a large number of publications by various authors exploring this issue.

For positioning piston actuators, the Phoenix axc 1050 controller was selected

Object, subject and research methods

Pneumatic Actuator Positioning

The positioning of the output link (for example, ultrasound) in the PR with cyclic control is provided at two extreme points and is ± xmax; ± φmax - maximum and minimum piston stroke during linear and angular movement.

In some cases, positioning of the output link at intermediate points is required. In this case, the positioning is carried out using external mechanical stops with damping when approaching each stop (to the point). Calculations and practice show that there can be 6 ... 9 or more such positioning points in pneumatic actuators, due to the high compressibility of the working fluid (air) and the speed of movement.

The number of positioning points can be increased by using the so-called positioners.

The simplest positioning scheme is shown in Fig. 1.

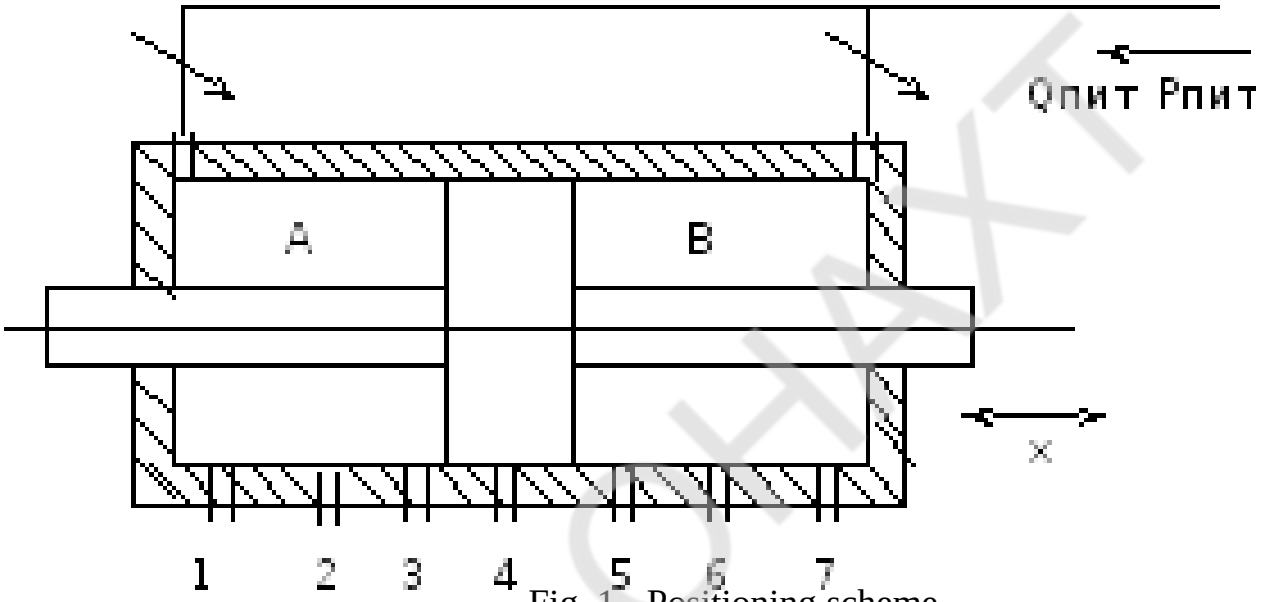


Fig. 1 - Positioning scheme

The air motor is made in the form of a cylinder with a false rod of double-acting. Power is supplied to both cavities simultaneously. With equal pressure in the cavities, the piston is at rest. Highways 1 - 7 serve to release air into the atmosphere. When you open one of the outputs at the command of the control system, the pressure in the corresponding cavity decreases. Under the action of the difference in forces, the piston will move until the outlet is closed and the pressures in cavities A and B are equal. Closing and opening of the outlet can be carried out mechanically or by a pneumatic distributor. The output is mechanically closed by the piston itself.

This method of positioning the output link is used most often.

Another method of positioning is the use of a mechanical brake, which serves to stop the output link. Braking is carried out in two stages, in the first - the speed of the output link decreases by 5–10% of the maximum. Here, using position sensors, braking points are determined at which the further movement of the output link begins to slow down. At the second stage, the output link is stopped at a given point using the brake.

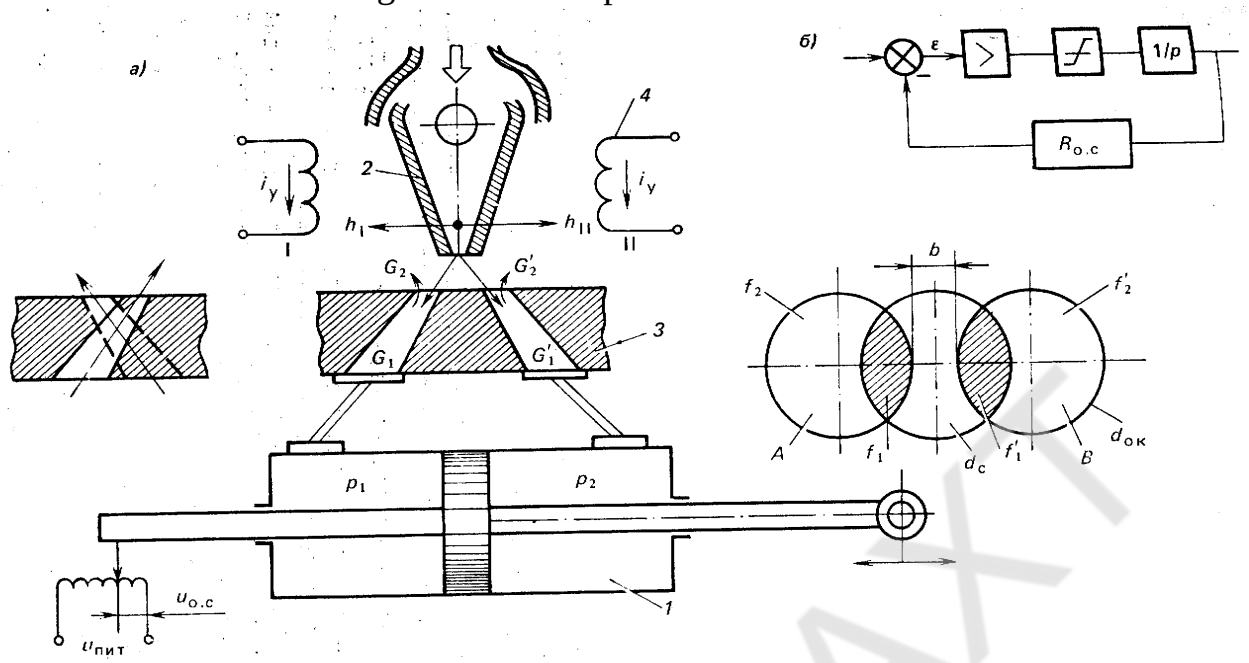
Positional control in PR pneumatic drives is used for a wide range of load capacities from 0.1 to 20 kg. and speeds from 500 to 1000 mm / s.

Pneumatic servo drive

The use of a follow-up pneumatic actuator would make it possible to solve the problem of using the PR contour control. As a result of this, the problem of accurate as well as intermediate positioning of the PR output link would also be solved. However, the

use of a servo drive in PR pneumatic devices is rarely used in practice, which is associated with a number of circumstances, primarily with the properties of the working fluid (air).

A schematic diagram of a pneumatic servo drive is shown in Fig.2



1 - cylinder; 2 - inkjet mechanism; 3 - receiver nozzles; 4 - control winding.

The distributor of compressed air is a jet mechanism 2, when it is deflected to the right and left, a proportional change in the air flow into the left or right cavity of the cylinder 1 through the nozzles of the receiver 3. The armature of the electromagnetic transducer (EPM) is located on the axis of the jet (not shown). When diluting the control currents iy in the control windings, a balance occurs of the forces acting on the armature, which, together with the jet, is in the middle position. If there is a difference in the control currents iy, the balance of forces is violated, the armature and the jet rotate by an angle □, which is proportional to the difference of the currents. The cylinder rod position sensor is a feedback potentiometer.

In the figure, fig. 2 is a structural diagram of a drive that performs closed-loop control. The comparison element compares the control signal with the feedback signal and generates an error signal ε, which is fed to the controller, consisting of the amplifier> and a nonlinear element with a saturation zone f and an integrating device 1 / p.

f - limits the signal in magnitude, 1 / p - increases the accuracy of operation.

Tracking pneumatic drives belong to throttle control systems, as to change the flow rate to the drive due to changes in the performance of the compressor forcing air, unpromisingly because of the compressibility of the air.

The principle of operation of the jet distributor is based on double energy conversion. First, in the jet tube, the potential energy of compressed air is converted into the kinetic energy of the air stream, then, in the nozzles of the receiver, the kinetic energy of the stream is converted into potential energy of the compressed air entering the working cavities of the cylinder. The pressure loss in this case is up to 10%.

To implement the layout for reproducing the experimental stand, the Phoenix axc

1050 controller was used

Conclusions

The paper considers the task of automating the control of the positioning process of piston actuators that implements the task of moving an object to the required position. Study of system performance compared to other drives.

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LATCH AUTOMATIC CONTROL SYSTEM FOR MONITORING THE DOSING OF BULK SUBSTANCES

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Abstract. *The paper considers a theoretical mechanical model of a tank for dosing bulk solids using valves on pneumatic cylinders and a PLC (programmable logic controller) that controls pneumatic-electric valves, briefly discusses the issues of existing analogues, the advantages of pneumatic-electric valves over pneumatic. The main goal of the work is the automatic control of valves using PLCs to ensure a given dosage rate. Using a PLC simplifies the control of valves due to pre-recorded scenarios for a given amount of dosed substance, as a result of which the chance of pouring it into the carriage is reduced.*

Keywords*: PLC (programmable logic controller), pneumatic cylinder, gate valve, pneumatic distributor, shipment carriage.*

Introduction

The automatic valve control system is based on an industrial controller, namely a programmable logic controller (hereinafter PLC).

PLCs are devices designed to collect, transform, process, store information and generate control commands. They are implemented on the basis of microprocessor technology and work in local and distributed control systems in accordance with a given program. From small to powerful and high-speed PLC systems provide the most demanding customers with comprehensive capabilities and flexibility in implementing modern network solutions in distributed control and monitoring systems. PLCs provide the most demanding customers with comprehensive capabilities and flexibility in implementing modern network solutions in distributed control and monitoring systems. According to the technical capabilities that determine the level of tasks to be solved, PLCs are divided into classes: nano, micro, small, medium and large. Initially, they were intended to replace relay-contact circuits assembled on discrete components - relays, counters, timers, hard logic elements.Programmable controllers find application in various industries. They are also used in the field of education and in the system of continuing professional training.

Ferrous and non-ferrous metallurgy. Of particular importance in these industries are safety requirements. Programmable controllers are used to control transport operations using coke oven batteries, loading blast furnaces, and to automate foundries. They are also used to solve problems associated with gas analysis and quality control.

Metalworking and automotive industry. These are precisely the industries where PLCs are widely used. They can be found on automatic lines and assembly lines, on stands for testing engines, as well as on presses, automatic lathes, grinding and modular machines, welding machines, automatic cutting machines.

Chemical industry. Currently, PLCs are used to control technological installations, devices for dosing and mixing products, treating chemical production waste, as well as in plastic processing plants and some units in rubber production.

Oil production. In addition to applications similar to the previous industry, PLCs are used at pumping and distribution stations to control operation and monitor trunk pipelines.

Transport and handling operations. Programmable controllers are used in sorting parcels, mail, mechanized management of warehouse operations, packaging, conveyor shipment, picking up products on pallets, in the elevator facilities, hoisting mechanisms, etc. (Types of PLCs in Fig. 1)

Fig. 1 - Types of programmable logic controllers

Analytical analysis of the literature

We have considered a large number of publications by various authors exploring this issue.

PLC is considered as a device for monitoring and controlling pneumatic cylinders of gate valves to achieve a predetermined dosing value.

Object, subject and research methods

Using an industrial PLC to control the dosing of bulk solids, it was decided to create a model of the tank with valves based on pneumatic cylinders and pneumatic distributors.

As a PLC, we use the PHOENIXCONTACT industrial controller of the AXC 1050 family.

AXC 1050 is a highly efficient controller with an Ethernet interface and Axioline F. The bus controller is Axioline, and it's easy to switch the Axioline module to the second controller.

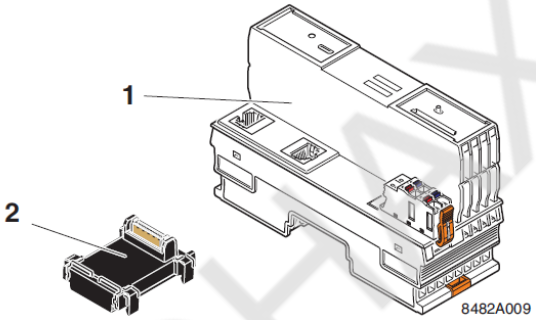
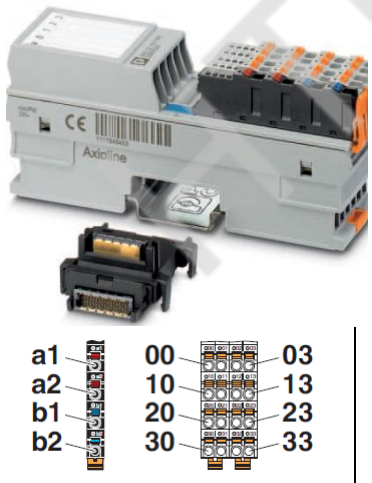


Fig. 2 Checked view of the controller and that's one-way tire

Axioline Digital Station Modules

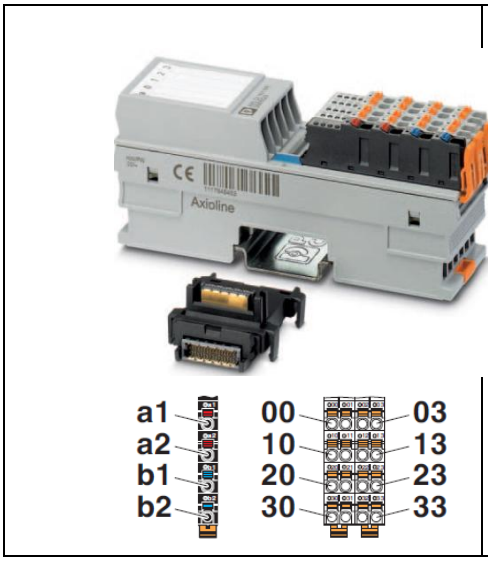
AXLFDI16 / 1 1Nm - a digital input module, digital inputs: 16, 24 V constant line (in Fig. 3).



Terminal point	Color	Assignment	
Supply voltage input			
a1, a2	Red	24 V DC (U_l)	Supply for digital input modules (bridged internally)
b1, b2	Blue	GND	Reference potential of the supply voltage (bridged internally)
Digital inputs			
00 ... 03	Orange	IN01 ... IN04	Digital inputs 1 ... 4
10 ... 13	Orange	IN05 ... IN08	Digital inputs 5 ... 8
20 ... 23	Orange	IN09 ... IN12	Digital inputs 9 ... 12
30 ... 33	Orange	IN13 ... IN16	Digital inputs 13 ... 16

Fig. 3 digital input module

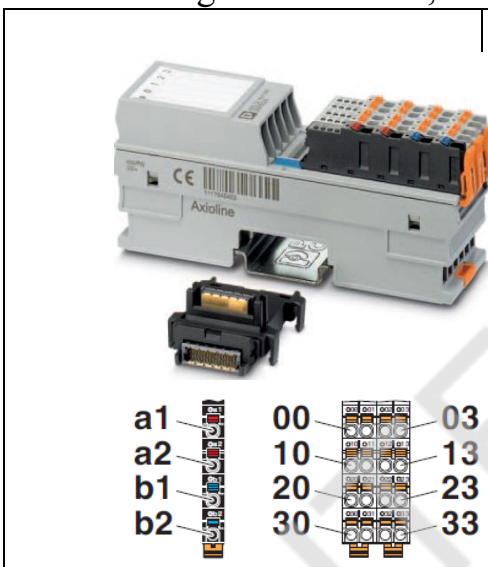
AXL F DO16 / 1 1H - digital drive module, digital output: 16, 24 V, constant current, 500 mA (Fig. 4).



Terminal point	Color	Assignment	
Supply voltage input			
a1, a2	Red	24 V DC (U_O)	Digital output module feed-in (bridged inter nally)
b1, b2	Blue	GND	Reference potential o supply voltage (bridg internally)
Digital outputs			
00 ... 03	Orange	OUT01 ... OUT04	Digital outputs 1 ... 4
10 ... 13	Orange	OUT05 ... OUT08	Digital outputs 5 ... 8
20 ... 23	Orange	OUT09 ... OUT12	Digital outputs 9 ... 12
30 ... 33	Orange	OUT13 ... OUT16	Digital outputs 13 ... 1

Fig. 4 Digital Drive Module

AXL F AI2 AO2 1H - analog module input to input, 2 inputs, 2 outputs (in Fig. 5)
- Arrow ranges: 0 mA ... 20 mA, 4 mA ... 20 mA, ± 20 mA
- Range: 0 V ... 10 V, ± 10 V, 0 V ... 5 V, ± 5 V



Termi-nal point	Color	Assignment	
Supply voltage input			
a1, a2	Red	24 V DC (U_A)	Analog module feed-i (bridged internally)
b1, b2	Blue	GND	Reference potential o the supply voltage (bridged internally)
Analog inputs			**IN01, IN02**
00, 01	Orange	U1+, U2+	Positive voltage conn tion for channel 1 and
10, 11	Orange	U1-, U2-	Negative voltage con nection for channel 1 and 2
20, 21	Orange	I1+, I2+	Positive current conn tion for channel 1 and
30, 31	Orange	I1-, I2-	Negative current con nection for channel 1 and 2
Analog outputs			**OUT01, OUT02**
02, 03	Orange	U1, U2	Voltage connection fo channel 1 and 2
12, 13	Orange	I1, I2	Current connection fo channel 1 and 2
22, 23	Orange	GND	Reference potential fo all AO channels
32, 33	Orange	GND	

Fig. 5 Analog I / O module

The layout of the tank with valves based on pneumatic cylinders and pneumatic distributors is shown in Fig. 6

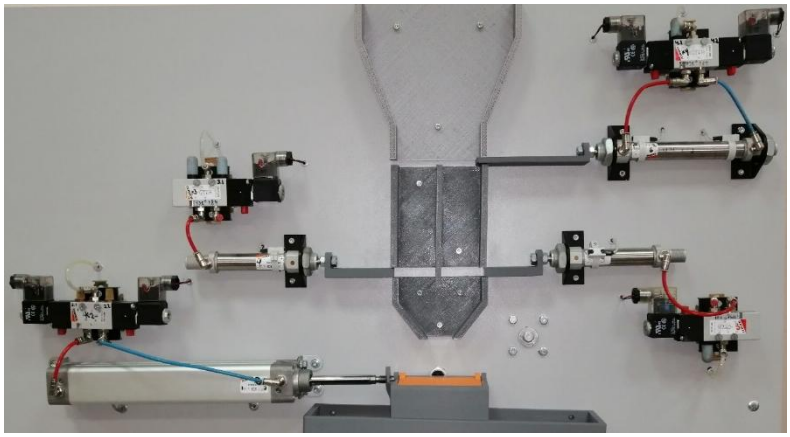


Fig. 6 Layout of a tank for dosing bulk solids

The layout consists of:

- Three gate valves: one long (Z 1.1) and two short (Z 2.1 and Z 2.2, respectively).
- Two pneumatic bistable cylinders, one of which (ПЦ 1.1) controls the gate valve (З 1.1) and the second (ПЦГК) cargo carriage (ГК) for further cargo transportation and two monostable cylinders (ПЦ 2.1, ПЦ 2.2, respectively).
- Two bistable electro-pneumatic valves (EPR PC 1.1) and (EPR CC), respectively, and two monostable electro-pneumatic valves (EPR PC 2.1) and (EPR CPU 2.2), respectively.
- Cargo carriage (GK) for further transportation of goods.

The principle of the model in the simulation:

Bulk substances (in this example, grain) fall into the zone in front of the gate valve (Z 1.1), which is initially in the closed state (as well as Z 2.1 and Z 2.2). After the valve is opened (З 1.1), the grain enters the substance separation section and, when the desired value is reached, the valve (З 1.1) closes. Further, under a given dosing condition (specified by the program in the PLC), either both valves (Z 2.1 and Z 2.2) or only one are opened. After that, they close and the load carriage replaces the filled tank with a new one. Then the cycle repeats.

Conclusions

The paper considers the task of creating a tank for dispensing bulk solids using valves based on the PHOENIXCONTACT PLC of the AXC 1050 family. Investigation of maintaining the stability of the operation of metering valves.

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METHOD OF INCREASING THE HIDDEN CHANNEL BAND CAPACITY FOR INFORMATION PROCESSING TECHNOLOGIES AND TRANSMISSION OF VIDEO INFORMATION RESOURCES

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Abstract.*The urgency of the work is confirmed by the need to find new steganographic methods of concealing data.*

The purpose of the work is to develop a method for increasing the capacity of the information transmission channel in prospective automated intelligence processing systems.

The analysis found that digital steganography methods have several disadvantages: low resistance to attacks, low amount of steganographic capacity, and are unstable when transmitting images and active attacks of the enemy, possible loss of data. The development of systems that use images and video to transmit data is forcing digital steganography techniques to protect data.

The quality indices of the developed steganographic method were calculated. This method allows you to hide bits in image blocks and has a channel bandwidth 20% higher than other methods of hiding information. The developed method is resistant to known active attacks and steganographic analysis by the enemy.

Recommendations for increasing bandwidth when using embedding methods in the conversion domain are defined.

Keywords: *digital steganography, image - container, discrete - cosine transformation, discrete wavelet - transformation.*

I Introduction

Restrictions on the use of cryptographic tools in a number of countries and the emergence of the problem of protecting the property rights to digital information make the popularity of research in the field of steganography. With the advent of global computer networks, access to information has increased significantly, which has led to an increased threat of data breach in the absence of security measures. Historically, the direction of steganography appeared first, but was largely displaced by cryptography.

A common feature of these methods is that a hidden message sticks to some harmless object that does not attract attention. Interest in steganography has been revived in the last 15 years, due to the widespread adoption of multimedia technologies and the emergence of new types of communication channels.

Steganography methods allow not only the hidden transmission of data, but also successfully solve the problems of interfering authentication, protection of information from unauthorized copying, tracking of information dissemination by communication networks, searching for information in multimedia databases. These circumstances allow, in the context of traditionally existing information flows or information environments, to address important information security issues in a number of applications.

The relevance of the research is a reliable protection of information from unauthorized access is not fully resolved the problem. In today's world, telecommunication systems are widely used and rapidly evolving in all spheres of human activity.

Therefore, the issue of information security is urgent. One of the possible solutions to the problem of improving information systems is to use digital steganography methods.

II Analytical review of literature

Today, a great number of different steganographic methods are offered, some of them universal, others intended for a wide range of tasks. For the comparative assessment of the quality of steganographic means, well-known indicators can be used to give quantitative and qualitative estimates [1].

Existing quantitative metrics are used to benchmark the performance of steganographic tools that operate on pixel-level images, although after proper adaptation, they can be applied to other methods of image description as well as to audio data [4]:

– relative steganographic capacity w_{rel} steganographic system.

The value of the relative steganographic capacity indicates the percentage of volume w_{emb} embedded volume information w_{init} image container. This value is used to evaluate the efficiency of the steganographic system by the specific volume of embedded information relative to the image volume of the container. The value w_{rel} relative steganographic capacity of the system is calculated by the following formula:

$$w_{rel} = \frac{w_{vol}}{w_{am}}, \tag{2.1}$$

$$w_{emb} = \frac{3 \cdot z_{\text{line}} \cdot z_{\text{column}}}{\omega}, \tag{2.2}$$

where z_{line} – the size of the image of the original vertically;

z_{column} – the size of the image of the original horizontally;

ω – number of elements required to embed 1 bit.

The percentage of the relative steganographic capacity of the system is estimated on the basis of the following expression:

$$w_{rel} = \frac{w_{emb}}{w_{am}} \cdot 100\%. \tag{2.3}$$

– probability P_{cor} unmistakably deleted data by an authorized user.

This value is used to estimate the error-free information retrieved under authorized access. This probability is calculated by the following formula:

$$P_{cor} = \frac{w_{seiz}}{w_{emb}}, \tag{2.4}$$

where w_{seiz} – amount of embedded information, bits;

w_{emb} – the amount of unmistakably deleted data, bits.

Where P_{cor} assumes a value of one, the amount of error-free embedded embedded data by an authorized user is 100%.

- the peak signal to noise ratio (h) of the image with the embedded data when unauthorized access. This value characterizes the visual distortions that are introduced into the image container during the embedding process and is calculated by the following formula:

$$h = 20\lg(255 / MSD), \tag{2.5}$$

where *MSD* – the squared deviation of the embedded image relative to the container image and is calculated using the following formula:

$$MSD = \sqrt{\frac{\sum_{i=1}^{z_{\text{lint}}} \sum_{j=1}^{z_{column}} (a_{ij} - a'_{ij})}{z_{line} z_{column}}}, \quad (2.6)$$

where a_{ij}, a_{ij}`– elements of the initial and steganographically transformed image, respectively;

z_{line} – the size of the image of the original vertically;

z_{column} – the size of the image of the original horizontally;

The most important qualitative characteristics of steganographic systems, created using different methods, include:

- bandwidth.

The number of bits of a hidden message that can be transmitted by this method in a fixed size image;

- stability.

Ability to remove hidden information after general image processing operations: linear and nonlinear filters (blur, sharpening, median filtering), lossy compression, contrast adjustment, repaint, resampling, scaling, rotation, noise, trimming, cropping , pixel shifts in a narrow color quantization neighborhood, and more. The notion of resilience does not preclude attacks on embedding methods that are based on knowledge of the algorithm of concealment or removal. Persistence means resistance to "blind", unintended modifications, or general image operations;

- invisibility.

Characteristic responsible for the inability of the human vision to detect a steganographic message without the use of 28 special means. This concept is based purely on the properties of the human visual system [2].

Hidden information is considered invisible if the average person is unable to distinguish the media with the hidden information from the media without it.

The commonly accepted scheme of experiment (the so-called blind test), which is often used in psycho-visual experiments, is based on the fact that subjects are randomly offered a large number of carriers with and without information, and it is suggested to choose which media contain hidden data.

Note that the concept of invisibility can be defined in another way and be related to the statistical model of the image source. It is then considered that the hidden information is invisible if the filled container image agrees with the source model from which the original image was taken and can be calculated objectively;

- security.

The concept of security includes procedural attacks such as IBM attacks or attacks based on the knowledge of partial modification of the media due to the presence of attachments. The embedded information cannot be deleted by targeted attacks based on the known embedding and retrieval algorithm (except for the secret key) and the knowledge of at least one carrier with a hidden message;

- complexity of embedding and extraction.

The number of standard operations that will be performed to embed and detect a hidden message.

The above requirements are mutually competitive and may not be optimal at the same time. If you want to hide a large message inside the image, then it is impossible to require absolute invisibility and high stability. An optimal compromise is always needed.

On the other hand, if resistance to large distortions is required, then a message that must be safely hidden cannot be too long.

The estimates obtained are used to analyze the selected steganographic methods of embedding information and to make a multi-criteria selection of the best method. By formulas 2.1 - 2.6 we will calculate quantitative indicators for the following methods:

- the least significant bit;
- Podolchuk method;
- the Tao method.

From the analysis of Table 2.1 it can be seen that these existing steganographic methods have a low probability of data extraction and a low peak signal to noise ratio. This makes the steganogram vulnerable to all sorts of attacks.

Table 2.2 shows the main attacks.

Table 2.1 - Quantitative values of steganography methods

Quality Score	Steganography methods		
	least significant bit	Podolchuk	Tao
Relative capacity,%	6,25	12,5	3,1
Probability of data retrieval	0,5	0,75	0,7
Peak ratio signal noise	12,53	19,43	18,54

Table 2.2 - Basic range of attacks on the steganost system

Attack Types	The purpose of an attack		
	Detecting the fact of the presence of embedding	Destruction of the embedded message	Remove embedded message
Active	Visual attack	Noise in the data link	
Passive	Steganographic analysis	Obstruction, compression attacks	Steganographic analysis

Let's perform a comparative analysis of quantitative indicators for the following methods:

- A1 (least significant bit method (LSB));
- A2 (Bengal-Memon-Eo-Jung method);
- A3 (discrete wavelet transform method);
- A4 (Koha-Zhao method).

To understand the values described in Table 2.3, the following is the calculation of the coefficients for bandwidth.

Table 2.3 - Comparative analysis of quality indicators of steganography methods

	bandwidth	complexity of detection	invisibility	security	complexity of embedding
A1	0,509	0,453	0,147	0,018	0,453
A2	0,023	0,072	0,076	0,216	0,072
A3	0,063	0,020	0,293	0,381	0,020
A4	0,038	0,120	0,044	0,216	0,120

For the LSB method the bandwidth depends on the image size (h - height, w - width) and is calculated according to [3]:

$$C = h \cdot w \cdot 3. \tag{2.7}$$

The Koha Zhao method uses a block of 8x8 discrete-cosine transform coefficients to embed one bit of information, so the throughput is determined by:

$$C = \frac{h \cdot w}{8 \cdot 8}. \tag{2.8}$$

Methods using a first-level discrete wavelet transformer can offer bandwidth:

$$C = \frac{h \cdot w}{4}. \tag{2.9}$$

For other characteristics, the stability was evaluated by the number of common image processing operations that can be performed with a steganographic system formed by a particular method without losing the ability to detect the embedded information [4].

Invisibility was evaluated by quantitative image quality (IF). Security took into account the robustness of the methods to attacks.

The complexity of embedding and deleting was calculated by the number of standard operations that must be performed to embed and remove a hidden message.

In this case, the steganographic container was filled with only 10% of the maximum throughput. Analyzing the existing methods of hiding data in the image container identified the main disadvantages.

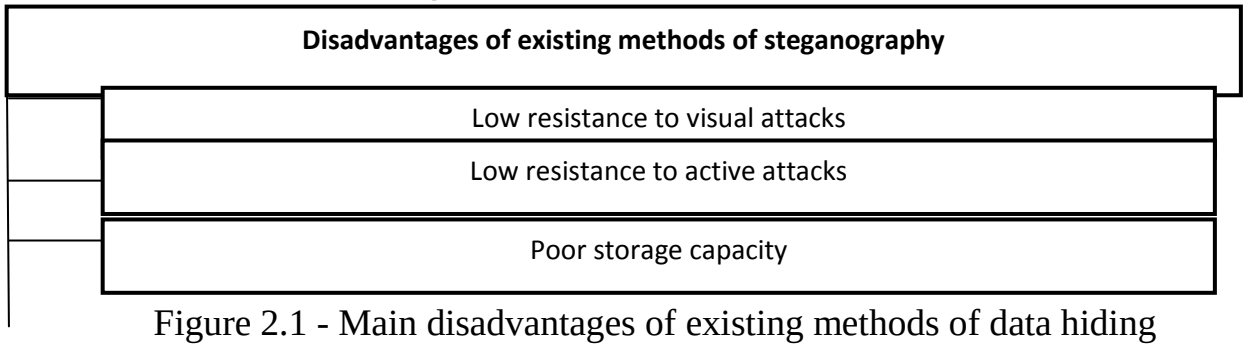

Figure 2.1 - Main disadvantages of existing methods of data hiding

The steganogram's resistance to visual attacks by the attacker is low. This disadvantage is due to the fact that embedding the hidden information is achieved by modifying the elements of the presentation of the steganogram.

This is accompanied by the introduction of visual distortions of the image deterioration of its quality. In the event that the attacker has the original image-container, the fact that there is a hidden embedding in the steganogram can be detected.

Low embedded data resistance to active attacker attacks. Among these attacks, compression attacks are the most common. They are aimed at eliminating psycho-visual redundancy, which is also used for indirect steganographic concealment of information.

Using the attack data, the enemy is able to permanently destroy the embedded message. The poor value of the steganographic capacity. Existing embedding methods do not provide the required amount of embedded information. This disadvantage is due to the fact that the increase in the amount of embedding is accompanied by an increase in the number of modified elements and, as a consequence, an increase in image distortion.

III Object, subject and methods of research

Object of study - information security processes in control systems for advanced automated intelligence systems in the Air Force.

The purpose of the work is to develop a method for increasing the capacity of the information transmission channel in prospective automated intelligence processing systems.

Research methods - analysis and mathematical modeling of information security methods.

IV Work results

To provide additional noise immunity, bandwidth needs to be increased, since the use of noise-coding methods or duplication of information requires the transmission of additional bits.

In the course of the research, two methods for increasing the throughput were identified using embedding methods in the transformation domain.

The first method is based on the assertion that embedding in mid-range DCT coefficients will provide sufficient image stability, since they are usually not amenable to modification and loss of side compression algorithms. At the same time, the human eye does not have such high sensitivity to sense changes in these coefficients. Therefore, we propose a method that maximizes the use of midrange image components.

The second method of image stability enhancement uses not only the blue image matrix as embedded in conventional methods, but also green and red. In order to use this method, it is recommended to use green or red colored images without large monotonous areas as containers.

Intelligence, constant surveillance and timely transmission of information about the enemy's actions were the key to the success of combat operations in the war. Modern unmanned aerial vehicles make it easier to accomplish these tasks. Based on the results of the study of the advantages and disadvantages of existing methods of embedding information, its own method of steganographic concealment of information was developed. The essence of the developed steganographic method is that images and classified information are pre-processed to increase the bandwidth and stability of the stegosystem.

The method developed should ensure the reliability of the information in the images, embedding a relatively large amount of information and resistance to distortion. The image has a large number of segments, which will provide the opportunity to provide a relatively large volume for embedding information.

Step 1 - A discrete wavelet transform is applied to the image, which results in the image being decomposed into four areas: LL is the low-frequency region, and three areas (LH, HL, HH) are the high-frequency regions.

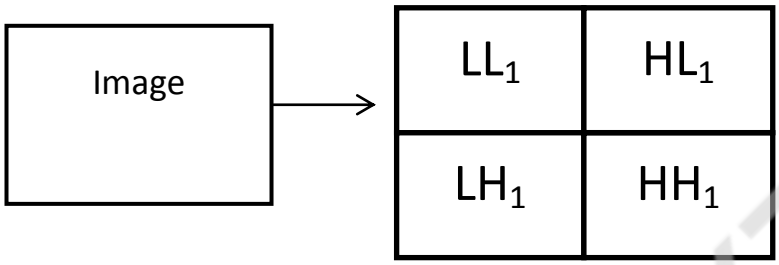

Figure 4.1 - The first level of wavelet transform

Step 2 - the selected area (LH, HL, HH) is divided into blocks 8x8 and discrete-cosine transformation is applied to each block:

$$\Omega(\upsilon,\nu)=\frac{\xi(\upsilon)\cdot\xi(\nu)}{\sqrt{2N}}\cdot\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}C(x,y)\cdot\cos\left[\frac{\pi\cdot\upsilon\cdot(2x+1)}{2N}\right]\cdot\cos\left[\frac{\pi\cdot\nu\cdot(2y+1)}{2N}\right]$$

where C (x, y) - respectively, the elements of the original and reproduced by the coefficients of discrete-cosine image transformation with dimension NxN;

x, y – spatial coordinates of image pixels;

Ω(υ, ν) – an array of discrete-cosine transform coefficients

(υ, ν) – coordinates in the frequency domain;

$\xi(\upsilon)=\frac{1}{\sqrt{2}}$, if $\upsilon\approx 0$, and $\xi(\upsilon)=1$, if $\upsilon>0$.

Step 3 - It was suggested that not all segments (blocks) of the container should be used for embedding, but only those that are most suitable for this purpose.

Suitable for embedding hidden information are those image segments that simultaneously satisfy the following two requirements:

- in the segment there are no sharp differences in brightness;
- the segment is not too monotonous.

Segments that do not meet the first requirement are characterized by the presence of several too large values of the low-frequency coefficients of the discrete-cosine transform, comparable in magnitude with the DC component.

Units that do not satisfy the second requirement are characterized by the equality of zero of most high-frequency coefficients. Thus, these features serve as a criterion for rejecting unfit containers.

These rejection requirements are taken into account using two thresholds: P_L, (for the first requirement) and P_H (for the second requirement), excess (P_L) or failure to reach (P_H)

which will indicate that the visual modification visibility of the segment in the frequency domain will be extremely high, making the last bit of the message unsuitable.

Step 4 - from the block belonging to the mid-frequency area, are selected (for greater stability of the girder system - pseudorandom) three coefficients of discrete-cosine transformation with coordinates $(\upsilon_1,\nu_1),(\upsilon_2,\nu_2),(\upsilon_3,\nu_3)$ respectively.

In addition, these coefficients should correspond to the cosine functions with medium frequencies, which will ensure the concealment of information in significant areas of the human visual signal system, and the information will not be distorted by JPEG compression with low compression ratios.

Step 5 - if you want to make the embedding "0", these coefficients are changed so that the third factor is less than each of the first two; if you want to hide "1", then the coefficient with coordinates becomes greater than the others:

$$\begin{cases} (\Omega_b)_{\upsilon_3\nu_3} < (\Omega_b)_{\upsilon_1\nu_1}; \\ (\Omega_b)_{\upsilon_3\nu_3} < (\Omega_b)_{\upsilon_2\nu_2}. \end{cases} \quad M_b = 0;$$

$$\begin{cases} (\Omega_b)_{\upsilon_3\nu_3} > (\Omega_b)_{\upsilon_1\nu_1}; \\ (\Omega_b)_{\upsilon_3\nu_3} > (\Omega_b)_{\upsilon_2\nu_2}. \end{cases} \quad M_b = 1,$$

where M_b – block number;

– coordinates of discrete-cosine transform coefficients

Ω_b – matrix of 8x8 coefficients of decomposition.

Step 6 - embedding information is such that the difference in the absolute values of the coefficients of the discrete-cosine transformation exceeds some positive value of P, such as P = 50, when transmitting bit "0", and for the transmission of bit "1" this difference becomes smaller compared to the same negative value of P:

$$\begin{cases} (\Omega_b)_{\upsilon_3\nu_3} < \min\left[(\Omega_b)_{\upsilon_1\nu_1}, (\Omega_b)_{\upsilon_2\nu_2}\right] - P, \text{ by } \mathrm{M}_b = 0; \\ (\Omega_b)_{\upsilon_3\nu_3} > \max\left[(\Omega_b)_{\upsilon_1\nu_1}, (\Omega_b)_{\upsilon_2\nu_2}\right] + P, \text{ by } \mathrm{M}_b = 1. \end{cases}$$

The higher the P value, the more the system created by this method is more resistant to compression and interference, but the image quality can be significantly degraded.

If such modification results in too much degradation of the image, the coefficients are left unchanged and the block and the quality of the container are not used. The use of three coefficients of discrete-cosine transformations instead of two and, most importantly, the rejection of modification in case of unacceptable image distortions, significantly reduces the visibility of the sheganogram.

The developed method is created by integration of the offered methods of increase of stability, security and throughput of steganographic systems.

By formulas 3.1 -3.6 we will analyze the indicators of the developed method. The results obtained are shown in Table 4.1.

Table 4.1 - Quality indicators of the developed method

	Relative capacity%	Probability of data retrieval	Peak signal to noise ratio
developed мethod	4,6	1	23,56

Well-known indicators that provide quantitative estimates can be used to benchmark the quality of steganographic tools. They operate with pixel-level images. In these ratios, - denotes the pixel of the empty container with coordinates (x, y) and through - the corresponding pixel of the filled container. The quality of the stegosystems presented in this paper was evaluated by the following characteristics:

- signal-to-noise ratio (SNR), which is a dimensionless value equal to the useful signal-to-noise ratio. The higher the ratio, the less noise distorts the image:

$$SNR = \frac{\sum_{x,y} (C_{x,y})^2}{\sum_{x,y} (C_{x,y} - S_{x,y})^2}.$$

- normalized mean absolute difference (NAD), showing the degree of difference between the output container and the container with the built-in secret file, is calculated as follows:

$$NAD = \frac{\sum_{x,y} \left| C_{x,y} - S_{x,y} \right|}{\sum_{x,y} \left| C_{x,y} \right|}.$$

- image quality (IF) is one of the main evaluation characteristics for image stegoalgorithms:

$$IF = 1 - \frac{\sum_{x,y} \left(C_{x,y} - S_{x,y} \right)^2}{\sum_{x,y} \left(C_{x,y} \right)^2}.$$

– mean square error (*MSE*):

$$MSE = \frac{1}{X \cdot Y} \sum_{x,y} \left(C_{x,y} - S_{x,y} \right)^2.$$

– average absolute difference (AD), which determines the average of the difference module between pixels of an empty and filled container. High AD value indicates poor image quality:

$$AD = \frac{1}{X \cdot Y} \sum_{x,y} \left| C_{x,y} - S_{x,y} \right|.$$

The methods were tested on images of different sizes 128x128 with a hiding power for the developed algorithm: P = 50. The results of the calculation of the proposed characteristics are shown in table. 4.2.

Table 4.2 - Quantitative values of steganography methods

The distortion rate	Developed method	least significant bit method	Bengal-Memon-Eo-Jung method	Koha-Zhao method
AD	0,649	0,494	3,042	11,400
SNR	9375	4975	781,6	137,69
IF	1	≈1	0,998	0,993
MSE	2,113	0,494	-	178,3

By formulas 2.7 - 2.9 we will calculate the throughput of the presented methods.

Table 4.3 - Bandwidth values of steganography methods

Quality Score	Developed method	least significant bit method	Bengal-Memon-Eo-Jung method	Koha-Zhao method
Bandwidth	0,086	0,058	0,023	0,038

V Conclusions

An analysis of existing methods of hiding data in the image container showed that these methods have a low probability of correct data retrieval, unstable to existing attacks, and have low steganographic bandwidth.

A method for steganographic concealment of data was developed using the discrete wavelet transform method and the Bengh-Memon-Yeo-Jung method. Primary LH, HL image areas were selected for comparison. Selected blocks using the Bengh-Memon-Eo-Jung method are resistant to compression attacks and introduce slight distortions to the image, allowing the image to be used for steganographic hiding of data.

The quality indices of the developed steganographic method were calculated. This method allows you to hide the bits in the image blocks the high probability of correctly extracting the embedded data. The developed method is resistant to known active attacks and steganographic analysis by the enemy.

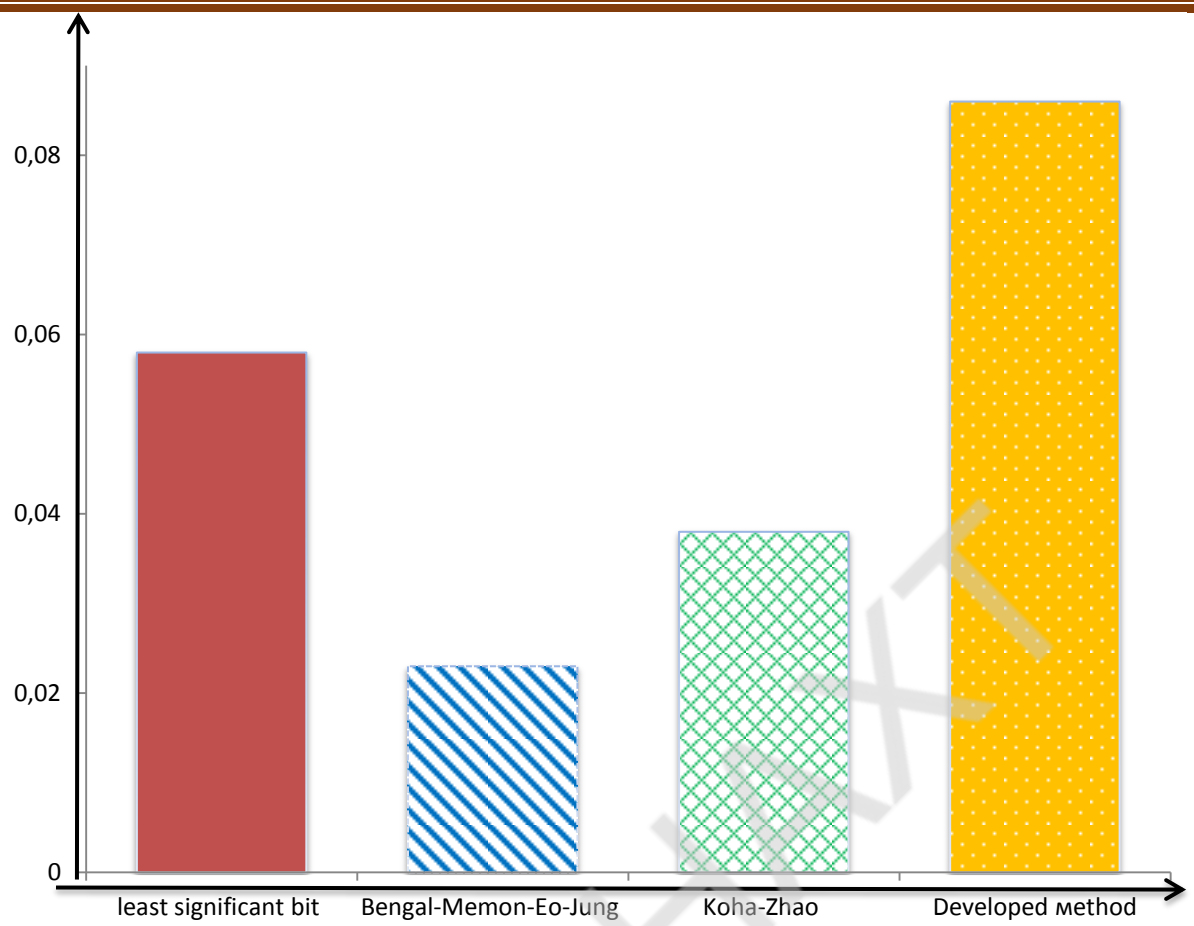

Figure 4.3 - Bandwidth of digital steganography techniques

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DYNAMIC SCHEDULING STRATEGY OF INTELLIGENT RGV

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Abstract. *With the development of the intelligent industry, intelligent processing systems have received extensive attention, and the planning of the production process is the key to the entire processing system. This paper mainly studies the dynamic scheduling problem of RGV in different situations without faults, and gives the corresponding algorithm, discusses the scheduling strategy and operation efficiency, and tests the practicability of the model and the effectiveness of the algorithm.*

In the case of a trouble-free process, firstly, the maximum production material in a unit shift is the goal, and the above blanking time, waiting time, remaining working time, moving time and other constraints are used, and the recursive relationship between loading time and waiting time is used at the same time A 0-1 RGV dynamic scheduling 0-1 planning model for a trouble-free process is established. Based on this model, using the idea of directed acyclic shortest, the corresponding global optimization algorithm is designed, and the three sets of data are used to calculate the optimal scheduling strategy of RGV within the unit shift. At this time, the system's operating efficiency is 365, 347, 374 per shift. Finally, a process error detection model is established, and sensitivity analysis is performed to determine that the model has strong stability. Comparing the global optimization algorithm with the traditional greedy local optimization algorithm, the improvement percentages are 2.52%, 3.27%, and 2.18%, indicating that the algorithm is effective.

For the case of two programs without failure, the improvement is based on the case-one model. Increase the tool selection 0-1 variable, tool selection position, cleaning sequence and work flow constraints, with the goal of completing the second process with the largest amount of materials, and establish a trouble-free two process RGV dynamic scheduling 0-1 model. Combined with this model, the corresponding global optimization algorithm is designed. Then based on the 3 sets of data, 3 sets of tool arrangements are calculated. At the same time, the optimal scheduling strategy of RGV in one shift was obtained. At this time, the system's operating efficiency was 248, 203, and 243 per shift, respectively. Finally, based on a process error detection model, a two-process error detection model was established, and a sensitivity analysis was performed to determine that the model is more stable. Comparing the global optimization algorithm with the traditional greedy local optimization algorithm, the improvement percentages are 5.46%, 0.49%, and 0.41%, indicating that the algorithm is effective.

Finally, the paper evaluates the advantages and disadvantages of the model, proposes improvements, promotes the model, and obtains the intelligent RGV dynamic scheduling strategy in the event of a fault.

Keywords: *intelligent processing system,dynamic scheduling, global optimization, 0-1 planning, directed acyclic*

1 Problem background and restatement

Background of the problem

With the advent of the era of Industry 4.0, in the face of global competition, manufacturers at home and abroad are facing the globalization of competition, the company's automation awareness and the automation industry are constantly developing, and intelligent processing systems have emerged. Intelligent processing systems mainly include rgv systems and agv systems. The agv system is mainly guided by the driverless system, and the rgv system relies on the track for movement.The rgv system has a simple structure and strong anti-interference ability. It is widely used in logistics systems and factory processing systems, and is more suitable for the needs of modern production. Different, rgv system is divided into assembly type rgv intelligent system and transportation type rgv intelligent system [1], which provides convenience for material transportation and workshop assembly. According to the movement mode, it can be divided into ring orbit type and linear reciprocating type [1] The ring-track rgv system has high working efficiency and adopts the mode of multiple vehicles working at the same time.The linear reciprocating rgv system generally only has one rgv for linear reciprocating motion, so its line planning and dynamic scheduling are particularly important.

Restatement of the problem

An existing intelligent processing system is composed of 8 CNC machine tools cnc, 1 guide car rgv, one rgv linear track, one loading conveyor and one unloading conveyor. Cnc can complete the tasks of sending and receiving instructions and loading and unloading processing, And there is a possibility of failure.The rgv can orientate the track, send and receive instructions, load and unload, and clean the material.

The schematic diagram of the intelligent processing system is shown in Figure 1:

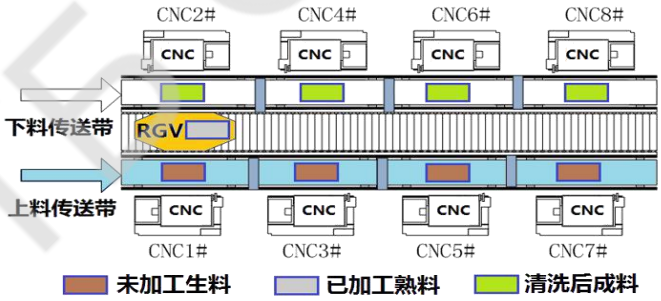

Figure 1 Schematic diagram of intelligent processing system

The processing process is divided into two cases: one ideal process and two ideal processes. For the two cases, complete the following tasks:

Task: Use the parameters of the system operation found on the Internet to test the practicability of the model and the effectiveness of the solution algorithm, and give the rgv scheduling strategy in the processing system and the operation efficiency of the processing system. The parameters are shown in Table 1:

Table 1: 3 sets of data table of intelligent processing system operating parameters Time unit: second

System operation parameters	Group 1	Group 2	Group 3
rgv time required to move 1 unit	20	23	18
rgv time required to move 2 units	33	41	32
rgv time required to move 3 units	46	59	46
cnc processing time to complete a one-step material	560	580	545
cnc processing time to complete the first operation of a two-process material	400	280	455
cnc processing time required to complete the second operation of a two-process material	378	500	182
rgv is cnc1 #, 3 #, 5 #, 7 #	28	30	27
rgv is cnc2 #, 4 #, 6 #, 8 #	31	35	32
rgv time required to complete a material cleaning operation	25	30	25

Model assumptions

Assumption 1: The capacity of each CNC machine tool cnc is 1 unit, which means that only one material can be processed at a time; Assumption 2: Do not consider the time for the robot to switch the grip of the robot;

Assumption 3: For the material that has failed, the time of unloading is the time of failure;

Hypothesis 4: On the loading conveyor, when there is raw material removed, there will be a raw material replacement immediately; on the unloading conveyor, when clinker is placed, it will be transported away immediately.

Explanation of symbols

symbol	Description
x_{ij}	Whether the i-th item is placed in the 0-1th CNC's 0-1 variable
Q_{ij}	0-1 variable of whether the j-th CNC works when the i-th material is loaded
R_{ij}	0-1 variable whether the i-th material is being cleaned at the j-th CNC
t_j	Time required for j-th CNC machine to load and unload at one time

c	Time to finish cleaning a material
m	Number of materials processed
ZF_j	0-1 variable of whether j is installed with the first process tool
ZS_j	0-1 variable of whether the jth stage is equipped with the second process tool

4 Problem analysis

4.1 Overall analysis of the problem

This question is to study the dynamic scheduling problem of intelligent rgv processing system, so it is necessary to understand the working principle of intelligent rgv processing system [2]. According to the different processing methods, the processing system is divided into four working states: one process without failure, two without failure. One process, one process with faults, two processes with faults.

4.2 Analysis of a trouble-free process

Task 1: Investigate the problem of dynamic programming of the materials processed by the unit shift. The factors to be considered before each planning include the working status of each cnc job, the time consumed by displacement, the remaining cnc working time, and cleaning time. The most demand, get the shortest time course, determine the most processed materials.

Task 2: Bring 3 sets of data into the task 1 model to find the scheduling strategy and the system's operating efficiency. Test the practicability of the model from the aspects of possible errors and stability, and compare the effectiveness of the algorithms by comparing different algorithms.

4.3 Analysis of two failure-free processes

Task 1: On the basis of question 1, add a second process, the goal is to process the most materials per unit shift. Before planning, you must consider both the assignment of the cnc process and the connection between the two processes. Simulate all The distribution of cnc operations, the shortest time route is determined according to the connection relationship between the two operations, and the most processed materials are determined.

Task 2: Based on the first case, increase the error analysis of loading and unloading, test the practicability of the model from the aspects of possible errors and stability, and compare the effectiveness of the algorithms by comparing different algorithms.

5 Model establishment and solution

Due to format requirements, if all the formulas are typed in the article, the article will be too long, which will cause the number of pages to exceed the standard. Therefore, the introduction of various constraints and formulas is given in the form of pictures after using latex typesetting.

5.1 rgv scheduling for a fault-free process

5.1.1 Establishment of a Failure-Free Process Scheduling Model——Task 1

5.1.1.1 Selection of variables

To facilitate the same labeling, the 8 cncs are numbered accordingly, and the numbering diagram is shown in Figure 2:

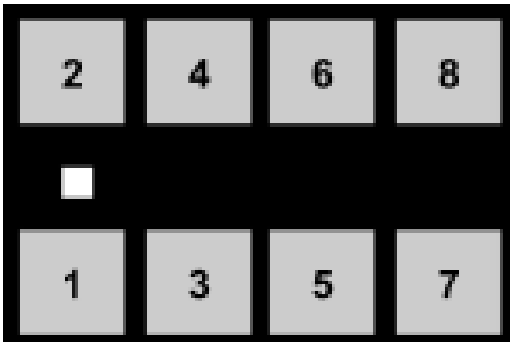

Figure 2 CNC numbering diagram of CNC machine tools

As shown in Figure 2, the numbers 1 to 8 are CNC machine tools cnc, and the white squares are the guide cars rgv.

(1) Selection of 0-1 variables

$$x_{ij}=\begin{cases}0, \text{第}i\text{个物料不放置在第}j\text{台}CNC\\ 1, \text{第}i\text{个物料放置在第}j\text{台}CNC\end{cases}(1)$$

$$Q_{ij}=\begin{cases}0, CNC\text{不工作}\\ 1, CNC\text{工作}\end{cases}(2)$$

$$R_{ij}=\begin{cases}0, \text{第}i\text{个物料不在第}j\text{台}CNC\text{清洗}\\ 1, \text{第}i\text{个物料在第}j\text{台}CNC\text{清洗}\end{cases}(3)$$

(2) Selection of time variables

$$TM_i=\sum_{j=1}^{n}(x_{ij}\cdot T_{L_i j})(4)$$

$$TL_i=\sum_{j=1}^{n}(x_{ij}t_j)(5)$$

$$TC_i=\sum_{j=1}^{n}R_{ij}x_{ij}c \quad (6)$$

$$T_i=TW_i+TM_i+TJ_i+TL_i+TC_i \quad (7)$$

Among them, tw_i is the possible waiting time; tm_i is the moving time; tj_i is the processing time, which is determined by the processing method and the nature of the workpiece itself; tl_i is the loading and unloading time; tc_i Is the cleaning time.

(3) Selection of ordinal variables

Set the number of materials processed in a shift working time as m.

In order to obtain the distance between the 1st-i material and the i-th material processing machine CNC, the serial number of the 1st-i material processing station is required. Because RGV is initially in the middle of the 1st CNC and the 2nd CNC Position, when i-1 = 0, $L_1 = 1$ (8)

In order to obtain the serial number L_i of the 1-i material processing station, the definition of the j label of the station is used as the intermediate variable for conversion. Here, the logarithmic algorithm is used, that is, the basic relationship between the index and the logarithm can be converted to a as a base to get

$$n = \log_a(a^n) \quad (9)$$

Using equation (3), when i-1> 0 $L_i = \log_2\left(\sum_{j=1}^{n}(x_{i-1,j}\cdot 2^j)\right)$ (10)

$$L_i = \begin{cases} 1, & i = 1 \\ \log_2\left(\sum_{j=1}^{n}(x_{i-1,j}\cdot 2^j)\right), & i > 1 \end{cases} \quad (11)$$

The CNC serial number w_I in the working state when the i-th material is loaded. In order to extract the CNC serial number that is in the working state when the i-th material is loaded, the basic relationship between the index and the logarithm can be converted to each other. Extract the CNC serial number, i.e.

$$w_{ik} = \log_2\left(\sum_{k=1}^{m} x_{kj}R_{kj}\cdot 2^j\right) + m - i \quad (12)$$

Among them, R_{kj} is a 0-1 variable whether the k-th material is cleaned at the j-th CNC; m is the number of processed materials.

5.1.1.2 Determination of constraints

(1) Constraints on 0-1 variables

$$\sum_{j=1}^{n} x_{ij} = 1 \quad (13)$$

$$\sum_{j=1}^{n} x_{ij} = 0 \quad (14)$$

$$0 \le \sum_{j=1}^{n} x_{ij} \le 1 \quad (15)$$

$$R_{ij} \le \left\lfloor \sum_{k=1}^{i} x_{ij} / 2 \right\rfloor \le R_{ij}\cdot M \quad (16)$$

Among them, R_{ij} is a 0-1 variable whether the i-th material is cleaned at the j-th CNC; M is a very large constant.

(2) Time constraint

$$T_i, TM_i, TJ_i, TL_i, TC_i > 0 \quad (17)$$

TW_i ³0

$$\sum_{i=1}^{m} T_i £ T \quad (18)$$

$$\sum_{i=1}^{m} T_i > T \quad (19)$$

$$t_{2\alpha} > t_{2\beta+1} \quad (20)$$

$$TD_i = TU_{i+N} \quad (21)$$

$$Q_{ij} £ \sum D_{ij} £ Q_{ij} \cdot M \quad (22)$$

$$TW_i = \left\lfloor \sum_{j=1}^{n} Q_{ij} / n \right\rfloor \cdot \min\left\{ D_{ij} \right\} \quad (23)$$

Among them, Q_{ij} is a 0-1 variable whether the j-th CNC is working when the i-th material is loaded; n is the total number of CNC machine tools CNC, this question is 8; D_{ij} is the remaining working time.

(3) Recursive constraint

$$TU_i = 0, i = 1 \quad (24)$$

$$TU_{ij} - TU_{i-1j} = TM_i + TC_{i-1} + TW_i, i > 1 \quad (25)$$

Among them, tm_i is the moving time; tc_i is the cleaning time; tw_i is the waiting time.

$$D_{ij} = 0, i = 1 \quad (26)$$

$$D_{ij} - D_{i-1j} = xij[T_{i-1} - TC_{i-1} - TM_{i-1}] \quad (27)$$

Among them, T_{i-1} is the total working time; x_{ij} is a 0-1 variable whether the i-th material is placed on the j-th platform.

5.1.1.3 Determination of the objective function

Considering that in actual factory production, as many products as possible will be produced for sale within a fixed time, so we set the maximum number of production materials as the goal.

$$\max \sum \sum x_{ij} \quad (28)$$

Among them, whether the i-th material is placed in the 0-1 variable x_{ij} of the j-th CNC.

5.1.1.4 Model establishment

Based on the analysis of 5.1.1.2 and 5.1.1.3, with formula (28) as the target and

formulas (14) to (27) as constraints, a single

The target maximum production material model 0-1 planning expression is as follows:

$$\max \sum \sum x_{ij}$$

s.t.

Recursive constraints:

when $i=1$ Time

$$\begin{cases} TU_i = 0 \\ D_{ij} = 0 \end{cases} \tag{29}$$

when $i \geq 1$ Time

$$\begin{cases} TU_{ij} - TU_{i-1j} = TM_i + TC_{i-1} + TW_i \\ D_{ij} - D_{i-1j} = x_{ij}(T_{i-1} - TC_{i-1} - TM_{i-1}) \end{cases} \tag{30}$$

Time constraints:

$$\begin{cases} \sum_{i=1}^{m} T_i £ T \\ \sum_{i=1}^{m+1} T_i > T \\ t_{2\alpha} > t_{2\beta+1} \\ Q_{ij} £ \sum D_{ij} £ Q_{ij} \cdot M \end{cases} \tag{31}$$

0-1 variable constraints:

$$\begin{cases} 0 £ \sum_{j=1}^{n} x_{ij} £ 1 \\ R_{ij} £ \left\lfloor \sum_{k=1}^{i} x_{ij} / 2 \right\rfloor £ R_{ij} \cdot M \end{cases} \tag{32}$$

Ordinal equation constraint:

$$\begin{cases} L_i = \begin{cases} 1, & i = 1 \\ \log_2 \left(\sum_{j=1}^{n} (x_{i-1,j} \cdot 2^j) \right), & i > 1 \end{cases} \\ w_{ik} = \log_2 \left(\sum_{k=1}^{m} x_{kj} R_{kj} \cdot 2^j \right) + m - i \end{cases} \tag{33}$$

Time equation constraints:

$$\begin{cases} TM_i = \sum_{j=1}^{n} (x_{ij} \cdot T_{L_i j}) \\ TL_i = \sum_{j=1}^{n} (x_{ij} t_j) \\ TC_i = \sum_{j=1}^{n} R_{ij} x_{ij} c \\ TW_i = \left\lfloor \sum_{j=1}^{n} Q_{ij} / n \right\rfloor \cdot \min\left\{ D_{ij} \right\} \\ TD_i = TU_{i+N} \\ T_i = TW_i + TM_i + TJ_i + TL_i + TC_i \end{cases} \quad (34)$$

Variable constraints:

$$\begin{cases} TW_i \text{³} 0 \\ T_i, TM_i, TJ_i, TL_i, TC_i > 0 \\ 0 \text{£} \sum_{j=1}^{n} x_{ij} \text{£} 1 \\ x_{ij,} R_{ij,} Q_{ij} \hat{I} \{0,1\} \end{cases} \quad (35)$$

Model description:

Recursive constraints, time constraints, 0-1 variable constraints, sequence equation constraints, time equation constraints, and variable constraints are listed separately, which reflects the time relationship of each part during the entire period of the material operation.

5.1.2 Solving the rgv scheduling model-task one

The difficulty of this algorithm is the search of the optimal path x_{ij}. During the search of the optimal path, two conditions need to be met: (1) RGV cannot move without receiving an instruction; (2) the shortest time.

Analysis shows that when rgv waits in place, if the next instruction needs to be displaced, because rgv cannot arrive in advance, it will waste the displacement time, so we consider setting the path to the cnc that rgv first arrives and waits in place. The last cnc arrived at the same location, satisfying

$$\left[\frac{a_1}{2} \right] = \left[\frac{a_{end}}{2} \right]$$

That is, the cnc numbered 1 and the cnc numbered 2 are in the same position, so we can abstract the optimal path problem as: starting from the initial cnc position, traversing all cnc positions, and finally reaching the directed acyclic loop of cnc at the same position The shortest problem, and then solve the shortest time.

For a dynamic scheduling planning problem with the largest total number of materials processed in a given time, traditional intelligent algorithms take longer to solve and are easily trapped in local optimal solutions. Based on the dynamic scheduling model, we designed As the goal, the time equation constraint is a recursive condition, and the overall time is a fault-free rgv scheduling algorithm for a process.The algorithm design is as follows:

Step1: Initialize variables. Establish RGV displacement time adjacency matrix T, CNC loading and unloading time direction t, CNC's remaining work completion time matrix D, and ith start feeding time TU i to complete cleaning material time C;

Step 2: Optimal path selection. According to the shortest path, make the i-th material select the j-th platform, record the CNC number a i = j of the i-th material selection, and update the remaining work according to the recursive equation constraint (30) Time D ij = D ij + T, if D ij = 0, go to Step 3, otherwise go to Step 4;

Step3: Update the start time of the i + 1 material and the start time of the i-N material according to the time equation constraint (34) TU i = TU i + minmax (T ij, D ij) + t j + cR ij, turn to Step2;

Step4: Find the station with the minimum remaining working time min (D ij), wait in place for the small remaining working time min (D ij), and update the remaining working time D ij according to the recursive equation constraint (30)) = D ij-min (D ij}, update the start time of the i + 1th material TU i+1 = TU i + min (D ij), go to Step 2;

Step5: According to the overall time constraint formula (34), determine the starting time TU i + c + t j> T i of the i-th material, and the algorithm ends.

5.1.3 Calculation of Scheduling Strategy and Job Efficiency-Task Two

(1) Solve the scheduling scheme

First, the moving time, processing time, loading and unloading time, and cleaning time of the three sets of data are brought into the dynamic scheduling model in 5.1.1, and the algorithm in 5.1.2 is used to solve. The first set of scheduling solutions is shown in Table 2. As shown

Table 2 The first group of dynamic scheduling schemes

Processing material serial number	Processing cnc number	Feeding start time	Cutting start time
1	4	20	611
2	6	71	740
3	5	102	687
4	8	150	869
5	7	181	816
6	2	255	1084
7	1	286	1031
8	3	334	958
9	4	611	1222
□	□	□	□
363	6	27992	28613
364	7	28068	28689
365	8	28121	28742

(2) Solving operation efficiency

The definition of operation efficiency is the number of materials produced in a shift. The operation efficiency of the three sets of data is shown in Table 3:

Table 3 Three sets of operating efficiency

	First group	Second Group	The third group
Work efficiency	365	347	374

5.1.2 Verification of Model Utility-Task Two

For rgv's dynamic scheduling problem, if it is limited to only one scheduling problem, its practicability is not strong. Therefore, we use the three sets of data in Table 1 in the title to study the practicability of the model from the two aspects of error detection and sensitivity test.

A. Use a process processing error detection model for inspection

a) Cnc job inspection at the same time

After the intelligent processing system is started, there may be several CNCs sending signals to RGV at the same time, so it is necessary to check whether the CNC is scheduled at the same time, otherwise confusion will occur. Let the time when the i-th material starts to be unloaded is TD_i, the time for the i + N (N ∈ Z) material to start feeding is TU_{i+N} if all the time data matches

$$TD_i = TU_{i+N} \quad (36)$$

It means that in this shift, cnc is not repeatedly scheduled at the same time.

b) Inspection of clinker processing time after cleaning

When processing, it may happen that the material is washed without being processed completely. It is necessary to calculate the processing time of the clinker after cleaning. Let the time when the i material starts to be unloaded is TD_i The time when the i + N (N ∈ 物料Z) material starts feeding is TU_{i+N}, the loading and unloading time t_j, and the working time is complete T_i.

$$TD_i - TU_i - t_j \, ^3 T_i \quad (37)$$

It means that in this shift, there is no case where the material is not cleaned after being processed completely.

From this, a processing error detection model is established, and this model is used to verify the three sets of scheduling schemes in the first case. The test results are shown in Table 4:

Table 4 Three sets of test results

	First group		Second Group		The third group	
	cnc inspection	processing time inspection	cnc inspection	processing time inspection	cnc inspection	processing time inspection
Number of tests	365	365	347	347	374	374
Number of errors	0	0	0	0	0	0
Error rate	0%	0%	0%	0%	0%	0%

Known from Table 4, no abnormalities were found in the three groups of scheduling schemes, indicating that the scheduling scheme can be applied in practice.

B. sensitivity analysis

Combining the recursive constraints in 5.1.1.4, considering the two variables of cleaning time tc and moving time tm, and because the moving time tm is related to the moving distance, a sensitivity analysis is performed on the cleaning time tc to check the stability of the model. 1 second For the step size, the cleaning time is changed, and the sensitivity analysis is performed. The test results of the first group are shown in Table 5. The complete results of the three groups are shown in the appendix.

table 5 Partial sensitivity analysis results

Cleaning time	Total number of items	Cleaning time	Total number of items
1	357	26	364
2	357	27	364
3	357	28	364
□	□	□	□
13	357	45	318
14	357	46	314
15	365	47	311
□	□	48	307
24	365	49	304
25	365	50	301

Visualization of the results of the sensitive analysis test is shown in Figure 3:

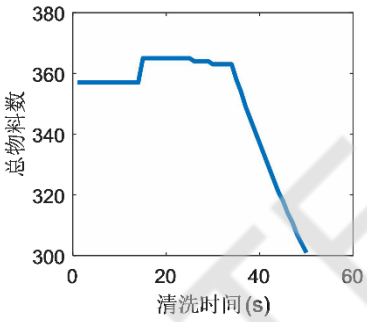

Figure 3 (a) The first set of visualization results

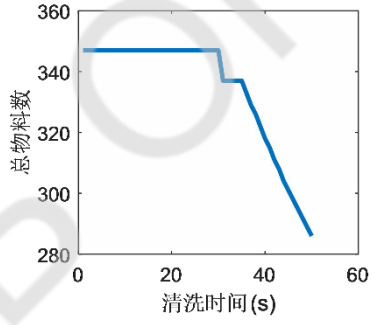

Figure 3 (b) The second set of visualization results

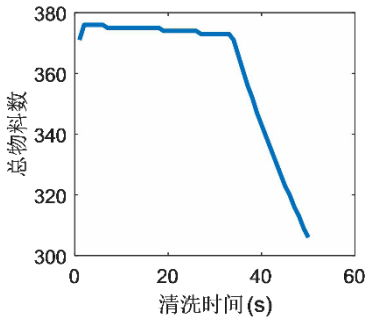

Figure 3 (c) The third set of visualization results

Through the joint analysis of Table 2 and Figure 3, it is calculated that when the cleaning time is between 1 and 38 seconds, the change rate of the total number of materials is within 6%, and the stability of the model is strong. In actual production and processing, the cleaning time generally does not exceed 35 seconds [3], so the model has strong stability and can be applied in actual production.

In summary, after solving the scheduling scheme, we first checked whether the model would cause actual errors, no errors were found through the test, and then a sensitivity analysis was performed on the model. It was found that the model was stable and could be used in actual production. Make sure the model is practical.

5.1.5 Verification of Algorithm Effectiveness-Task 2

In the process of using greedy-based local optimization algorithm for rgv dynamic scheduling, each scheduling is the current optimal solution, but it does not start from the overall scheduling optimization. Therefore, the greedy-based local optimization algorithm only obtains Locally optimal solution.

For example, when the rgv does not receive other job instructions, it waits in place until a cnc issues a job instruction. If the rgv is at another position at this time, the rgv needs to move to the target cnc before executing the corresponding job. During the process, displacement time overhead is bound to occur.

And if starting from the overall optimal, rgv makes the position of the target cnc exactly where it waits for instructions when performing dynamic scheduling, which can avoid unnecessary time overhead. Based on this, we have designed an overall dynamic scheduling algorithm. The operating efficiency of the rgv dynamic scheduling system was improved, and compared with the results of the local optimization algorithm based on greedy in three groups of environments, the results are shown in Table 6:

Table 6 Comparison of the results of two algorithms in one process

	First group	Second Group	The third group
Local optimization algorithm based on greedy	356	336	366
Global optimization algorithm	365	347	374
Lift percentage	2.52%	3.27%	2.18%

As shown in Table 6, the global optimization algorithm is more accurate than the greedy local optimization algorithm, so the algorithm is effective.

5.2 rgv scheduling of two processes without failure

5.2.1 Establishment and Solution of a Two-Process Scheduling Model with No Faults——Task 1

Compared with the first case, the second case has one more process than the first stage in the processing process, and the first and second processes need to be performed in order.The model in 5.1.1 needs to be modified, modified and added. The operation is similar.Once the constraints are obtained, the operation gets the result.

5.2.1.1 Variables and constraints

$$ZF_j \begin{cases} 0, \text{The first process tool is not installed} \\ 1, \text{The first process tool is installed} \end{cases} \quad (38)$$

$$ZS_j \begin{cases} 0, \text{The second process tool is not installed} \\ 1, \text{The second process tool is installed} \end{cases} \quad (39)$$

$$ZF_j + ZS_j = 1 \quad (40)$$

$$ZF_j + R_{ij} = 1 \quad (41)$$

$$R_{ij} \pounds \left\lfloor \frac{\sum_{k=1}^{i} x_{ij} ZS_j}{2} \right\rfloor \pounds R_{ij} \cdot M \quad (42)$$

$$x_{ij}\cdot\left[Q_{ij}ZF_j+(1-Q_{ij})ZS_j\right]=1 \quad (43)$$

$$(x_{ij}\cdot ZS_j) \quad (44)$$

$$TD_i=TU_{i+N} \quad (45)$$

$$TD_i-TU_i-t_j{}^3T_i \quad (46)$$

5.2.1.2 Algorithm steps

Step1: Initialize the variables. The number of the first process $n_1 = 1$, find the permutation and combination of C_{8n1} and find the CNC ZF_j of the first process, and the CNC of the first process. ZS_j, others are the same as 5.1.2Step1;

Step 2: Optimal path selection. When the i-th material selects the j-th CNC, $x_{ij} = 1$, determine the two types of CNCs.

Working status Q_{ij}, according to constraint formula (43), that is, $x_{ij}(Q_{ij}ZF_j + (1-Q_{ij})ZS_j) = 1$, judge the second knife The order is related to the first knife order, the other is the same as 5.1.2Step2;

Step3 ~ Step5: same as 5.1.2Step3 ~ Step5;

5.2.2 Calculation of Scheduling Strategy and Job Efficiency-Task Two

Same as above, the result is easy to get:

Table 7 Tool arrangement

	First group	Second Group	The third group
First process tool	1、3、5、7	4、5、7	1、3、5、6、8
Second process tool	2、4、6、8	1、2、3、6、8	2、4、7

Then the three sets of data movement time, processing time, loading and unloading time, and cleaning time are brought into the dynamic scheduling model in 5.2.1, and solved using the algorithm in 5.2.2. The first group of scheduling schemes obtained is shown in Table 8. As shown, the three complete scheduling schemes are detailed in the supporting materials annex.

Table 8 The first set of dynamic scheduling schemes

Processing material serial number	Step 1 cnc number	Feeding start time	Cutting start time	Step 2 cnc number	Feeding start time	Cutting start time
1	7	46	520	8	548	996
2	3	107	612	4	640	1120
3	5	155	1072	4	1120	1569
4	1	216	691	2	719	1224
5	7	520	968	8	996	1445
6	3	612	1176	2	1224	1673
7	1	691	750	6	811	1341
8	1	750	1280	6	1341	1790
9	7	968	1417	8	1445	1894
□	□	□	□	□	□	□
246	5	27563	28012	4	28060	28509
247	3	27667	28116	2	28164	28613
248	1	27771	28220	6	28281	28730

(1) Solving job efficiency

The definition of operating efficiency is the number of materials produced in a shift.

The operating efficiency of the three sets of data is shown in Table 9:

Table 9 Three sets of operating efficiency

	First group	Second Group	The third group
Work efficiency	248	203	243

5.2.3 Sensitivity analysis

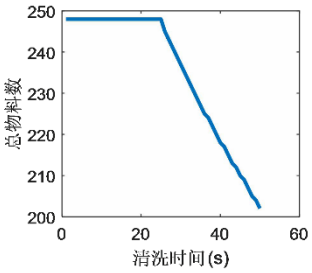

Figure 6 (a) The first set of visualization results

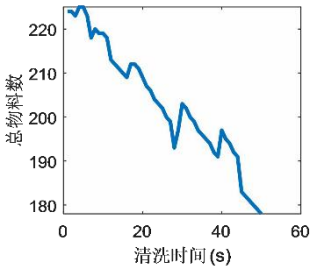

Figure 6 (b) The second set of visualization results

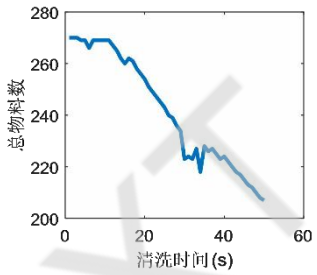

Figure 6 (c) The third set of visualization results

Through the joint analysis of Table 10 and Figure 6, it is calculated that when the cleaning time is between 1 and 32 seconds, the total material change rate is within 6%, and the model is more stable. In actual production and processing, the cleaning time generally does not exceed 35 seconds [3], so the model has strong stability and can be applied in actual production.

In summary, after solving the scheduling scheme, we first checked whether the model would cause actual errors, no errors were found through the test, and then a sensitivity analysis was performed on the model. It was found that the model was stable and could be used in actual production. Make sure the model is practical.

5.2.4 Verification of Algorithm Effectiveness-Task 2

As in 5.1.5, the global optimization algorithm and the greedy-based local optimization algorithm are compared in three sets of environments.The results are as follows:

Table 11 Comparison of the results of the two procedures and two algorithms

	First group	Second Group	The third group
Local optimization algorithm based on greedy	235	202	242
Global optimization algorithm	248	203	243
Lift percentage	5.46%	0.49%	0.41%

As shown in Table 11, the global optimization algorithm is more accurate than the greedy local optimization algorithm, so the algorithm is effective.

Evaluation and promotion of 6 models

6.1 Model advantages

This paper establishes a non-linear programming model with time recursive equation as the constraint and the maximum total number of materials as the target according to the system's operation flow. The mathematical formula is used to derive the model with high accuracy. The improved model is used when searching for the optimal allocation scheme The simulation algorithm, because the total number of schemes is less, saves additional memory overhead and time consumption than the intelligent algorithm; this model combines dynamic scheduling and directed acyclic graph in graph theory, that is, it can clearly represent the working status of each cnc .

6.2 Model Disadvantages

Because the pursuit unit produces the most materials in this area, the global search algorithm used is more complicated.

6.3 Generalization of the model

This model is a large 0-1 planning model, which can be directly applied to the actual production with a large number of CNCs; if the amount of sample data increases, the moving time T and the remaining working time D are calculated before each move, and min {T , D) in the shortest time, you can predict the next demand signal in advance; for the RGV dynamic scheduling model of the three processes, you can restrict the connection equation by adding the second to the third and prohibit the first process from reaching The concatenation of the third process results in an RGV scheduling plan for the three processes.

7 Conclusions

Generalizing the problem to a faulty situation, the results are as follows:

For the case of a faulty process, the improvement is based on the situation-one model. Three random factors are added: faulty parts, fault time, and processing time. Constraints such as time recursion and cleaning time are modified to produce materials in one shift. As a goal at most, a faulty process rgv dynamic scheduling 0-1 model is established. Based on this model, the corresponding global optimization algorithm is designed. Then based on 3 sets of data, the optimal scheduling strategy of rgv within a shift is obtained. The operating efficiency of the system is 357, 343, and 366 per shift. Finally, a process is used to process the error detection model to determine the stability of the model. The global optimization algorithm is compared with the traditional greedy local optimization algorithm to improve The percentages are 1.42%, 3.62%, and 1.10%, indicating that the algorithm is effective.

For the two faulty processes, improve on the basis of the second model. Add constraints such as prop selection 0-1 variables, tool selection position, cleaning sequence, and work flow to achieve the maximum amount of materials in the second process Then, a 0-1 model of rgv dynamic scheduling with two faults is established. Based on this model, the corresponding global optimization algorithm is designed. Then, based on 3 sets of data, the optimal scheduling strategy of rgv within a shift is obtained. At this time, the system The operating efficiency is 241, 192, and 236 per shift. Finally, two procedures are used to process the error detection model to determine the stability of the model. The global optimization algorithm is compared with the traditional greedy local optimization

algorithm to increase the percentages. It is 6.63%, 0.52%, and 2.16%, indicating that the algorithm is effective.

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USING VR AND AR TECHNOLOGIES IN INCLUSIVE EDUCATION FOR CHILDREN WITH DISABILITIES

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Abstract. *We are currently at a stage similar to the transition between theater and cinema. Initially, films were just another way of showing a theater. Some time passed before the filmmakers developed new technologies, ways of presenting a story unique to this environment. Thus, the same will be true for VR. Currently, a virtual reality computer game is simply a traditional computer game, but displayed on another medium. Over time, a paradigm shift will occur that we cannot know. In other words, VR is a revolution,*

although it took 50 years from the original idea in the laboratory to become a revolutionary product in the broad sense of the word.

Keywords: *virtual reality, augmented reality, integration, inclusive education, full immersion.*

Relevance. Along with the development of artificial intelligence and neural networks, virtual reality technology and its close fellow augmented reality have been popular for several years, which are likely to have a profound transformative impact on the way we live and work. In the next few years, virtual and augmented reality applications will become increasingly complex as devices become more productive and able to lay computer graphics on our understanding of our immediate environment and are increasingly being used in entertainment, education, healthcare and industry. Our understanding of how people can usefully move and interact in a virtual or augmented environment will also evolve, which will lead to the creation of more "natural" and innovative methods of interaction in inclusive education for children with disabilities.

I. Introduction

Virtual reality (VR) began its march about 50 years ago in the form that we would recognize it today - although the equipment was completely different. In the 1980s and 1990s, VR reappeared on the basis of a different generation of hardware (for example, CRT displays instead of vector updates, electromagnetic tracking instead of mechanical tracking). This attracted the attention of the public, and many engineers, scientists, celebrities, and business people hailed VR as the start of a new era when VR will soon make a difference. Then VR disappeared from the public eye and was rumored to be "dead". Over the past 25 years, a huge amount of research has been carried out in a variety of fields - from medicine to business, from psychotherapy to industry, from sports to travel. Scientists, engineers and people working in the industry continued their research and applications, using and exploring various forms of VR, not knowing that this topic is actually dead.

Over the past 25 years, when VR was supposed to "die," numerous studies are continuing, both in the development of this technology and in the field of its application in various fields. All these were applications that were being worked on at that time. In this article I will describe how VR was used in the field of education that has already shown results and can have significant benefits for people and society, and more specifically in inclusive education. With VR technology available on a massive scale, the potential for these benefits is significant. However, as Jaron Lanier [21] also said in 1990, "there is a really serious danger that expectations will be too high." This remains true today, but we can be a little less cautious, because research over the past quarter century has shown results that stand on a fairly solid scientific basis and have every chance of further development.

II. Analytical review of the literature

The study of my chosen problem was carried out by such authors as Argelaguet Sanz, F., Multon, F., and Lécuyer [1], Aristidou, A., Stavrakis, E., and Chrysanthou [2], Aronov, D., and Tank, D. W. [3], Arora, A., Lau, L. Y., Awad, Z., Darzi, A., Singh, A., and Tolley, N. [4], Banakou, D., Hanumanthu, P. D., and Slater, M. [5], Banakou, D., and Slater, M. [6], Bergström, I., Kilteni, K., and Slater, M. [7], Blanke, O., Slater, M., and Serino, A. [8], Blom, K. J., Arroyo-Palacios, J., and Slater, M. [9], Bolton, J., Lambert,

M., Lirette, D., and Unsworth, B. [10], Buckley, C. E., Kavanagh, D. O., Traynor, O., and Neary, P. C. [11], Buckley, C. E., Kavanagh, D. O., Traynor, O., and Neary, P. C. [12]. The writings of these authors describe the main points of the beginning of the study and the results that gave at least some result in the fields of medicine, sports, education and motion capture.

Authors such as Casu, A., Spano, L. D., Sorrentino, F., and Scateni, R. [13], Claessen, M. H., Van Der Ham, I. J., Jagersma, E., and Visser-Meily, J. M. [14], Cohen, O., Druon, S., Lengagne, S., Mendelsohn, A., Malach, R., Kheddar, A. [15], Cohen, O., Koppel, M., Malach, R., and Friedman, D. [16], Connolly, M., Seligman, J., Kastenmeier, A., Goldblatt, M., and Gould, J. C. [17], Ewert, D., Schuster, K., Johansson, D., Schilberg, D., and Jeschke, S. [18], Freina, L., and Ott, M. [19], Friedman, D., Pizarro, R., Or-Berkers, K., Neyret, S., Pan, X., and Slater, M. [20] they suggest that the implementation and integration of virtual reality technology into the life of every person provides extensive development opportunities, especially education and healthcare. The authors also share assumptions about the possibility of a complete immersion of consciousness in the virtual world, its advantages and disadvantages.

III. Object, subject and research methods

Mission – research of methods for integrating virtual and augmented reality technology into inclusive education.

Tasks:

- To identify methods for the further development of virtual and augmented reality technology for inclusive education;
- Identify a number of virtual reality applications where there is some evidence or at least debate about its usefulness in the global education system.

Subject of research – the results of the development of technological progress in the field of virtual and augmented reality around the world.

Object of research – virtual and augmented reality in the field of inclusive education.

Hypothesis

Over the next 30 years, each persons life will be directly or indirectly connected with VR and AR technologies, including in education.

IV. Work results

For starters, its worth stopping at the general meaning of VR and AR technology. The scope of virtual reality in education is very extensive. There are several reasons why VR is a great tool for education. Firstly, it can turn the abstract into tangible. This can be especially useful in science teaching. For example, suppose that using a collaborative virtual environment has the advantage of teaching students geometric concepts compared to traditional paper and pencil.

A second advantage in education is that it supports participation and action, not just observation. One example of this is surgical training, for example, it is worth emphasizing how VR is increasingly used in neurosurgery training and is ideally combined with a

tactile interface. Indeed, a European consensus program for teaching endoscopic surgery in artificial reality was developed and agreed.

The third advantage is that it can replace methods that are desirable, but practically impossible, even if it is possible in reality. For example, if a person must visit Niagara Falls in the first week, the Grand Canyon in the next and Stonehenge in a week, it is impossible for a person to visit all these places. However, virtual visits are possible, and such environments are under development.

A fourth advantage in education is that it violates the boundaries of reality as part of research. For example, changing the gravity of the earth to simulate the loss of the ozone layer or observing the appearance of a supernova from the first place as in a movie theater, which in the end is almost impossible to do in real reality.

In the field of VR for healthcare, surgical preparation has been thoroughly investigated. The use of simulations in surgical training planning is essential. To give a good example of why VR is necessary for surgery: interventional cardiology currently has no other satisfactory learning strategy than patient education. It seems that acquiring such training on a virtual human body would be the best option.

In the training of medical students and, in particular, surgeons, there is a corresponding potential role for augmented reality as a tool for studying anatomy using virtual 3D models. Although there are studies trying to gauge how useful augmented reality can be to improve the study of anatomy - including studies suggesting that VR can replace the use of corpses in Medicine.

Nevertheless, even the visualization of 3D models of the body for the study of anatomy gives good results for training, and therefore this area, which should expand in the future, integrating fully immersion systems and various forms of manipulation and interaction of students with body models.

But the most socially important and undoubtedly promising aspect of the use and integration of VR and AR technology in the education system is the possibility of its widespread use in inclusive education for children with disabilities. At the moment, there are no innovative high-tech teaching methods in this area, and virtual reality technologies can give us this opportun

Traditional inclusive education is directly related only to special communication approaches to learning, depending on the students illness, for example, children with ASD (Autism Spectrum Disorder) need social support, preparation for lessons, and a child with cerebral palsy (Cerebral Palsy) mainly needs help in movement. But regardless of the disease, in most children with special needs, intelligence and / or mental motility is preserved. But due to their limitations, they cannot learn equally with other children.

One of the most acute social problems at the present time is the formation of negative social attitudes, especially the concepts of “strange”, “other” and similar prejudices. Children from families and social groups with pronounced prejudices begin to assimilate the same negative attitudes in early school age; in the youthful period, these views are fixed.

As mentioned above, the use of virtual and augmented reality technology accelerates the learning process, including in children with disabilities. The use of interactive and engaging events with the effect of presence improves intellectual performance, and in cases with limited movements, I improve the motor skills of arms, legs, torso, depending on the scenario being performed.

It is important to note in this methodology the ability to contact and improve the communication abilities of children with disabilities is several times more effective than attempts to gradually return and adapt children to the social environment. The ability to create virtual playgrounds, classes and events, regardless of social inequality and prejudice in all aspects, is one of the main advantages of VR technology. This practice perfectly affects the childs communication abilities and motivates the further development of this area.

Separate mention requires a new concept which, unfortunately, is currently used only in novels and works of the science fiction genre "complete immersion." But it is worth noting that research is also being carried out in this direction, but comparing with other areas like entertainment, the industry development trend shows rather dubious indicators.

Full immersion is a state of consciousness, often artificial, in which the subjects awareness of his physical condition is reduced or completely lost. This mental state is often accompanied by a sense of the infinity of space, over concentration, a distorted sense of time, as well as ease of action. The term is widely used to describe immersion in virtual reality, the art of installation and video games, but it is not clear whether this word is used uniformly. This term also refers to commonly used fashion words, so its meaning is rather vague, but it carries a hint of something exciting.

The feeling of immersion in virtual reality can be described as the complete presence inside the suggestible space of virtual objects, where everything related to this space necessarily assumes its “reality”, and the subject seems completely disconnected from the external physical world.

Immersion in virtual reality is a hypothetical technology of the future, which now exists for the most part as virtual reality in art projects. It consists in immersion in an artificial environment where the user feels exactly the same as in the usual reality of consensus.

The most thoughtful method is to create sensations in which virtual reality is “inserted” into the nervous system directly, this method can be called “Direct stimulation of the nervous system”. In functional / ordinary biology, a person interacts with the reality of consensus through the nervous system. Through nerve impulses, he receives input from all sensory organs. They give neurons sensations of increased perception. If a person receives artificially created nerve impulses at the input, his nervous system will adequately respond and form real output nerve impulses that allow him to interact with virtual reality. In this case, real input impulses from the body to the central nervous system should be prevented.

In the future, this method will help to fully live a full life for people who have some limitations, and for some they will give the opportunity to start a new “virtual life”.

V. Conclusions

In this article, we mainly examined the possibilities of VR in the field of education that have occurred since its inception. By focusing on applications and especially those whose results have some level of research support. This area is changing extremely fast, and the ingenuity of people is amazing, with new ideas and projects appearing daily. Here, I briefly list some of the latest ideas that have attracted attention along with the needs for improving inclusive education. Basically, these are ideas that are in the process of

implementation, without any results or, possibly, even without any level of implementation, but which have great prospects for further development. At some point, it may seem that we are talking about the distant future, but this future has already come and I hope this future will be bright for everyone.

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DEVELOPMENT OF MOBILE APPARATUS AND MEASURING COMPLEX FOR WASTEWATER COMPOSITION CONTROL

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Abstract. *The purpose of the work is to consider the main anthropogenic sources of pollution of the water environment, to familiarize with the criteria of pollution of water bodies, analysis of methods for determining the level of pollution according to the relevant criteria, development of a hardware complex monitoring the status of sewage. The object of designing is a hardware complex of sewage monitoring.*

The development of the hardware complex is based on the review of existing analogs of hardware and software complexes, the development of appropriate

requirements for the creation of appliance and development of methods and tools for the implementation of this complex.

A general algorithm of the system as a whole and algorithms of each subsystem operation are made. They include algorithms for data collection, data processing and sending the latest to the server. It has chosen a way to connect device to the Internet. For data transmission GSM standard digital mobile communication is used. The GSM standard supports packet data (GPRS). Characteristics such as efficiency, network coverage, security are especially important for wireless data transmission.

Hardware and software complexes have proven themselves well in places of wastewater discharge on the relief and in reservoirs, including on remote production facilities.

Key words: *hardware, sewage, GSM standard, physico-chemical composition, turbidity, acidity*

I. Introduction

The continuous development of all sectors of industry, energy, agriculture and public utilities requires significant water consumption, as a result - increasing the amount of wastewater. By getting into surface and groundwater sources, wastewater pollutes them with harmful impurities that are dangerous for human life. The current state of Ukraine's water resources is in a critical position. Official statistics show that every year more than 300 million cubic meters of untreated wastewater are discharged into the reservoirs of Ukraine[1].

Conservation and protection of water resources from pollution is one of the most important problems of humanity. Special attention is paid to the protection of reservoirs from pollution by sewage of industrial enterprises, most of which are located in large cities. Currently, a large number of businesses continue to produce untreated or under-treated sewage. Effective pollution prevention and sewage treatment systems should be used to prevent the discharge of contaminated water.

This paper deals with the problem of water pollution. The purpose of the work is to develop water pollution control systems. The subject of the study is pollution control of the wastewater, the subject is the hardware quality control of wastewater. According to the goal, the main tasks and methods of solving the problem are: studying the basic characteristics of wastewater, developing a structural scheme of the hardware complex, developing algorithms for the modules of the complex, the calculation and selection of appropriate equipment. The wastewater pollution control system will identify and warn at an early stage about emergencies related to wastewater pollution. The main fields of application of this development are agriculture, mining, metallurgical and chemical industry, communal enterprises.

II. Analytical review of literature

Poor water quality is the result of irrational human activity on the planet. There are huge reserves of water on Earth, but the share of fresh water is only 2.5 - 3% of the total, with 85% of fresh water being contained in the form of ice. In some places, fresh water is

not enough to cover the needs of agriculture and industry, and in some places, even to meet the needs of domestic consumption [2].

As for Ukraine, 70% of the population is supplied with fresh water, however, according to monitoring data, 40% of the population consumes untreated water that does not meet sanitary requirements. Over the last ten years, the trend of water pollution has been decreasing, but this level remains quite high, as the water pollution level by industry has decreased by only 3% and the pollution by household water has decreased by 5%. Wastewater from livestock farms, irrigation of crops, minerals, acid rain, municipal runoff, water transport, radioactive waste come to the reservoirs and pollute them with bacteria and viruses [3]. Consider the main characteristics of wastewater.

Sewage is water formed as a result of the discharge of various industrial wastes, as well as atmospheric precipitation, which flows from the environment into the reservoir in contaminated form.

Sewage is divided into:

• domestic, which come from public utilities: wastewater from cooking facilities, toilets;

• industrial, formed as a result of various technological processes of heating or cooling of liquids, gases, any production, mine water of mines and quarries. Dangerous pollutants of industrial wastewater are residues of petroleum products, phenols, synthetic surfactants, heavy metals, organic substances with long decomposition, including various pesticides. Mine and mine waters have in their composition high mineralization, acid reaction of environment, a large number of mine elements, which are in dissolved and suspended forms. The wastewater of this subgroup is divided into contaminated and conditionally clean. Contaminated water needs pre-treatment before being dumped or reused; conditionally clean water does not require pre-treatment;

• atmospheric sewage formed by rain, snow, hail, watering. The wastewater of this group is usually contaminated with substances of mineral and organic origin. The level of wastewater pollution is expressed in the concentration and mass of impurities per unit volume (g / l or mg / l), as well as in the quantitative and qualitative composition of mineral, organic and biological pollution.

The composition of domestic wastewater is relatively uniform and is characterized by the presence of organic contaminants in the undissolved, dissolved and colloidal state. Accordingly, by physical condition, household sewage is divided into the following categories:

• insoluble - large suspended suspensions with particle sizes exceeding 0.1 mm, foams, suspensions and emulsions with particle sizes ranging from 0.1 μm to 0.1 mm;

• colloidal - particle size in the diameter from 1 nm to 0.1 μm;

• soluble - molecular-dispersed particles, the size of which does not reach 1 nm.

By nature, pollution substances are divided into:

• mineral - contaminants include particles of sand, clay and slag, solutions of salts, alkalis, acids and other substances;

• organic - contaminants are of animal and vegetable origin.

• biological - contamination includes yeast and molds, microorganisms, algae and bacteria [4].

Formulation of the problem

Considering the effects of water consumption from polluted reservoirs, it becomes obvious that the problem of water quality in reservoirs is quite urgent and needs a comprehensive solution. The level of control and purification of reservoirs is extremely low today, which can lead to death. We offer a solution to the problem by controlling wastewater emissions.

The control over the operation of wastewater treatment plants and the pollutant emissions into the reservoir is carried out in order to prevent and stop the pollution of water bodies by untreated and insufficiently treated wastewater, as well as to reuse them in industry and agriculture. The practical importance of this work is to control the quality of achieving an appropriate level of wastewater treatment.

The necessary tasks of this work are:

• elaboration of literary sources on the topic of pollution of reservoirs, identification of important aspects of quality control of reservoirs;
• analysis of requirements for water quality criteria;
• analysis of existing analogues;
• development of algorithms of operation of the hardware complex;
• development and selection of the necessary components of the hardware complex;
• putting the finished product into operation.

Having analyzed the literature sources, the requirements for the criteria of wastewater quality have been analyzed and it has been found that the treated wastewater has to satisfy the following requirements:

• biochemical oxygen consumption does not exceed 50 mg / l
• no floating organic pollutants;
• the content of suspended particles does not exceed 60 mg / l;
• oil (condensate) content does not exceed 5 mg / l when extracted with ether;
• chromaticity - more than 20 units (platinum-cobalt scale);
• hydrogen index ph = 6-9 [6].

Overview of existing solutions

There are many different indicators of water quality. Depending on the prospect of further use of the test water, its analysis is carried out in the context of certain chemical or physical properties of interest at the moment.

Unfortunately, there are no universal instruments that allow one survey to conclude on all existing quality parameters. But there are quite a number of devices that can measure the general characteristics of the pollution level.

Analyzing the market of existing measuring and measuring complexes, we can conclude that there are a large number of devices with fairly similar functionality.

There is a demand for small-sized devices capable of real-time tracking of common water indicators such as temperature, acidity, turbidity. The field of application of the devices has no limits - hydroponics, fish farms, cultivation of various types of aquaculture, control of technological processes, laboratory and field research.

Let's look at competitors' measuring and measuring complexes and find out their advantages and disadvantages.

The analyzer of quality of water and solutions AZ-86021 (ph / DO) is intended for measurement of level of acidity (ph), temperature and concentration of dissolved oxygen in a liquid. The advantages of the analyzer are its small size, mobility and ease of use. The disadvantages of the device are the lack of ability to scale the device, the number of sensors is limited, there is no ability to automatically measure performance on remote sites.

The BlueBox System water analysis system is modular and scalable for projects of any size. It is possible to extend the base number of sensors. Data can be transmitted over the Internet or mobile telephone systems. The disadvantages of the system are its size, cost and complexity of installation and use.

PQ45 Portable Analyzer. The most popular measurement parameters for this system are chlorine and ph. The advantages of the system are its small size and ease of use. The disadvantages are the limited use of sensors and the inability to monitor water quality remotely.

900R water analyzer. The device is designed to measure ph, ORP, ion concentration, electrical conductivity, TDS, salinity, conductivity, and dissolved oxygen content analysis. The advantage of the device is the presence of a large number of parameters of the measured quality. The disadvantages of the device is the inability to automatically remotely control the water composition [7].

Analyzing the available analog devices, we can conclude about the basic functional characteristics that should be created by the hardware-programmable complex:

• device mobility;
• scale of the device;
• possibility of remote work.

The available characteristics make it possible to cover the shortcomings of the existing complexes and surpass their functionality, as a result - increasing the demand for the product among the existing competitors. The advantages of the hardware-complex are complemented by the software that has the ability to:

• storing information on a server that does not require additional disk space on the user's computer;

• universal customized web interface, no need to install additional software for mobile devices or personal computers, access to data is provided via the Internet;

• use the web server to manipulate the data, not deploy the server on the device.

Thanks to the ability to scale the complex, the cost of the device is much lower, unlike competitors, and may vary depending on the number of sensors required for the task. Advantages include the fact that the development of the system is the result of combining the hardware and measurement system with the appropriate software. This fact provides the ability to use the system conveniently unlike competitors who require separately installed special software or performance metrics without remote monitoring.

III. Object, subject and methods of research

The purpose of the study is to develop water pollution control systems.

The object of the study is pollution control. **The subject** of the study is hardware for quality control of wastewater. According to the goal, the main tasks and methods of

solving the problem are: studying the basic characteristics of wastewater, developing a structural scheme of the hardware complex, developing algorithms for the modules of the complex, the calculation and selection of appropriate equipment. The wastewater pollution control system will identify and warn at an early stage about emergencies related to wastewater pollution. The main areas of application of this development are agriculture, mining, metallurgical and chemical industries, utilities.

IV. Work results

Considering the effects of water consumption from polluted reservoirs, it becomes obvious that the problem of water quality in reservoirs is quite urgent and needs a comprehensive solution. The level of control and purification of reservoirs to date is extremely low, which can lead to death. We offer a solution to the problem by controlling wastewater emissions.

The control over the operation of wastewater treatment plants and the pollutant emissions into the reservoir is carried out in order to prevent and stop the pollution of water bodies by untreated and insufficiently treated wastewater, as well as to reuse them in industry and agriculture. The practical importance of this work is to control the quality of achieving an appropriate level of wastewater treatment.

The necessary tasks of this work are:

• elaboration of literary sources on the topic of pollution of reservoirs, identification of important aspects of quality control of reservoirs;

• analysis of requirements for water quality criteria;

• analysis of existing analogues;

• development of algorithms of operation of the hardware complex;

• development and selection of the necessary components of the hardware complex;

• putting the finished product into operation.

Having analyzed the literature sources, the requirements for the criteria of wastewater quality have been analyzed and it has been found that the treated wastewater has to satisfy the following requirements:

• biochemical oxygen consumption does not exceed 50 mg / l

• no floating organic pollutants;

• the content of suspended particles does not exceed 60 mg / l;

• oil (condensate) content does not exceed 5 mg / l when extracted with ether;

• chromaticity - more than 20 units (platinum-cobalt scale);

• hydrogen index ph = 6-9 [5].

Having understood with the basic functional requirements to the created hardware complex, we proceed to the stages of development of algorithms of operation of the hardware complex and selection of the necessary constituent components of the complex. Before the stage of selection of the necessary components of the hardware complex, let us define the criteria of wastewater quality, on the basis of which we will pass to the stage of selection of components.

The hardware complex is based on basic physico-chemical indicators of wastewater quality, the amount of which can be changed at will. Such indicators include: temperature; hydrogen index ph; turbidity.

Water temperature is an important factor influencing the physical, chemical, biological processes occurring in water bodies. Oxygen mode and intensity of self-purification processes depend on temperature. Temperature values are used to study thermal pollution, calculate the degree of water saturation with oxygen, various forms of alkalinity, the state of the carbonate-calcium system.

The requirements for the water quality of the reservoirs used for bathing, sports and recreation indicate that the summer water temperature as a result of wastewater run-off should not increase by more than 3 ° C compared to the average monthly temperature of the hottest month of the year over the last 10 years. In reservoirs of fishery purposes, it is assumed that the temperature of the water as a result of wastewater descent is not more than 5 ° C compared to the natural temperature [6].

The turbidity of natural waters is caused by the presence of impurities caused by insoluble or colloidal inorganic and organic substances of different origin. In accordance with the hygienic requirements for the quality of drinking water, the turbidity should not exceed 1.5 mg / dm3.

Water turbidity is determined turbidimetrically - the power of the beam passed through the water sample is measured. Turbidimetric method is used to determine reservoirs having variable composition and the form of fine particles. Without pre-filtration, turbidimetry samples will determine not only colloidal but also coarser particles.

Ph of water is one of the most important indicators of water quality. The concentration of hydrogen ions is of great importance for chemical and biological processes occurring in natural waters. The magnitude of ph depends on the development and vital activity of aquatic plants. Ph of water also affects the processes of transformation of various forms of biogenic elements, alters the toxicity of pollutants.

The content of hydrogen ions in natural waters is determined by the quantitative ratio of the concentrations of carbonic acid and its ions.

For the convenience of expressing the content of hydrogen ions, a value was introduced, which is the logarithm of the concentration of ions, taken with the inverted sign:

$$ph = - lg [H +] \quad (1)$$

Ph changes are closely related to photosynthesis processes (due to CO2 consumption by aquatic vegetation). The source of hydrogen ions are also humic acids present in soils. Hydrolysis of heavy metal salts plays a role when significant amounts of iron, aluminum, copper, and other sulfate sulfates get into the water.

The pH value in river waters is in the range of 6.5-8.5, in the atmospheric precipitation 4.6-6.1, in the swamps 5.5-6.0, in the marine waters 7.9-8.3. The concentration of hydrogen ions is prone to seasonal variations. In winter, the pH for most river waters is 6.8-7.4, in summer 7.4-8.2.

According to the requirements for the composition and properties of water of reservoirs of drinking water use points, water of water bodies in recreation areas, as well as water of fishery water bodies, the value of ph should not go beyond the range of 6.5-8.5 [7].

Having become acquainted with the basic goals and tasks of qualification work, we proceed to the implementation of algorithms and methods of implementation of the hardware complex in the next part of the work.

The hardware-programmable complex is used for the problems of prompt detection of water composition of the test solution. The composition of the water is determined by the levels of ph, turbidity and temperature. Because the composition of the waste fluid that comes in for processing fluctuates sharply over the course of not only a day, but also one hour, the use of hardware will help reduce test and data processing time.

Having analyzed the requirements for the security being created, the prerequisite is the operation of the device on remote sites. Today, there are a large number of technologies that allow the transmission of information over long distances. Data technologies are divided into wired and wireless.

Wired technologies include methods using copper and optical cables. The use of copper cables is characterized by high financial costs and low data rates. It is advisable to use such cables only in premises of a small type, otherwise the installation of protective equipment is required. Negative factors affecting copper cables are atmospheric phenomena in the form of rain, snow, sun, as well as the oxidation of conductors. All these factors lead to the rapid failure of appliances. Instead of using copper cables, fiber optic cables replace them. They are characterized by high reliability, data transfer speed and durability, but the cost of such cables remains high. High speed, reliability and security are the main advantages of using wired networks. Wired network security is achieved through a physical factor in order to connect to the network with the necessary physical access to the cable. The negative factors of using wired networks include the possibility of laying cables at short distances in cities where there is no difficulty in their installation, and the dependence of users on the location of the cable [8].

The most popular wireless data technologies are: Wi-Fi; Bluetooth; ZigBee; GPRS.

Wi-Fi is the IEEE 802.11 wireless standard. The advantages of this technology are the speed of data transfer (up to 11 Gb / s at the moment), ease of use - in places where no cable can be used wireless networks, mobility - users do not depend on the location of the Wi-Fi router within the range of Wi -Fi, malware - radiation from devices is much less than from a mobile phone.

Disadvantages include range and security, and can be easily cracked by criminals. The 2.4 GHz band is also a disadvantage, as it may interfere with the use of Bluetooth devices and even microwave ovens. For the most part, the stated speed of Wi-Fi networks is not true, since the speed of connection to the access point is distributed among all clients, the speed depends on the number of antennas used, obstacles, distance to the access point [9].

Bluetooth is a wireless data technology, up to 10 meters away. The advantages of using Bluetooth technology include convenience, speed of data acquisition, versatility of use. The disadvantages include the range, interference reduction, interference with other devices.

ZigBee is a personal wireless network, created in 2003. Unlike previous technologies, it consumes less power and runs at low speed, well suited for controlling wireless sensors, meters, and other equipment. ZigBee has a range of 10 to 100 meters and a bit rate of 250 Kbps. The advantages of this technology are fault tolerance - even when interference occurs, the data will be delivered to the destination, reduced power swelling -

the presence of such a factor provides long-term work from autonomous power sources, the availability of sleep mode, the ability to change the routing algorithm, the ability to use channels of several frequency bands, relatively low frequency bands. cost, cryptographic protection in data transmission.

GSM is the international standard for high-quality mobile digital communication through public key encryption. GSM technology was founded in 1987 and adopted as the European standard for digital mobile technology. The key to technology success is the ability to support Internet and SMS services. GSM networks operate in the 900 MHz or 1800 MHz frequency range. The technology allows to transmit voice information, to transmit data in synchronous and asynchronous modes, to send short text SMS messages, to send multimedia MMS messages [10].

GPRS is a packet data system that operates similarly to the Internet. When transmitting data, the latter are broken down into separate packets, then delivered to the recipient and combined into one unit. The block diagram of GPRS is shown in Figure 1. Packages can be delivered separately in any way. Packages are in the form of IP, so it is possible to use any standard transport and application layer protocols used on the Internet (TCP, UDP, HTTP, HTTPS, SSL, POP3, XMPP). Also, when using GPRS, the mobile phone acts as an external network client and is assigned an IP address (fixed or dynamic). GPRS technology is an add-on to GSM technology and allows data to be transmitted at a higher rate, unlike GSM, where the maximum data rate is 14.4 Kbps, GPRS transmission speed can theoretically reach 171.2 Kbps. GPRS consists of two main blocks - SGSN (GPRS support node) and GGPRS (GPRS gateway node). SGSN is the brain of the system, it is a GSM network switch. There may be several SGSN nodes in the system, each of which is responsible for its area of the network. The SGSN node can support up to 2000 packets per second, while controlling up to 10,000 users online. The main tasks of SGSN are routing packet data streams between MS and GGSN, providing subscriber authentication, message encryption. GGSN is the gateway between the network (more precisely, its part for GPRS data transmission) and external information backbones (Internet, corporate intranet networks, other GPRS systems). The main task of GGSN, therefore, is to route data from and to the subscriber via SGSN. GGSN's secondary functions are data addressing, dynamic IP issuance, and tracking of external network and subscriber information (including service billing). Another component of the GPRS system is the PCU, a packet control device. The PCU connects to the BSC base station controller and is responsible for directing data traffic directly from the BSC to the SGSN [11].

The advantages of the GSM standard are the small size of the devices, the good quality of communication, the ability to support a large number of simultaneous connections, the low level of industrial interference, the protection of information during data transmission, widespread distribution, a large number of users. The GSM standard is the most widespread in the world, with an annual increase of 1 million users. Today, the number of users reaches more than 4.4 billion people. However, GSM technology is not perfect and like any other technology it has its drawbacks. The disadvantages include the low data rate and the ability to transfer data no more than 120 kilometers from the nearest base station. Despite the drawbacks of the GSM system, it is quite popular and easy to use when connecting equipment in remote areas, in cities where cable routing is impossible or

inexpedient and expensive. Such systems are characterized by low speeds, but they are sufficient to transmit small amounts of information.

Considering the possible data transfer options and requirements for the security being created, we can conclude that wireless data technology is needed since the device is always located in remote areas of the data center and the number of devices used may vary. In this case, the use of leading technologies is an inexpedient and expensive solution for the long-distance cable routing in physically unfavorable conditions. Therefore, it was decided to equip the GSM GPRS devices with a mobile communication module. Technology covers about 99% of Ukraine's area, so there are no problems with long-distance data transmission. The speed of GPRS technology is enough to send small amounts of information, namely sensors from the sensors, to the data center for processing.

Summing up, we have all the necessary components to create a hardware complex to control the composition of hydrogen samples. The necessary components of the complex are: microcontroller; GSM GPRS module; ph sensor; turbidity sensor; temperature sensor.

The general algorithm of system operation is as follows: sequential collection of data from sensors, preparation of data for sending, sending of data to the server. Users are able to view real-time data using the website software.

The device consists of sensors of temperature, turbidity, acidity and SIM module. The board is powered by a USB cable. The ds18b20 temperature sensor is connected to the board via external power, 3 wires are used: the sensor's ground (GND) is connected to the board's (GND) ground, the Vdd is connected to the 5V output of the board, Data is to the seventh digital pin. Because the sensor uses a 1-Wire interface, it is necessary to include a 4.7 ohm resistor between the power line and the data line. The transmission of any information is possible only by issuing a low level in the data line, ie, shorting it to a common wire (GND), and in high logical level the line will return itself, due to the presence of an external resistor 4.7 kOhm.

The turbidity sensor is connected to the board as follows: GND line to board ground (GND), Data line to analog input A0 board, power line to 5V board output. The sensor also has a gain card that has an analog-to-digital switch. The switch works in both analogue mode - measuring the turbidity level of the test environment by changing the output voltage level and in digital mode - a logic level "1" appears on the output when the turbidity reaches the limit value set by the built-in potentiometer.

The ph level sensor is connected in the same way: GND line to the board ground (GND), Data line to the analog input A1 of the board, power line to 5V output of the board. The sensor also has a PH2.0 interface board, which houses a gain control potentiometer and a power LED. When the sensor is connected to the Arduino board, a blue LED lights up on the sensor board. The sensor comes with a fluid that has a known ph level of seven. After connecting the sensor, it is necessary to check its values, if the obtained values of the liquid of known acidity differ, the programmed way should be set the shift value. It is also possible to adjust the sensor performance using a built-in potentiometer.

The SIM800l wireless data module requires an additional power source. Since the module requires a current consumption of 2A and the Arduino card is not capable of supplying such a current level, it is advisable to use an external source with an additional

DC voltage converter. The main condition for such a connection is the common ground for all elements of the system, so the earth converter line has common contact with the SIM800l ground line and the Arduino board. The TX data line of the SIM800l module is directly connected to the Arduino board, and the RX data line is connected to the board via a voltage divider, two 10kO resistors.

As a result of connecting all the components, we get the scheme shown in Figure 1, for simplicity of connection uses a breadboard.

The figure shows the unit in a single housing. Inside are an Arduino board, a DC-DC 5V voltage drop, a circuit board for all components, a sensor board, and a sim module.

The main task of the hardware complex is to measure the level of water pollution, but in addition to the basic tasks there are additional, less-significant, which are responsible for the location and identification of the device. Having summed up all the tasks, we will list them together:

- obtaining the device identification number;
- obtaining the coordinates of the location of the device;
- obtaining indicators from the temperature sensor;
- obtaining indicators from the turbidity sensor;
- obtaining indicators from the ph level sensor;
- sending metrics to the server.

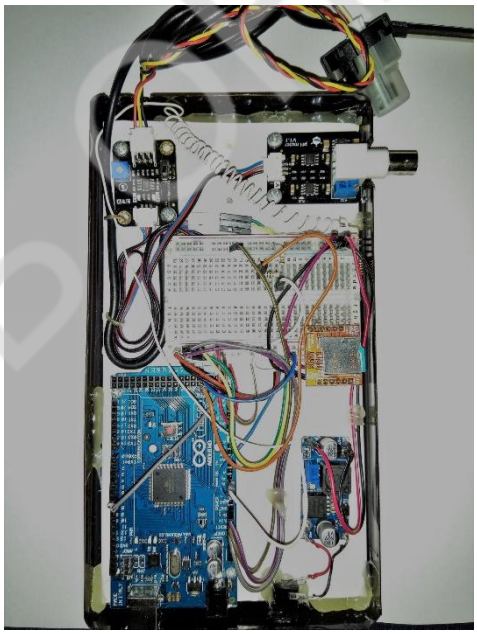

Figure 1 - Connecting existing components to an Arduino board

Data from a developed device can be viewed by a user on a developed website. The site contains the following pages: current data; archive; archive of data in the form of graphs.

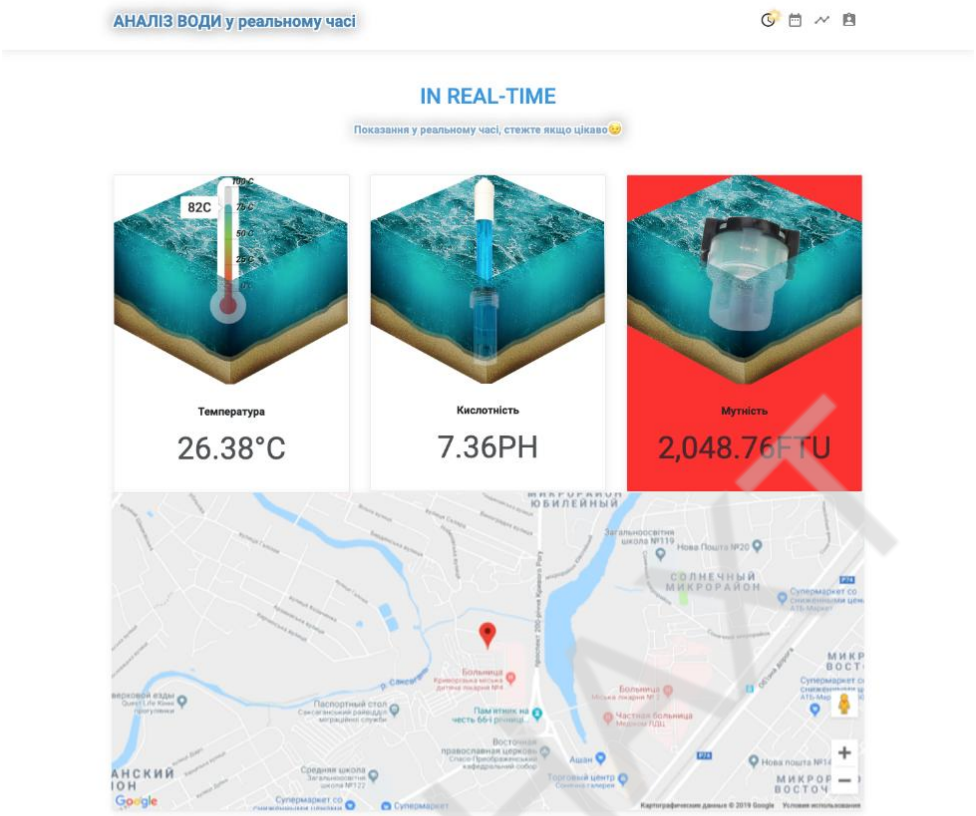

Figure 2 - Website developed

Conclusions

As a result of the work done, a wastewater quality control system was created. The following tasks were performed during system creation:

• literary sources on the topic of pollution of reservoirs were elaborated, important aspects of quality control of reservoirs were identified;

• requirements for water quality criteria are analyzed;

• analogue products are analyzed;

• algorithms of the hardware complex operation were developed;

• the product has been commissioned.

The device allows to control the operation of treatment plants and emissions of pollutants into the reservoir. The practical importance of the device lies in the timely prevention and cessation of contamination of water bodies with untreated and insufficiently treated wastewater.

The main advantage of the device is the ability to work on remote objects, the results are stored on a web server and available for viewing at any time. The advantage of the device is its cost and its small size. Such parameters make it available for own use on the farm, in agriculture, in utilities and industrial enterprises. The disadvantages are the

quality of components, compared to the more expensive industrial analog devices, it is lower and needs improvement.

The device was created as a cheaper possible variant - a prototype of already existing devices, and in the future it is possible to improve the system on the basis of already developed components.

Test results indicate that each component of the instrument is serviceable and ready for use. The next step is the introduction of the appliance in every field of use, starting from one's own farm and ending with industrial enterprises.

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ASSESSMENT OF THE FUZZY STATE OF COMPLEX SYSTEMS

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Abstract. The paper considers the problem of estimating the state of the enterprise (on example of the IT company). The problem is presented in the form of two problems. The first problem is the aggregation of the initial information and the second problem is the identification of the state of a complex system. To solve the problem of aggregation of initial data authors used the fuzzy cluster analysis, namely the fuzzy k-means method. The results allow to formalize linguistic variables, which are characterized by the term-sets and definition range. The numerical results were approximated by analytical membership functions. The solution of the first task allows to generate a set of possible fuzzy reference situations. Each situation is characterized by the reference informational granule, which contains information about formalized linguistic variables. The second problem was solved by using the method of fuzzy logic in the MATLAB environment. In this test case, the search of the situation in which the IT-company is located was performed. At this stage, the current situation belongs to comparison with each reference situation. In this way, authors determined the most similar reference situation to the current situation. An analysis of the resulting situation allows to argue the state of the IT company. The solution of the second task allowed to establish assessment of IT company state. The theoretical and practical results can improve the efficiency of complex system management.

Keywords: complex system management, condition assessment, fuzzy cluster analysis, fuzzy situational approach, reference situations, informational granule

I Introduction

Information technologies are rapidly evolving with each passing day and in turn there is a growing need for using of certain software products in various fields of activity. Many modern enterprises sooner or later face the situation, when to improve the functioning of the organization it is necessary to implement specialized software for automation, data processing, etc. In order to implement this, it is important to determine how the company intends to obtain the necessary software. In this situation, there are 3 common options. The first is to create a software product by themselves, but it is possible only if there is an IT department at the enterprise, whose employees posess the necessary skills and will be able to create a product that meets the requirements of the enterprise. The second option is to acquire a license for an existing software product, but it is quite difficult to find a product that is appropriate for the company and satisfies all the needs. If the first and second options are not suitable, the company chooses the third. IT companies come to the rescue here.

The rapid development of information technology has led to the emergence of a large number of IT companies engaged in custom software development. As already mentioned, the need for software in today's modern world is very great, so we can say that an IT company is a very promising and profitable business.

Due to the fact that there are many such companies and their number is only growing, there is a huge competition between them. In order for this business to be

successful and profitable it is necessary to perform a huge amount of work, to execute orders qualitatively and to keep control of the state of the company at different intervals of time.

II Analytical review of literature

The group of researchers propose a technology for assessing the state of complex systems. It was decided to use the methods of fuzzy logic to solve the problem. The solution consists of two main stages, namely, aggregation of the initial data and assessment of the state of a complex system.

The solution to the problem of aggregating information is to adjust the source data for use, that is, leading to fuzziness. In order to better understand this problem, the works of A. Genkin “New Information Technology for Danish Analysis” and Borisov A.I., Aleksev A.V., Krumberg O.A. “Models adopted on the basis of linguistic knowledge” turned out to be very useful.

The second task is to identify a fuzzy situation that characterizes the state of a complex system. Having studied all possible methods for solving this problem using the work of A.N. Melikhov's “Situation Systems with Fuzzy Logic”, it was decided to use the Mamdani algorithm in fuzzy inference systems.

As an object of research, and from a directly complex system, an IT company was chosen. In order to get acquainted with the structure of the enterprise, the intricacies of functioning and the attributes used as input data, an analysis of many sources was carried out, the most useful work was A. Pogorilogo “Basic Element of Effective Video IT”.

All calculations were carried out with MATLAB. All methods used in the work are present in this environment. In order to familiarize yourself with the procedure for using these methods, the work of A. Leonenkov "Something model in MATLAB and fuzzyTECH." is useful.

The results of the literature review showed that these problems are completely underdeveloped and very poorly covered.

III Object, subject matter and methods of research

Description of the object of study. The subject of the study is the IT company Z, whose head office is located in Kiev. The company has offices in other major cities of Ukraine, namely: Kharkiv, Lviv, Odessa and Dnipro, as well as abroad in Budapest and Krakow. The company was established in 2007, but is expanding very rapidly and opening new branches outside Ukraine. At present, the company employs about 1000 employees with various programming technologies.

The company is characterized by the fact that it develops custom software for foreign companies. The company operates on the B2B (Business to Business.) Model, that is, produces services and products not for the end-user, but for other business companies. Services offered by developers - development, testing, support and support of custom software and business applications, creation of dedicated centers of development, testing and quality control of software, as well as IT consulting taking into account industry specific business (finance, insurance, medicine, biotechnology, energy).

Formulation of the problem. The group of researchers formulated the statement problem to assess the state of a complex system in terms of situational control in a fuzzy environment.

The condition of the control object can be assessed by the values of attributes – the distinguishing features of the object. The power of the set of features is determined by the goals of object management and the features of the control system. A set of values of features that describe the state of a control object and the environment at a particular point in time, will be called as a situation in current work.

Note that when describing the values of the features can be obtained unjustifiably large number of situations. In this case, it is advisable to aggregate the information.

In the work it is proposed to use expert knowledge to construct a decisive table. Naturally, when describing situations, the expert's attention will focus on the typical typical situations that arise when managing the object. The number of typical or reference situations is significantly less than the total number of situations.

The set of reference situations describe the possible states of the object fairly fully, taking into account management features. However, it is impossible to take into account all the features of management. This leads to the need to use the notion of a fuzzy situation.

Let the authors give a formal definition of "fuzzy situation". Let Y – be a set of features which values describe the state of the control object. Each attribute Y_i is described by a linguistic variable $< Y_i, T_i, D_i >$, where $T_i = \{T_{1i}, \dots, T_{mi}\}$ – is a term-set of a linguistic variable Y_i, mi – the number of values of the trait; D_i – base set of attribute Y_i.

The number of possible situations on business – is greater, and the number of decisions taken is much less. As there are many more situations of casualty and leather, you can set up one of the most common types, then the task of managing, roughly speaking, needs to be reduced to the next level, if necessary. Thus, the problem of identification is presented in the vision of two tasks. The first one is agregation of the input of information and the second – identification of the situation, which describe the current state of the IT – company.

Approaches to solving the problem. The research problem can be solved using one of the following approaches:

– situational approach;

– system approach.

The group of researchers decided to consider these approaches to solving the research problem in more detail.

The systems approach views the organization as an open system consisting of several interconnected subsystems. Systems theory helps the manager understand the relationship between the individual parts of the organization, between the organization and the environment. The main drawback - systems theory does not identify the main variables that affect the control function, does not say about the impact of the environment on the performance of the organization.

The situational approach broadened the practical application of systems theory by identifying the major internal and external variables that affect an organization. He argues that management techniques and concepts should be appropriate to the particular situation. The main disadvantage of this approach is that only those factors that are most relevant to the organization and its leader can be taken into account.

Considering these approaches, it was concluded that the application of a systematic approach is ineffective to solve our research problem. Therefore, the formulation of the research problem was formulated in terms of situational management.

Thus, the solution to the problem of assessing the status of the IT company consists of two stages: aggregation of information and assessment of the state of the company.

The problem of aggregation is proposed to be solved with the use of fuzzy cluster analysis to make the input data unclear and to describe linguistic variables. There are two basic clustering methods that allow you to simultaneously split the output into classes and represent the resulting classes as fuzzy sets, namely:

– method of fuzzy k-means clustering;
– Gustavson-Kessel method.

From these algorithms, it is proposed to use the fuzzy k – mean clustering method, as it is fairly accurate, easy to implement, and reliable. In the second method, not all of the above items are executed.

The solution to the second problem (state estimation) is proposed to be obtained using fuzzy logic. Among the possible methods are:

– Mamdani algorithm;
– Fuzzy inclusion of situations.

It was decided to evaluate the state of the company using the algorithm of Mamdani, since this algorithm is implemented in the Matlab package, unlike other, which will allow to conduct test accounts and compare them with those obtained in the developed software solution.

An algorithm for solving the problem of assessing the financial condition of an IT company. Based on the formulation of the task, the assessment of the status of the IT company is considered in terms of situational management in a fuzzy environment. Thus, the state of the company can be judged by the values of attributes – the distinguishing features of the object. The number of features that characterize the status of the company is determined by the goals of object management and features of the management system. A set of feature values that describe the state of a control object and the environment at a particular point in time is called a situation. In other words, the state of the company will be presented in the form of a situation of many formed reference situations, which most accurately characterizes the state of the IT enterprise.

In order to solve the problem of the research, an algorithm of a sequence of actions has been formed, which must be carried out in order to adequately assess the current state of the company. The main steps are:

1 Generation of input data. At this stage, all management goals and features of the IT company should be analyzed. As a result, a set of features will be generated, which will be presented in the form of the current situation in the IT company.

2 Normalization of the output data. All the features that describe the status of the company have different dimensions. During the assessment, there will be a need to compare these traits. Thus, in order to make it possible to compare the features it is necessary to bring them to a single scale. As a result of rationing, all features should be represented in the range [0; 1].

3 Data aggregation. The task of the study involves the construction of a fairly complex mathematical model. In order to reduce the scope of the problem and to simplify

the procedure of state estimation, it is advisable to aggregate the input features, that is, to describe them as linguistic variables. This will create many reference situations and greatly simplify the IT company assessment process.

4 Formation of set of the reference situations. At this stage, the formation of all possible states in which the company may be located. The number of situations will depend on the number of input features and the results of information aggregation.

5 Formation of the current situation. Based on the values of the characteristics that characterize the status of the company, the current situation is formed, which describes the current state of affairs in the company. Aggregation results will be used to shape the current situation.

6 Identification of the most similar reference situation with the current one. The last stage of the process of assessing the condition of the company, which involves finding the most similar situation from the generated list of reference, with the current situation. The result will be one situation that will most accurately characterize the status of the company. This situation is considered in more detail and formed the argumentation of the state of the IT company in which it is currently located.

Rationg of the input data. The attributes that characterize the status of the company have different dimensions. In order to be able to compare these features it is necessary to bring them to a dimensionless appearance. Thus, the intervals considered should be reduced to a single scale. To qualitatively assess the status of the company, we should focus on a method that allows less fuzzy term sets of linguistic variables to be obtained. After analyzing the methods of valuation, it was decided to use sigmatic data normalization:

The method of sigmatic rationing has the advantage over most other methods, because it is more reliable to focus on normalization not on extreme values, but on typical, that is, statistical characteristics of data, such as mean and variance. Sigmatic normalization allows to find a natural way out of this situation and at the same time all values $x_i^* \in [0; 1]$. Sigmatic normalization is carried out by the formula (1).

$$x_i^* = f\left(\frac{x_i - \overline{x}}{\sigma}\right), \quad (1)$$

$$where\ \overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (2)$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n}}; \quad (3)$$

$$f(a) = \frac{1}{1 + \exp\{-a\}} \quad (4)$$

Input data aggregation. Aggregation of information refers to the concentration of individual flows of information in the information pellet - the only aggregate, which gives the opportunity to get a general picture of the situation in the system. The information pellet is a linguistic variable.

As previously defined, the formation of the information pellet will be carried out using one of the most common fuzzy clustering k-means clustering algorithms. One of the

main disadvantages of this algorithm is that it is necessary to specify in advance the number of clusters that will be clustered. But this is not a problem for solving the research problem, since within the given task, the number of clusters k is determined in advance. The number of clusters in this task will depend on the number of terms of each linguistic variable.

As a result of the algorithm, the following data will be obtained: V_{ip} – Cluster centers for each attribute p, F_p – a matrix of the affiliation of each element to all possible clusters.

To solve the problem of information aggregation, the following solution algorithm was constructed:

1 In the first stage of the algorithm, the input data is specified. In our case it is:

– input attributes $X = \{x_1, x_2, \dots, x_p\}$;

– The number of clusters (terms of the linguistic variable) $k = \overline{1, M}$;

– exponential weight $m = [1; \infty)$ (by default $m = 2$).

Each element will be closer to one of the points. Not all of them will aspire to one center of gravity, so several clusters are formed. We now have k clusters, and each element is a member of one of them;

2 Then it is necessary fill the membership matrix F_p randomly, which is sized $M \times c$ of fuzzy partitioning. At each iteration, the membership matrix will change until the aggregation of information is completed, so the initial filling of the matrix does not require any knowledge. It is only important that the generated matrix satisfies the condition (5):

$$\sum_{i=1}^{c} \mu_{ki} = 1, k = \overline{1, M}. \quad (5)$$

That is, the degree of belonging of each element to a certain set cannot be more than 1.

3 In the next step, it is necessary to define the cluster centers by the degree of membership by the formula (6).

$$V_i = \frac{\sum_{k=1}^{M} \mu_{ki}^m x_k}{\sum_{k=1}^{M} \mu_{ki}^m}, i = \overline{1, c} \quad (6)$$

Each term of a linguistic variable is referred to as a center, that is, a value that achieves the maximum degree of certainty. There will be one center for each term.

4 In this step, the distances between the new cluster centers and the data points are calculated. Finding the distance between points is done using the Euclid distance by the formula (7). This formula is the most widespread in cluster analysis.

$$D_{ki} = \sqrt{\|x_k - V_i\|^2}, k = \overline{1, M}, i = \overline{1, c} \quad (7)$$

Knowledge of distances from points to clusters allows to determine the value of belonging of elements to clusters.

5 It is now necessary to list the degree of affiliation of the objects to the cluster. This is done using the formula (8). This way, the values in tha matrix F_p are changing.

$$\mu_{ki} = \frac{1}{\sum_{j=1}^{c} \left(\frac{D_{ki}}{D_{kj}}\right)^{2/m-1}}, k = \overline{1, M}, i = \overline{1, c} \quad (8)$$

6 Steps 3 to 5 are repeated until the cluster centers have stopped changing. Thus, when the cluster centers cease to change, the execution of the algorithm ends. The cluster centers V_i and membership matrix D_{ki} obtained as a result of the last iteration are finite. These results will be used in the future. Namely, the cluster centers and the membership matrix of each trait will be used to form a set of reference situations, the current situation and to make the input traits indistinct. Using the value of the membership matrix, it is possible to graphically represent the membership functions of the elements of each attribute in all possible terms.

Formation of the set of reference situations. A set of values of characteristics that describe the state of an IT company at a certain point in time, let's call it a situation. If p – the number of attributes, m_i – the number of attribute values $y_i \in Y(i \in J = \{1,2, \dots, p\})$ then the number of possible situations in the company will not exceed than $m_1 \times m_2 \times \dots \times m_p$. Having formed the set of all possible situations, their number will prove unreasonably large. In order to solve this problem, information was aggregated.

All possible states of a company can be described by a set of so-called, reference situations. Each is a set of linguistic meanings of features. The number of reference situations is much less than the number of all possible situations and fairly accurately describes the state of the IT company and will not exceed $t_1 \times t_2 \times \dots \times t_p$, where t_i – the number of attribute terms $y_i \in Y(i \in J = \{1,2, \dots, p\})$.

For example, the condition of an IT company is characterized by two attributes x_1 and x_2. Definition range of x_1 is between 0 and 15 and x_2 betweet 0 and 50. This way, the maximum number of possible situtions is $15 \times 50 = 750$. Two linguistic variables $\{x_1, T_1, D_1\}$ and $\{x_2, T_2, D_2\}$were described by aggregating the data, where $T_1 = T_2 = \{$"few","$enough$","$many$"$\}$, $D_1 = [0; 15]$, $D_2 = [0; 50]$. Thus, it becomes possible to form a set of reference situations. Their number will be equal $3 \times 3 = 9$ and they will be formed as follows:

$S_1 = \{\ll$ "t_{11}" $>/x_1 >/ \dots /\ll$ "t_{p1}" $>/x_{\mathrm{p}} >.$
$S_2 = \{\ll$ "t_{11}" $>/x_1 >/ \dots /\ll$ "t_{p2}" $>/x_2 >.$
…
$S_s = \{\ll$ "t_{12}" $>/x_1 >/ \dots /\ll$ "t_{pk}" $>/x_2 >.$
…
$S_{\mathrm{r}} = \{\ll$ "t_{1k}" $>/x_1 >/ \dots /\ll$ "t_{pk}" $>/x_2 >.$

Formation of the current state of the company. In order to get an assessment of the status of an IT company, it is necessary to determine what the situation in the set of benchmarks is able to most accurately characterize the current state of affairs in the

company. To do this, it is important to form the current situation S_0 and compare it with each reference situation. In order to shape the current situation of the company, it is necessary to refer to the data obtained as a result of the argumentation, the membership matrix F_p and to determine for each attribute with what probability and to which term the current meaning of the attribute belongs. Based on the above current situation S_0 can be represented as follows:

$$S_0 = \{\ll \max(\mu_1(x_1), \mu_2(x_1), \dots, \mu_k(x_1)/"t_{1k}" >/x_1 >, \dots,$$
$$\ll \max(\mu_1(x_p), \mu_2(x_p), \dots, \mu_k(x_p)/"t_{pk}" >/x_p >\}, \quad (9)$$

where k – the number of terms/clusters,

p – the number of attributes,

$\mu_k(x_p)$ – the degree of belonging of attribute x_p to the k–th term,

t_{pk} – the name of the term with the highest degree of certainty.

Identification of the most similar reference situation with the current one (Mamdani algorithm). One possible way to find the most similar situation from the set of benchmarks to the current situation is Mamdani's Fuzzy Algorithm. This algorithm consists of 6 steps, described below:

1 Forming a rule base. The rule base is a set of rules. The input variables are the linguistic attribute variables $x_1, x_2, \dots, x_p$. Output variable – Situation, which is the conclusion. Thus, as a result of the algorithm, we have to get one of the possible situations. The number of rules in the database should match the number of possible reference situations. The rule base for the research task will be as follows:

2

Rule 1: If x_1 «t_{11}» AND x_2 «t_{21}» AND … AND x_p «t_{p1}»» THEN Situation = S_1

Rule 2: If x_1 «t_{11}» AND x_2 «t_{21}» AND … AND x_p «t_{p2}»» THEN Situation = S_2

…

Rule r: If x_1 «t_{1k}» AND x_2 «t_{2k}» AND … AND x_p «t_{pk}»» THEN Situation = S_r

3 Fuzzification of input variables. At this stage, the input features are made fuzzy. An input database of rules and an array of input data are input. The purpose of this step is to get truth values for all the sub-rules from the rule base.

4 For each rule, the degree of belonging of the input value to a particular term set is determined. The minimum value is selected from the specified values using the formula (10).

$$c_j = min\{\mu_j(x_1), \dots, \mu_j(x_p)\}, \overline{j = 1, r} \quad (10)$$

For this purpose can be used matrixes of the resulting clustering, or substituting the original values of the features in the corresponding functions obtained by the approximation.

5 At this point, truncated sets are searched. The number of truncated sets must match the number of rules. All truncated sets were defined by the formula (11).

$$\mu_i^*(y) = mi\,n\{c_i, \mu_j(S)\}, \overline{i = 1, r} \quad (11)$$

6 Next, the union of the original set was constructed. It is the union of all truncated sets and is defined by the formula (12).

$$\mu_i^{**} = max\{\mu_i^*(S)\} \quad (12)$$

7 In the last step, a clear value of the original variable was defined, ie the situation number describes the status of the company. For the dephasification, it was decided to use the maximum center method. In the method of the center of maxima is the arithmetic mean of the elements of the universal set with maximum degrees of accessories, the formula (13).

$$y = \frac{\sum_{x_j \in G} x_j}{|G|}, \quad (13)$$

where G – the set of items with the maximum degree of belonging;
$\sum_{x_j \in G} x_j$ – the sum of the elements of the set G;
$|G|$ – the power of the set G.

IV RESULTS

A test case was considered, in which 24 employees are currently employed in the company. For the projects under development, the company received from the customers 4200 USD, while the implementation of projects spent 950 USD. In the process of development 37 units were involved equipment.

This way:

$$x_1 = 24;$$
$$x_2 = 4200;$$
$$x_3 = 950;$$
$$x_4 = 37.$$

The vector characterizing the current state of the company will be as follows:

$$\overline{X} = \{x_1, x_2, x_3, x_4\} = \{24, 4200, 950, 37\}.$$

We use the results of data normalization and write the values of the features in dimensionless form:

$$x_1^{'} = 0{,}7275;$$
$$x_2^{'} = 0{,}3165;$$
$$x_3^{'} = 0{,}3359;$$
$$x_4^{'} = 0{,}7139;$$

Next, based on the input and the results of the data preparation (clustering and approximation) it became possible to form the current situation S_0, which characterizes the current state of the company. For each feature, the degree of belonging to each cluster is

determined and the maximum value is selected. So the current situation S_0 was formed as follows: $S_r, r = \overline{1,81}$

$$S_0 = \{\ll 0{,}98/many >/x_1 >, \ll 0{,}8364/few >/x_2 >, \ll 0{,}7326/many >/x_3 >, \ll 0{,}9538/many >/x_4 >\}.$$

Next, it is necessary to determine which situation is from the set of reference situations $S_r, r = \overline{1,81}$, is the most similar with the current situation S_0. For this purpose, it was decided to use the algorithm of fuzzy inference of Mamdani. The fuzzy k-means clustering method made it possible to represent term sets in the form of membership functions. In other words, the phasification of the input variables was performed, which is a prerequisite for applying the Mamdani algorithm. As an unput data, there are attributes $x_1^{'}, x_2^{'}, x_3^{'}, x_4^{'}$, which characterize the condition of the company and they are already reduced to a dimensionless form. The output must be a situation number from the list of reference situations most similar to the current situation. Based on the conditions of the problem, a rule base for the Mamdani algorithm was formed:

Rule 1: IF x_1 «few» AND x_2 «few» AND x_3 «few» AND x_4 «few» THEN Situation = S_1

Rule 2: IF x_1 «few» AND x_2 «few» AND x_3 «few» AND x_4 «enough» THEN Situation = S_2

Rule 3: IF x_1 «few» AND x_2 «few» AND x_3 «few» AND x_4 «many» THEN Situation = S_3

Rule 4: IF x_1 «few» AND x_2 «few» AND x_3 «enough» AND x_4 «few» THEN Situation = S_4

Rule 5: IF x_1 «few» AND x_2 «few» AND x_3 «enough» AND x_4 «enough» THEN Situation = S_5

…

Rule 77: IF x_1 «many» AND x_2 «many» AND x_3 «enough» AND x_4 «enough» THEN Situation = S_{77}

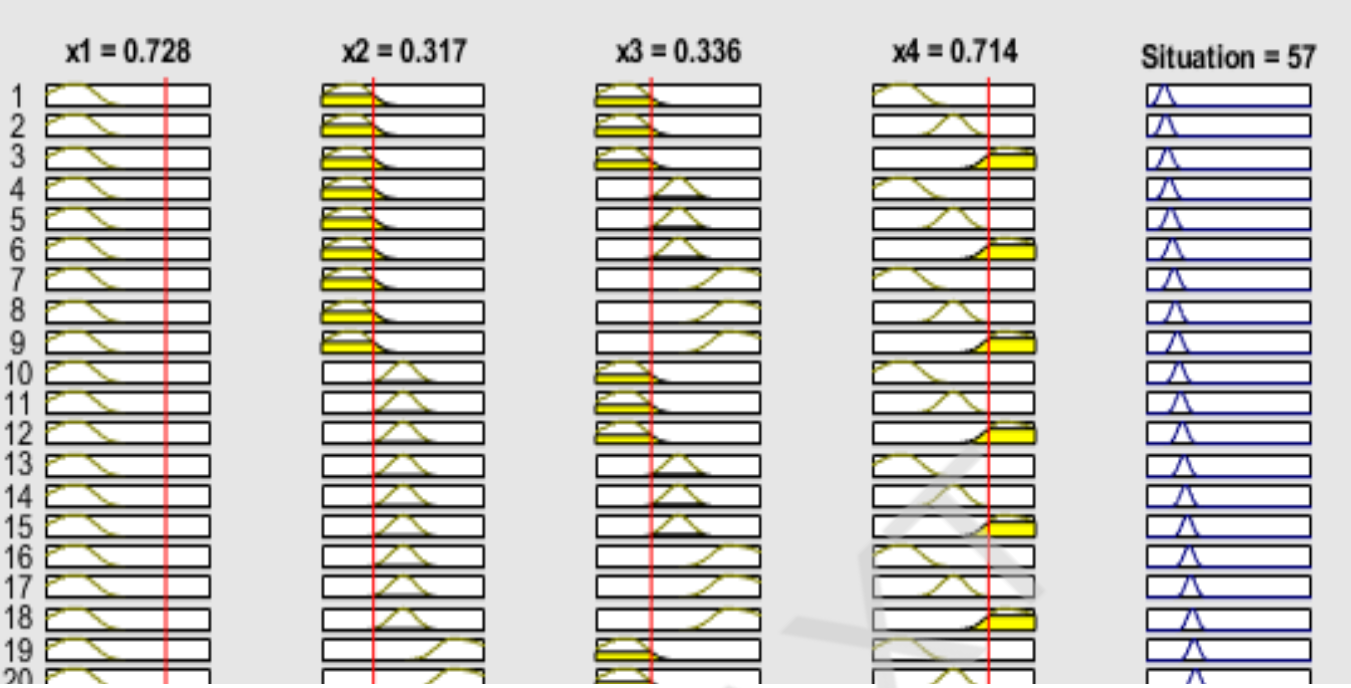
Rule 78: IF x_1 «many» AND x_2 «many» AND x_3 «enough» AND x_4 «many» THEN Situation = S_{78}

Rule 79: IF x_1 «many» AND x_2 «many» AND x_3 «many» AND x_4 «few» THEN Situation = S_{79}

Rule 80: IF x_1 «many» AND x_2 «many» AND x_3 «many» AND x_4 «enough» THEN Situation = S_{80}

Rule 81: IF x_1 «many» AND x_2 «many» AND x_3 «many» AND x_4 «many» THEN Situation = S_{81}

Thus, a rule base consisting of 81 rules was formed. Now you are ready to run the algorithm. The initial data was specified according to the conditions of the test example and the following result was obtained (pic. 3.2):



Picture 3.2 – The result of the implementation of the Mamdani algorithm

The results are presented in the table 3.7.

Table 3.7 – Obtained results

x_1	x_2	x_3	x_4	S
0.728	0.317	0.336	0.714	57

Thus, it can be concluded that among the set of reference situations one, most similar situation to the current situation S_0 was found. The situation number is $r = 57$. This situation was found in the list of reference situations and is written as follows:

$$S_{57} = \{\ll 0{,}992/many >/x_1 >, \ll 0{,}98/few >/x_2 >, \ll 0{,}991/few >/x_3 >, \ll 0{,}998/many >/x_4 >\}.$$

Further, this result is considered in more detail and reasoned readings of the current state of the IT company are formed.

It is worth to notice that when considering a real task, the number of input features, characterizing the state of the company will be significantly larger than in this test example. This example demonstrates the efficiency of the method of assessing the condition of complex objects cited by the authors. The solution will be relevant for any number of input parameters. The only nuance is that when solving a task of a rather large size, powerful computing resources may be needed.

V Conclusions

As part of the work, the problem of assessing the state of the enterprise (on the example of an IT company) was considered. The problem is presented in the form of two tasks, namely: aggregation of input information and identification of the state of a complex system.

Having identified the problem, the formulation of the problem was formulated and the possible methods for its solution were considered. The most feasible solutions were chosen among the possible methods.

A fuzzy k-means method was used to solve the problem of input data aggregation. Some numerical calculations were made and a test case was calculated. The numerical result obtained was approximated by the analytic membership functions. The solution of the first problem allowed to form many fuzzy reference situations. Each situation in this set is characterized by an information pellet.

The second problem was solved using the fuzzy logic method. A test case was calculated. During the calculations, using the fuzzy logic method, the current situation at the enterprise was compared with the reference situations. As a result, it was determined which of the reference situations is closest to the current situation. This made it possible to assess the status of the IT company.

The obtained theoretical and practical results allow to increase the efficiency of the process of managing a complex system.

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THE DEVELOPMENT OF THE TOOL FOR REAL-TIME NOTIFYING THE PEOPLE ABOUT LEVEL OF AIR POLUTION IN RECREATION ZONES

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Abstract.*The main goal of our research is to confirm the hypothesis of a relatively high level of air pollution in the city Kramatorsk and to create a tool for notifying the people of this information. This work demonstrate why the task of creating a convenient, accessible, functional, accurate interactive map of the state of environmental pollution in recreational areas of the city, which could allow residents to choose the least polluted recreation areas at the current time, is relevant.*

Keywords: *Interactive map, Air pollution, OpenStreetMap, API, Recreation zone, PM, Substance, Monitoring*

Introduction

The current environmental situation in Ukraine can be described as the maximum crisis, which was formed over a long period due to the neglect of objective laws of development and reconstruction of the natural resource complex of Ukraine. There were structural deformations of the national economy, in which preference was given to the development of raw-mining, the most environmentally dangerous industries in Ukraine. The level of contamination with various substances exceeds the norm not only in the so-called "work zones", but also in residential areas and recreational areas. Cities in industrial zones of Ukraine, in particular in the Eastern part of Ukraine, are most at risk. Recreational areas are created in order to allow people to relax and reduce the load received by the human body from the urbanized atmosphere of cities. But practice shows that the situation in recreation areas is also not satisfactory, and in some cases even more dangerous than in other places of the settlement. The most annoying thing is that most people do not even suspect that these places are as dangerous as, for example, work areas.

At the moment, Ukraine is gradually introducing automated monitoring systems for the state of environmental pollution, and even attempts to combine them into a single system are taking place. But almost no one thinks about convenient representation of the received and analyzed information for a wide audience, namely, for the population of the city. All this information, first of all, is often placed somewhere on the websites of local environmental departments, but not on the main pages of popular Internet resources of the city. enough to talk about creating targeted software that should be available to every resident of the city at hand. And, secondly, most often this information is presented in the form of dry figures with the specified maximum permissible concentration (MPC), and is not interpreted in any convenient way for the average user, and even more so does not report the possible consequences of the influence of exceeding the concentration of a substance on the human body.

1 Literature overview

Usually, cartography is defined as the science and art of creating and using maps. Arthur Robinson [1] defined the philosophy of the "Golden age of cartography" as follows: functional design or scientific creation of the principles of cartographic design, which is based on the perceptual and cognitive limitations of the target map user. This approach to map research has given rise to a communication model that describes the map as a conduit through which messages can be conveniently transmitted from the map creator to its user [2-4]. Also, some of the main views for cartography were supplemented during visual communication with advertising, art, education, and psychology in order to create specific recommendations for designing maps to avoid inconveniences during the transmission of these messages. Despite the fact that the communication model did not bring significant benefits through some differences in terms of practical, applied, critical, and social theory [5-8], the basic principles of design and use that took root in this era remain the basis of the modern cartographic curriculum to this day [9,10].

For geoinformative systems that include interactive maps, the interaction with them or how the user manipulates the map is central. Maps can be divided into two large groups: "dynamic" and "static", but instead of the concept of "dynamic", that is, those that can constantly change, the concept of "interactive" will be used in order to distinguish between the so-called "update" of the map that was caused by the system (animation, image shape, etc.) and what was caused by the user (opening the menu, entering any additional information). The digital revolution and the information age in ceneral, with the advent of new features, together prompted changes in the direction of how maps are created and used. Interactivity is one of the most important features of this kind [11,12].

To create a digital interactive map, it was decided to use public services with tools for creating and publishing custom maps. OpenStreetMap (OSM) was selected among all available services [13]. As noted in their reviews Gorchakov and Wagner [14, 15], OSM uses the same principles that formed the basis for the creation of Wikipedia. All the information on these maps was collected by a very large number of volunteers who provided data from street panoramas, satellite images, aerial photos, videos, and data from GPS trackers for this project. And despite its review of this service, it was concluded that for the city Kramatorsk, OSM maps contain more detailed and relevant information than all other services. The API documentation is also very convenient and freely available.

Today, the existing standards for assessing and calculating the level of environmental pollution in Ukraine are quite outdated, even since the Soviet Union [16]. In addition, we do not have regulatory documents for regulating the concentration of fine dust (PM2.5), which is one of the most problematic polluting substance in the world [17]. But despite all this, when choosing a mathematical model for predicting the level of air pollution, we must rely on our current standards, since the technological processes and cleaning technologies at enterprises in Ukraine are also very outdated and do not meet modern European requirements. Suffice it to say that one of Kramatorsk's enterprises, a metallurgical plant, uses cleaning technologies from the 19th century. Therefore, to assess the state of air pollution in recreational areas, taking into account existing data, the calculation methods were used, described in detail in the works of Berlyand [16], Cherkesov [18], Vetoshkin [19].

2 Object, subject and methods of study

The object of our research is information protection of the population from environmental problems.

The subject of the study is the implementation of a convenient tool for displaying information on monitoring and forecasting the concentration of harmful substances in the atmospheric air in recreational areas of the city Kramatorsk.

As a research method, a mathematical model was developed for a comprehensive assessment and visualization of the level of air pollution in recreational areas of the city Kramatorsk.

The maximum predicted concentration in the center of a recreational area can be calculated using the formula [20]:

$$C_{mf} = \sum C_i - C_T/1000 \quad (2.1)$$

C_{mf} – maximum predicted concentration (mg / m^3).

C_i – concentration from other sources (in our case plants) (mg / m^3).

C_T – the given concentration (average for the city, taken every 2 hours from the state website of the automated environmental monitoring system in the Donetsk region) (mcg / m^3).

Category C_i includes all substances that have flown from the plant to the selected recreational area, so the question here is the location of the zones and the distance to them from various sources of pollution. This parameter can be calculated using the formula:

$$C_T = (\frac{T_{max} - T_d}{T_{max}})C_Z \quad (2.2)$$

T_m – the maximum scattering distance of a substance is calculated using the formula [21]:

$$T_m = T_s \times V_f \tag{2.3}$$

T_s – the standard distance at zero wind speed at which the matter is dispersed, the standard is 5000 meters;

V_f – wind direction coefficient that varies from 0.5 to 1.5 depends on the wind direction and location of the SOURCE-ZONE line;

T_d – distance from the source of pollution to the recreational area;

C_Z – concentration of chemical substances that was released by the source of contamination (mg / m^3). In our case, we take the factories of our city as the source of pollution. Namely NKMZ, TPP, KZTS, FERROALLOY PLANT, EMSS, DONMET. The formula for calculating the concentration will look like this [16, 19-21]:

$$C_Z = \frac{A \times M \times F \times m \times n}{H^2 \times \sqrt[3]{V_1 \times \Delta T}} \tag{2.4}$$

A – coefficient which depends on the temperature stratification of the atmosphere that defines the terms vertical and horizontal dispersion of pollutants in the atmosphere ($C^2/^3 \times$ mg $\times$ grad$^1/^3$g). The coefficient A is calculated for adverse weather conditions observed in summer during the daytime with an intensely developed vertically turbulent climate. For Ukraine this coefficient is equal to 200;

M – the amount of harmful substance that is released into the atmosphere (g/s);

H – the height of the pollution source above ground level (in our case, the height of the pipes) (m);

V_1 – volume of the gas-air mixture (m^3/s);

ΔT – the difference between the temperature levels of the exhaust gas-air mixture and the ambient temperature in degrees Celsius;

F – a dimensionless coefficient that takes into account the rate of precipitation of particles in the atmosphere – for sterny gas 1, for dust cleaning with an efficiency of at least 90 % – 2;

M – the dimensionless coefficient that takes into account the conditions of the gas-air mixture output in our conditions is taken as 1;

N – dimensionless coefficient, which takes into account the conditions of the gas-air mixture output in our conditions, is taken as 1.

For correct calculations of predicting the concentration of harmful substances in recreational areas, we need to know the exact distance between all sources of harmful emissions and recreational areas. The shape of the Earth can be described as spherical. Calculating the distance using this method is more efficient and in many cases more accurate than calculating it for projected coordinates (in a rectangular coordinate system), because, first, you do not need to translate the graphic coordinates into a rectangular coordinate system (perform projection transformations), and, secondly, many projections, if they were incorrectly selected, can lead to significant length distortions due to the features of projection distortions. It is known that an ellipsoid rather than a sphere describes the Earth more accurately, but in this case we will consider calculating distances on the sphere. For distances, a sphere with a radius of 6372795 meters is used, which can lead to a calculation error of about 0.5% [22].

The mathematical model will be based on the spherical cosine theorem.

$$\Delta\sigma = 2\arccos\left(\sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos\Delta\lambda\right) \quad (2.5)$$

where $\varphi_1; \varphi_2$ – the latitude of two points in radians;

$\Delta\lambda$ – the difference of the coordinates in longitude;

$\Delta\sigma$ – the angular difference.

To convert the angular distance to metric, you need to multiply the angular difference by the radius of the Earth (6372795 meters), the units of the final distance will be equal to the units in which the radius is expressed, in this case – meters.

But, in our case, namely, in the case of relatively small distances and small bit depth calculations, the use of this formula can lead to significant errors associated with rounding. In order to prevent problems with small distances, the haversinus formula is used [22].

$$\Delta\sigma = 2\arcsin\left(\sqrt{\sin^2\left(\frac{\phi_2 - \phi_1}{2}\right) + \cos\phi_1 \cos\phi_2 \sin^2\left(\frac{\Delta\lambda}{2}\right)}\right) \quad (2.6)$$

Formula 2.6 is prone to the problem of antipodes points, and the following modification is used to solve it [22].

$$\Delta\sigma = \arctan\left(\frac{\sqrt{(\cos\phi_2 \sin\Delta\lambda)^2 + (\cos\phi_1 \sin\phi_2 - \sin\phi_1 \cos\phi_2 \cos\Delta\lambda)^2}}{\sin\phi_1 \sin\phi_2 + \cos\phi_1 \cos\phi_2 \cos\Delta\lambda}\right) \quad (2.7)$$

For convenient interpretation of information about the level of air pollution, the user needs to display data on the map in the form of recreational areas, painted in the appropriate color, which will change over the gradient.

First, we calculate the average ratio of the predicted concentration of substances to their corresponding MPC and hazard class according to the integrated assessment of atmospheric air pollution [23-24].

$$grad\varphi = \left(\sum_{i=1}^{n} \frac{C_p}{ПДК_{м.р.}} * k_h \right) / n \quad (2.8)$$

where $grad\varphi$ – the calculated coefficient for the gradient;

k_h – coefficient for calculating the force of exposure of a substance depending on its hazard class;

C_p – predicted maximum concentration of a substance in a recreational area;

$ПДК_{м.р.}$ – predicted maximum concentration of the corresponding substance in the recreational area;

n – the number of substances measured in the recreational area.

The color for the fill is defined in the RGB model (red, green, blue), where red, green, and blue are integer values from 0 to 255 for the red, green, and blue colors in the model, respectively. We introduce an additional modified coefficient for the gradient and values for colors in the RGB model. коефіцієнт для градієнту та значення для кольорів у моделі RGB.

$$grad\varphi_m = \begin{cases} (1 - grad\varphi) \,/\, k, grad\varphi < 1 \\ (grad\varphi - 1) \,/\, k, \;\; grad\varphi \geq 1 \end{cases} \quad (2.9)$$

when $grad\varphi_m > 1$ we accept $grad\varphi_m = 1$.

$$COL_{RGB} = \begin{cases} (255 - 255 * \; grad\varphi_m, 255, 0), grad\varphi < 1 \\ (255, 255 - 255 * \; grad\varphi_m, 0), grad\varphi \geq 1 \end{cases} \quad (2.10)$$

where $grad\varphi$ – is the calculated coefficient for the gradient;

$grad\varphi_m$– modified coefficient for the gradient;

k – coefficient for expanding the gradient with a small amplitude of values;

COL_{RGB} – ready color for painting in the RGB model.

3 The results of in-depth development of separate modules of software complex for realization of an interactive map of air pollution

To get records from the database for a certain date, we need to use the function shown in Fig. 3.1-3.2. It accepts the date that the user selected as a parameter. In order to pull out a record for a certain time, taking into account the possible error of a few seconds/minutes, we make a time interval of ±20 minutes, which will be specified as a query parameter in the database. In order to make a correct query, we also need to convert the received dates to the "American" format "MM-DD-YYYY" by working with an array of characters. Next, this function connects to the database, dynamically generates a query depending on the selected date, and writes the corresponding data to the variables of the "Air" object, processing an exception if it is not possible to connect to the database.

```
public int GetValues(DateTime date, int id)
    {
        int id_predict = 0;
        string lowdate = date.AddMinutes(-20).ToString();
        string highdate = date.AddMinutes(20).ToString();

        char[] bufstring = lowdate.ToCharArray();

        char[] lowstring = lowdate.ToCharArray();
        lowstring[0] = bufstring[3];
        lowstring[1] = bufstring[4];
        lowstring[3] = bufstring[0];
        lowstring[4] = bufstring[1];

        bufstring = highdate.ToCharArray();

        char[] highstring = highdate.ToCharArray();
```

Figure 3.1– function for requesting data from the database regarding the predicted maximum concentrations in recreational areas for a certain date

```
highstring[0] = bufstring[3];
        highstring[1] = bufstring[4];
        highstring[3] = bufstring[0];
        highstring[4] = bufstring[1];

        lowdate = new string(lowstring);
        highdate = new string(highstring);

        OleDbCommand selectCommand = new OleDbCommand();
        DataTable table = new DataTable();
        try
        {
           OleDbConnection objConnection = new
OleDbConnection("Provider=Microsoft.Jet.OLEDB.4.0; Jet OLEDB:Engine Type=5; Data
Source=F:\\Downloads\\BD.mdb");
           selectCommand.CommandText = "SELECT TOP 1 Prediction.id_prediction,
Prediction.prediction_CO, Prediction.prediction_NOx, Prediction.prediction_O3,
Prediction.prediction_PM10, Prediction.prediction_SO2 FROM Prediction WHERE
Prediction.id_rz = " + id.ToString() + " AND Prediction.date_time BETWEEN #" +
lowdate.Replace('.', '/') + "# AND #" + highdate.Replace('.', '/') + "# ORDER BY
id_prediction DESC;";
           selectCommand.Connection = objConnection;
           selectCommand.CommandType = CommandType.Text;
           OleDbDataAdapter adapter = new OleDbDataAdapter(selectCommand);
           adapter.Fill(table);
           table.PrimaryKey = new DataColumn[] { table.Columns["id_prediction"] };
           id_predict = Convert.ToInt32(table.Rows[0][0]);
           CO.Value = Convert.ToDouble(table.Rows[0][1]);
           NOx.Value = Convert.ToDouble(table.Rows[0][2]);
           O3.Value = Convert.ToDouble(table.Rows[0][3]);
           PM10.Value = Convert.ToDouble(table.Rows[0][4]);
           SO2.Value = Convert.ToDouble(table.Rows[0][5]);
        }
        catch (OleDbException exc)
        {
           table = null;
           MessageBox.Show(exc.Message, "Помилка", MessageBoxButtons.OK,
MessageBoxIcon.Error);
        }
        finally
        {
           selectCommand.Connection.Close();
        }          return id_predict;       }
```

Figure 3.2 – continuation of the database data query function with respect to the predicted maximum concentrations in recreational areas for a certain date

For better visual perception, a function was created to determine the color of the recreational area on the city map (from green to red) in RGB format, which is shown in figure 3.3. The color is calculated depending on the concentration of the harmful substance corresponding to the MPC and the hazard class, according to the integrated assessment of air pollution (formulas 2.8-2.10).

```
private Color DefinePolygonColor()
      {
         double level = ((Air.ValueCO.Value / Air.ValueCO.MPC) *
Air.ValueCO.Hazardclass + (Air.ValuePM10.Value / Air.ValuePM10.MPC) *
Air.ValuePM10.Hazardclass + (Air.ValueSO2.Value / Air.ValueSO2.MPC) *
Air.ValueSO2.Hazardclass + (Air.ValueNOx.Value / Air.ValueNOx.MPC) *
Air.ValueNOx.Hazardclass + (Air.ValueO3.Value / Air.ValueO3.MPC) *
Air.ValueO3.Hazardclass) / 5;
         Color color;
         if (level < 1.0)
         {
            level = (1.0 - level) / 0.4;
            if (level > 1.0) level = 1.0;
            color = Color.FromArgb(150, Convert.ToInt32(255 - (255 * level)), 255, 0);
         }
         else
         {
            level = (level - 1.0) / 0.4;
            if (level > 1.0) level = 1.0;
            color = Color.FromArgb(150, 255, Convert.ToInt32(255 - (255 * level)), 0);
         }
         return color;
      }
```

Figure 3.3 – function for determining the color of the recreational area in accordance with its level of pollution

To work with polygons on the interactive map, we created functions for creating and updating polygons, which are shown in figure 3.4, and which will already be painted in the appropriate color for the level of pollution. Polygons belong to an object of the "GMapPolygon" type, and are stored in it as a layer that belongs to a collection of layers.

```
public void UpdatePolygon(GMapPolygon polygon)
      {
         polygon.Fill = new SolidBrush(DefinePolygonColor());
         polygon.Stroke = new Pen(Color.Black, 1);
```

```
            polygon.IsHitTestVisible = true;
        }
        public TextBox CreateDisplayData()
        {
            TextBox textbox = new TextBox();
            textbox.Name = name;
            textbox.Multiline = true;
            textbox.Location = new Point(1010, 150);
            textbox.Size = new Size(160, 126);
            textbox.Visible = false;
            textbox.Font = new Font("Calibri", 15);
            textbox.Text = Air.ValuePM10.Value.ToString() + " / " +
Air.ValuePM10.MPC.ToString() + Environment.NewLine +
Air.ValueCO.Value.ToString() + " / " + Air.ValueCO.MPC.ToString() +
Environment.NewLine + Air.ValueSO2.Value.ToString() + " / " +
Air.ValueSO2.MPC.ToString() + Environment.NewLine +
Air.ValueNOx.Value.ToString() + " / " + Air.ValueNOx.MPC.ToString() +
Environment.NewLine + Air.ValueO3.Value.ToString() + " / " +
Air.ValueO3.MPC.ToString() + Environment.NewLine;
            return textbox;
        }
```

Figure 3.4 - functions for creating and updating polygons on the map

For drawing on the map the logos of pollutant sources with relevant information about ground-level concentrations, was created a function for creating of "markers" that are stored as a marker layer that belongs to a collection of layers. The function is shown in figure 3.5. The logo of a plant or other source of pollutants is set as a marker, and information about ground-level concentrations is set as text that is displayed when the mouse hovers over the marker.

```
        public void SetLogo(GMapOverlay overlay) {
            GMapMarker marker = new GMarkerGoogle(
            new PointLatLng(xcoord, ycoord),
            new Bitmap(logo, bitmapX, bitmapY));
            marker.Tag = name;
            marker.ToolTipText = name + "\n\n Розрахункові приземні
концентрації:\nCO: " + CO.Value.ToString() + " мг/м3\nNOx: " +
NOx.Value.ToString() + " мг/м3\nSO2: " + SO2.Value.ToString() + " мг/м3\nO3: " +
O3.Value.ToString() + " мг/м3\nПил: " + PM10.Value.ToString() + " мг/м3";
            marker.ToolTipMode = MarkerTooltipMode.OnMouseOver;
            overlay.Markers.Add(marker);}
```

Figure 3.5 – function for creating a marker for a pollutant source

To determine the exact distance between the source of emissions and the recreational area, was created a function to determine the distance, depending on the geographical coordinates of objects, shown in figure 3.6. The function makes calculations using the formula 2.7. Only two pairs of geographical coordinates are needed as parameters for this function: sources of pollutants and recreational areas. The radius of the earth is set by a constant.

```
...
{
        const int EarthRadius = 6372795;
        const int defaultRadius = 5000;
        double lat1 = xcoord * Math.PI / 180;
        double lat2 = x1 * Math.PI / 180;
        double long1 = ycoord * Math.PI / 180;
        double long2 = y1 * Math.PI / 180;
        double cl1 = Math.Cos(lat1);
        double cl2 = Math.Cos(lat2);
        double sl1 = Math.Sin(lat1);
        double sl2 = Math.Sin(lat2);
        double delta = long2 - long1;
        double cdelta = Math.Cos(delta);
        double sdelta = Math.Sin(delta);
        double y = Math.Sqrt(Math.Pow(cl2 * sdelta, 2) + Math.Pow(cl1 * sl2 - sl1 * cl2
* cdelta, 2));
        double x = sl1 * sl2 + cl1 * cl2 * cdelta;
        double ad = Math.Atan2(y, x);
        double dist1 = ad * EarthRadius;
...
}
```

Figure 3.6 – function for calculating the distance between the recreational area and the emission source by geographical coordinates

To calculate the maximum concentration of harmful substances in recreational areas, we need to take into account the number of harmful substances that are the main sources of pollution in the city, for this we will use the formula (Fig. 3.7) calculation of maximum surface concentrations at emission sources (formula 2.4).

```
public void FactoryConcentration(Substance.Name name, double tempout)

    {

        if (name == Substance.Name.CO) concCO = (160 * CO.Value * 0.9) /
(Math.Pow(sourceheight, 2) * Math.Pow(airvolume * (temperature - tempout), 1 /
3));

        if (name == Substance.Name.NOx) concNOx = (160 * NOx.Value * 0.9) /
(Math.Pow(sourceheight, 2) * Math.Pow(airvolume * (temperature - tempout), 1 /
3));

        if (name == Substance.Name.O3) concO3 = (160 * O3.Value * 0.9) /
(Math.Pow(sourceheight, 2) * Math.Pow(airvolume * (temperature - tempout), 1 /
3));

        if (name == Substance.Name.PM10) concPM10 = (160 * PM10.Value *
2.5 * 0.9) / (Math.Pow(sourceheight, 2) * Math.Pow(airvolume * (temperature -
tempout), 1 / 3));

        if (name == Substance.Name.SO2) concSO2 = (160 * SO2.Value * 0.9) /
(Math.Pow(sourceheight, 2) * Math.Pow(airvolume * (temperature - tempout), 1 /
3));      }
```

Figure 3.7 – the function of calculating the maximum ground level concentrations from emission sources

In figure 3.8 is the function for predicting the maximum possible concentrations in recreational areas, taking into account current concentrations, maximum surface concentrations near emission sources, distance from the source to the recreational area, and wind direction, using the example of PM10 dust.

```
{
...
        predictedConcentrationPM10 = Math.Round(back_pm10 / 1000.0 +
(pm10_1 * isFarther1 / defaultRadius * wind_fac1) + (pm10_2 * isFarther2 /
defaultRadius * wind_fac2) + (pm10_3 * isFarther3 / defaultRadius * wind_fac3)
            + (pm10_4 * isFarther4 / defaultRadius * wind_fac4) + (pm10_5 *
isFarther5 / defaultRadius * wind_fac5) + (pm10_6 * isFarther6 / defaultRadius *
wind_fac6), 6);
...
}
```

Figure 3.8 – function for predicting maximum possible concentrations in recreational areas

3.1 Interface Elements of the interactive PC map " CleanKramatorsk»

The software package "CleanKramatorsk: ZEPHYR" is an interactive map of the city Kramatorsk, which shows the main sources of emissions of pollutants into the atmosphere in the form of logos of these sources, the main recreational areas of the city in the form of painted planes in the color corresponding to the overall level of pollution (from green – the lowest to red-the highest) and interface elements for interaction with the map user. The interface with the main elements is shown in figure 3.9.

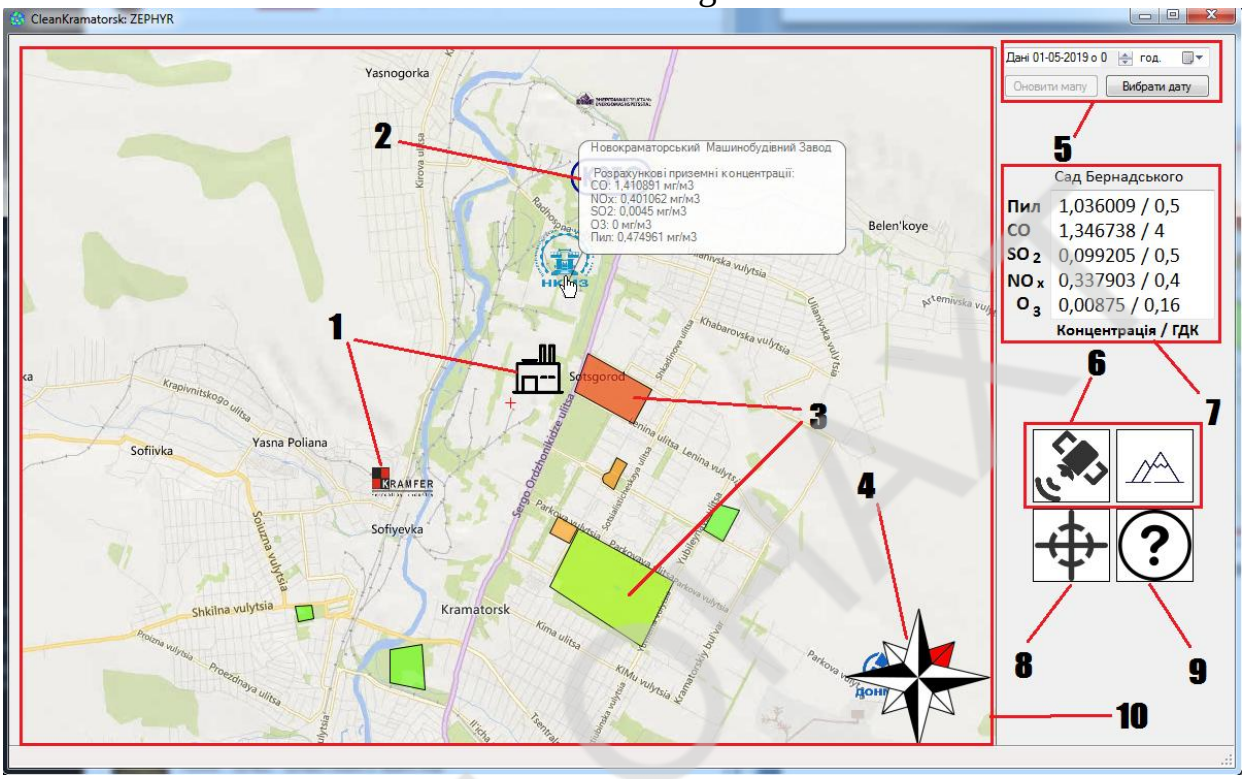

Figure 3.9 – interface elements of the «CleanKramatorsk» interactive PC map

Explanation of interface elements:

1– logos of sources of pollution with harmful substances;

2 – information about ground-level concentrations of harmful substances (appears when hovering over the logo with the mouse);

3 – recreational areas of the city;

4 – wind rose, which shows the current wind direction (the part painted in red);

5 – menu for selecting the date for which data will be displayed on the map. It includes a calendar for selecting a specific day of the year, an element for selecting a specific measurement hour (only even-numbered hours are selected), a "select date" button for checking the availability of data for the selected date, and a "update map" button for displaying data for the selected date (becomes active if the data check is successful);

6 – buttons for switching map mode: satellite and topographic;

7 – information about concentrations and the name of the recreational zone that the user is currently viewing (changes when the mouse hovers over a specific recreational zone);

8 – "set default position" button, which sets the default coordinates and scale when clicked;

9 – button for calling help;
10 – interactive map.

Conclusions

Based on the analysis of the existing literature and the conducted research has developed a comprehensive mathematical model for the assessment of air pollution in recreational areas of Kramatorsk, which consists of determining the exact distance between the pollution source and recreational area, forecasting the level of concentration of individual substances in the recreational area and determining the overall state of pollution, resulting in a specific color corresponding of the recreation area on an interactive map. A software product was developed in the form of an interactive map to inform the people about the projected level of air pollution in recreational areas of the city Kramatorsk. Based on the obtained forecast data, the hypothesis about the increased level of environmental pollution in the city Kramatorsk can be considered confirmed.

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AUTOMATIC CONTROL SYSTEM FOR TWO-MASS POSITION ELECTRIC DRIVE

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Abstract. *Continuous improvement of technological processes leads to the need for the development of machines and aggregates to which new performance requirements are imposed. The need for position regulation of mechanisms occurs in material-handling machines, metal-cutting machines, manipulators and metallurgical aggregates. Proper design, improved regulation, increased reliability of these systems can improve technological processes in enterprises, improve the quality of finished products, reduce energy consumption of production and raise the level of safety. Therefore, nowadays, this question is relevant.*

The development of control systems for objects of various types and levels of complexity is facilitated by the use of microcontrollers. Their application allows creating systems possessing such qualities as small dimensions, relative cheapness, simplicity and reliability, compatibility with the personal computer through standard interfaces.

The use of single-mass electric drive in the internal circuit of the positioning two-mass electric drive allows simplifying the synthesis of the controller and reducing the required computational power during modeling by representing the tracking electric drive with a first-order factor.

The results of this study was embedded in the educational process and production, discussed at conferences and also published in a specialized journal.

Keywords: *two-mass system, automatic control system, positioning electric drive, tracking actuator, PID controller, microcontroller, mathematical modeling.*

I. Introduction

Improvement of technological processes necessitates the development of machines and units, which are subject to new performance requirements. The use of actuators in the units of mechanisms with improved technical characteristics allows to improve the quality of finished products, reduce the energy intensity of production, increase the reliability of equipment used [1].

The main requirement for the actuators under study is to provide the necessary accuracy of the mechanism installation in a given point of space, and in some cases - to provide the necessary nature of movement of the actuating device. This makes the task of developing electric drive systems of actuating positional mechanisms relevant [2].

The proportional-integral-derivative (PID) controllers are one of the most common type of regulators [3]. The reason for this great popularity is the ease of construction and industrial use, clarity of operation and suitability for most practical tasks. Therefore, it is an important task to find the PID controller parameters that will provide the desired static and dynamic characteristics for a given system. Mathematical modeling plays a special role in this, because it allows you to study the object in more detail, the processes that take place in it, and find the necessary coefficients of the regulators, while saving time and costs for physical experiments.

The aim of this work is to develop and research a system for automatic control of a two-mass positioning electric drive with a tracing single-mass actuator in the inner circuit.

II. Analytical review of the literature

The principle of subordinate parameter control is widely known when the automatic control system is built as a multi-circuit. Generally the actuator has three-circuit structure, which consists of the external circuit of the position and two internal circuits – for speed and current. Issues of positioning electric drive construction are widely discussed in [4-7].

The construction principles of open-loop control systems of positioning electric drive which provide an time-optimal speed change over time are given in [8, 9]. In articles the control system with models that form control effects without controlling the real position of the mechanism is considered. In these systems, any change in parameters or load may cause positioning error. Therefore, such systems can only be used in cases where high accuracy is not required.

One of the most well-known types of regulators are PID controllers. Due to their advantages such as quick mode entry, precise control of adjustable value and rapid response to disturbing effects, they have become widely used. The DC positional drive system, using a PID controller, was considered in [10].

This work proposes the use of a closed-loop deflection control system, where the first mass is controlled by the tracking actuator and the second mass by the positioning actuator. Conditional separation of two-mass system into two single-mass system simplifies the development of the control system. This allows developing at first a tracking actuator control system. After having achieved the required accuracy and speed when controlling the first mass, a system for controlling the second mass is developed.

III. Object, subject and methods of research

The object of the study is the positioning electric drive of a two-mass system with a tracing actuator of a single-mass system in the inner circuit.

The subject of the study is the transient processes of the two-mass positional drive.

Research methods. The basis of the research is the methods of the theory of automatic control and the method of mathematical modeling for the development of control systems for tracing actuator of the first mass and for positional actuator of the second mass, as well as for the synthesis of the regulator of the position of the second mass and finding the coefficients of the PID controller. Physical experiments were also performed, the results of which were compared with those of mathematical modeling.

IV. Research results

It is known that positioning system (PS) is a closed-loop electric drive system intended to move the initially immovable actuating device of the working mechanism from a certain initial position to the preset position with a stop at the end of the displacement [11].

Traditionally, PS is built on the basis of the tree-circuit control system with the external contour for position regulation and internal contours for speed and current regulation.

The basic requirements for positioning electric drives are: positioning accuracy, which is usually defined as the deviation from a given position in which the actuating device is to be stopped; stability, which is estimated as the repeatability of the accuracy results with repeated testing of the same predetermined displacement; efficiency, which is

determined by the time of completion of a given displacement and the time of positioning; profitability, which is determined by the minimum of capital and operating costs [12].

The subordinate regulation scheme is widely used, first of all, in the positioning electric drives. Its advantage is the automation of the process of testing large displacements or angles of rotation of the output link of the motor, which is combined with the easy setup of the maximum speed and acceleration. In order to simplify the control scheme of the positioning electric drive, a current regulator is usually used instead of the acceleration regulator, which is relatively easy to measure and is a close analog of acceleration, in certain conditions [13].

If the DC motor rotating frequency control is to be performed with increased accuracy, for example in reversing positional drives, the use of microprocessors may be particularly effective. The actual rotating frequency is either immediately converted to a frequency-dependent signal (for example, using a pulse sensor), or measured by a tachometer-generator and converted by analog-to-digital converter into a digital signal. Armature current is measured in analog form and then converted to digital code. With the help of a microprocessor it is possible to calculate the average value of direct current and the rate of increase of current in the armature circuit for each impulse duration, the amplitude values of current can be written into memory. The control impulses for the converter are calculated as a function of these values.

Laboratory stand description

A stand that was created earlier was used for research [14].

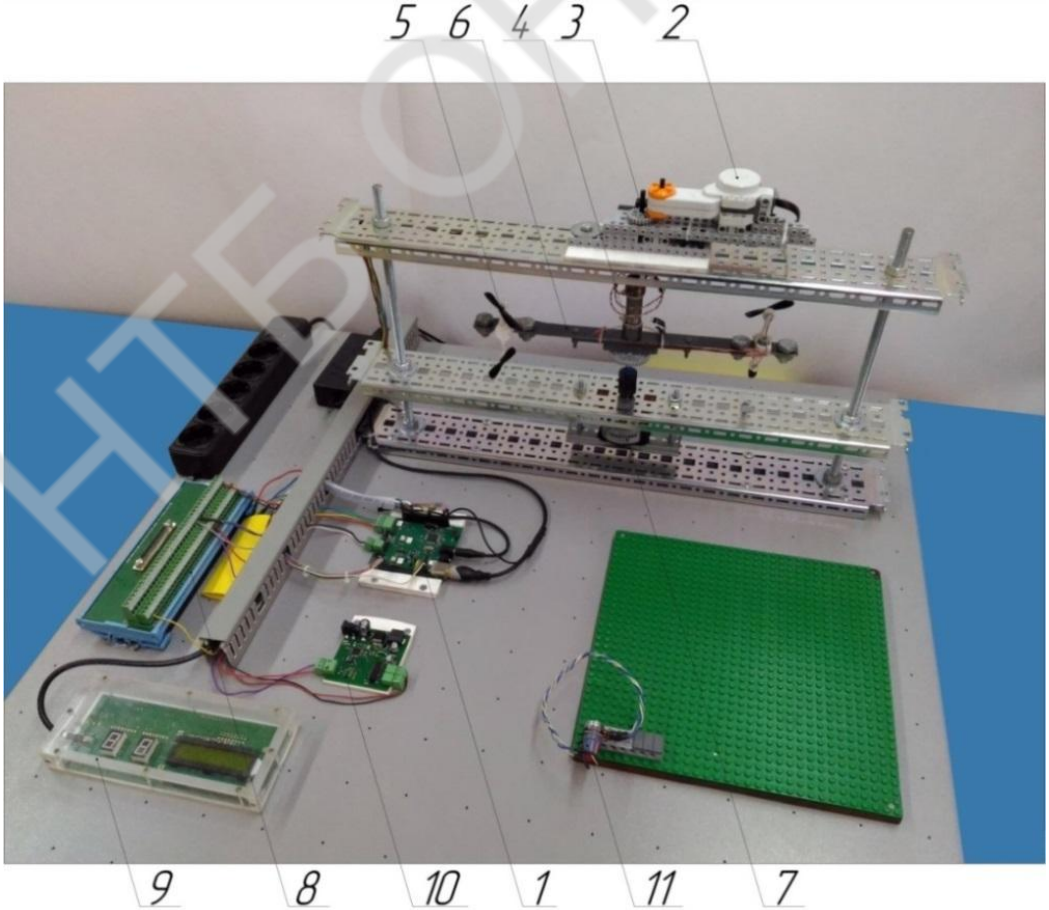


Figure 1. Photo of a laboratory stand

Description of the characteristics and functions of the stand components:

1. a microcontroller implemented on the basis of the microprocessor ADuC841;

2. LEGO NXT direct-current motor equipped with integrated gearbox and incremental encoder;
3. downshift gearbox with 1:3 gear ratio;
4. elastic element - a metal twisted spring that creates oscillations in a two-mass system;
5. four fans representing the moment of resistance;
6. actuating device represented by a metal plate having holes for M10 bolts, which is used for changing of inertia moment;
7. incremental second mass encoder;
8. PCI-1711U analog I/O board;
9. display unit - a data display device consisting of two seven-segment indicators and an LCD monitor having a field of 16 × 2 characters;
10. fan control board;
11. potentiometer, which sends position assignment signal of φ_{2a} using ADC.

Single-mass tracking actuator as a component of positioning electric drive of two-mass system

Depending on the control algorithm, the automatic control system can be divided into three categories: open, closed and combined [15].

The open system is operated without result control, i.e. without feedback.

In closed systems the control effect is reversed, directly depending on the controlled value.

Combined systems are a combination of two systems.

To rotate the second mass to a given angle, a closed deflection control system was developed, where the first mass is controlled by the tracking actuator and the second mass by the positioning electric drive. The main feature of the tracking system is the ability to work out an unknown variable input signal, unlike the positional system, which moves along a predetermined, previously known trajectory. Therefore, the task of the positional system is the formation of a given variable influence, which will provide a rotation of the second mass at a given angle. This effect is applied to the input of the tracking system and is worked out by the first mass, taking into account the disturbing effect caused by the elastic properties of the spring that connects the output shaft of the motor and the actuating device.

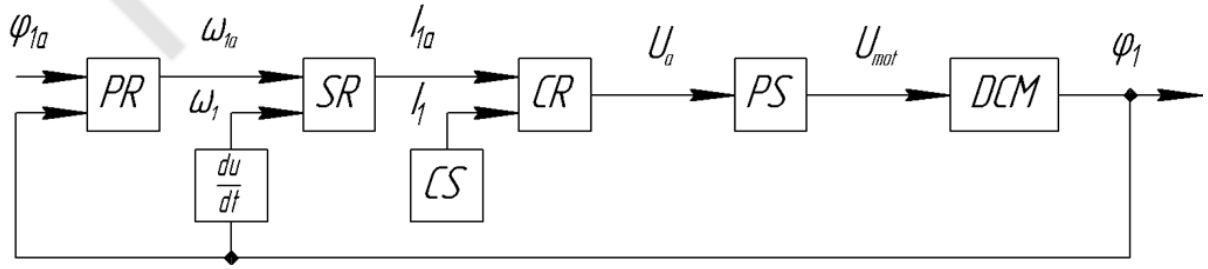


Figure 2. Structural scheme of the tracking actuator.

Figure 2 accepts the following conventions:

PR - position regulator;

SR - speed regulator;

CR - current regulator;

CS - current sensor;

PS - power switch;
DCM - LEGO NXT DC motor.

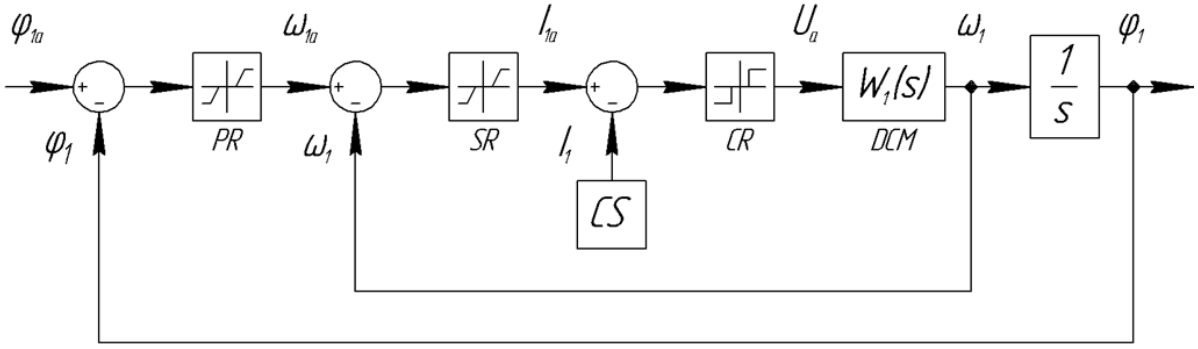


Figure 3. Functional scheme of the tracking actuator.

The tracking system of the first mass allows, with the given accuracy and speed, to work out a given variable action, that is the angle of rotation of the motor. The required precision and speed of the drive is achieved through the software implementation of the control system based on the ADuC841 microcontroller, as well as the presence of negative feedback on the angle of rotation. The programming language C was used.

Synthesis of the regulator of a two-mass positional drive system

The motion of a two-mass system is represented by the following equation [15]:

$$M_{12} - M_r = J_2 \frac{d\omega_2}{dt}, \quad (1)$$

where M_{12} - elastic moment;
M_r - moment of resistance;
J_2 - inertia moment of the second mass, $J_2 = 0{,}0032432$ [15];
ω_2 - angular velocity of the second mass.
$\omega_2 = \frac{d\varphi_2}{dt}$, mean $\frac{d\omega_2}{dt} = \frac{d^2\varphi_2}{dt}$.
The elastic moment is represented by the following formula:

$$M_{12} = c(\varphi_1 - \varphi_2), \quad (2)$$

where c - stiffness of the elastic linkage;
φ_1 - angle of rotation of the first mass;
φ_2 - angle of rotation of the second mass.
Further, having represented formula 1 with respect to formula 2, it turns out:

$$c(\varphi_1 - \varphi_2) - M_r = J_2 \frac{d\omega_2}{dt},$$

$$c(\varphi_1 - \varphi_2) - M_r = J_2 \frac{d^2\varphi_2}{dt},$$

$$\frac{c\Delta\varphi - M_r}{J_2} = \frac{d^2\varphi_2}{dt}. \quad (3)$$

The coefficients of viscous friction $K_{v.fr.}$ and the stiffness of the elastic linkage c were calculated experimentally. The determination of the stiffness coefficient was carried out by finding the period of oscillation of the second mass φ_2 when rotating the first mass φ_1 by a known angle.

The period T of the oscillation of the second mass φ_2 was determined according to the chart.

The following formula was used for the torsional oscillation period [16]:

$$T = 2\pi\sqrt{\frac{J_2}{c}}. \quad (4)$$

Knowing the moment of inertia and the period, the stiffness of the elastic linkage $c = 0{,}008$ was determined.

The determination of the coefficient of viscous friction was carried out by simulating attenuation similar to that which was taken on a physical object.

$K_{v.fr.}$ = 0,0002.

To create a mathematical model of the two-mass system of positioning drive, we found the transfer function of the first order aperiodic link $W(s) = \frac{1}{0{,}2s+1}$ of the first mass tracking actuator [17].

Having obtained the differential equation of motion of the two-mass system, the transfer function of the tracking actuator, and finding the coefficients of viscous friction and stiffness of the elastic linkage, a simulation model of the positioning drive was created.

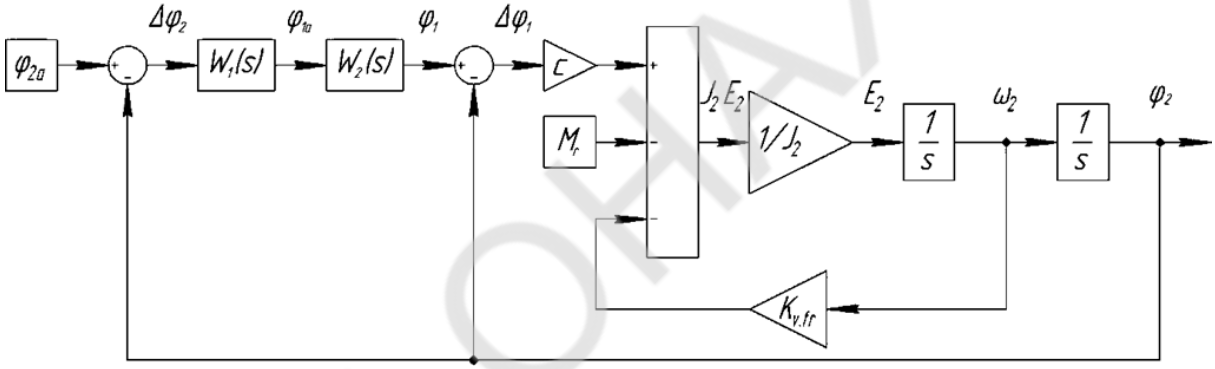


Figure 4. Mathematical model of a two-mass positioning drive system.

Figure 4 uses the following conventions:

$W_1(s)$ - transfer function of the position regulator of the second mass;

$W_2(s)$ - transfer function of the tracking actuator;

M_r - moment of resistance;

c - rigidity of the elastic linkage;

$K_{v.fr.}$ - coefficient of viscous friction.

For the synthesis of a regulator that could counteract the moment of resistance M_r, the mathematical model was transformed as follows. Instead of the position assignment of the second mass φ_{2a}, the moment of resistance M_r is fed to the input of the system.

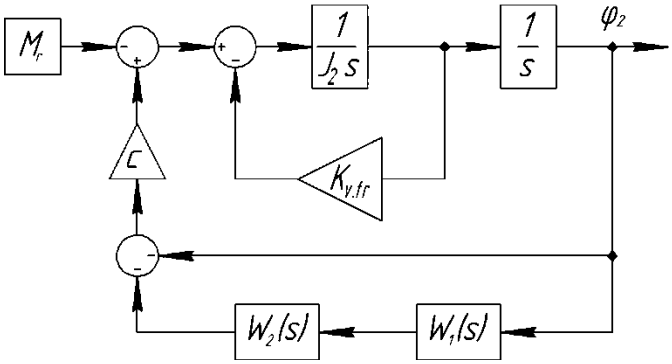


Figure 5. Converted mathematical model of positioning drive.

This scheme is described by the following transfer function:

$$W(s) = \frac{\varphi_2}{-M_r} = \frac{-1}{J_2 s^2 + K_{v.fr.} s + cW(s)_1 W(s)_2 + c}. \quad (5)$$

From this function, the transfer function of the second mass position regulator was derived:

$$W(s)_1 = -\frac{J_2 s^2 + K_{v.fr.} s + c + \frac{1}{W(s)}}{cW(s)_2}. \quad (6)$$

To obtain the transfer function of the second mass position regulator, it was necessary to find the desired function of the whole second mass position circuit $W(s)_{des.}$.

Systems that require high speed performance and minimal re-regulation are called systems with aperiodic reaction. These requirements are suitable for solving the set system tasks, so the desired transfer function must have a deadbeat response, as shown in formula 7 [18]:

$$W(s)_{des.} = \frac{\omega_n^3}{\alpha\omega_n s^2 + \omega_n^2 s + \omega_n^3}, \quad (7)$$

where $4{,}82/T_s$ - natural frequency;

T_s - settling time, T_s = 5 s;

α - coefficient at which the system has an aperiodic reaction, $\alpha = 1{,}9$.

After substituting the coefficients, the desired function has the form:

$$W(s)_{des.} = \frac{0{,}8958}{1{,}754s^2 + 0{,}9293s + 0{,}8958}.$$

The following has been done to find the transfer function of the regulator. The system was minimized and the received transfer functions were calculated using MatLab software. The function of the unknown regulator was equated to a coefficient.

Upon completion of folding, instead of the received transfer function, the desired function was substituted and deployed in reverse order until the transfer function of the second mass position regulator appeared:

$$W(s) = \frac{310{,}5s^3 + 1755s^2 + 1012s}{s^3 + 30s^2 + 300s + 1000}. \quad (8)$$

This transfer function was substituted into the basic model, and the transients of the output signal φ_2 were removed when applying the moment of resistance M_r and the position assignment of the second mass φ_{2a}.

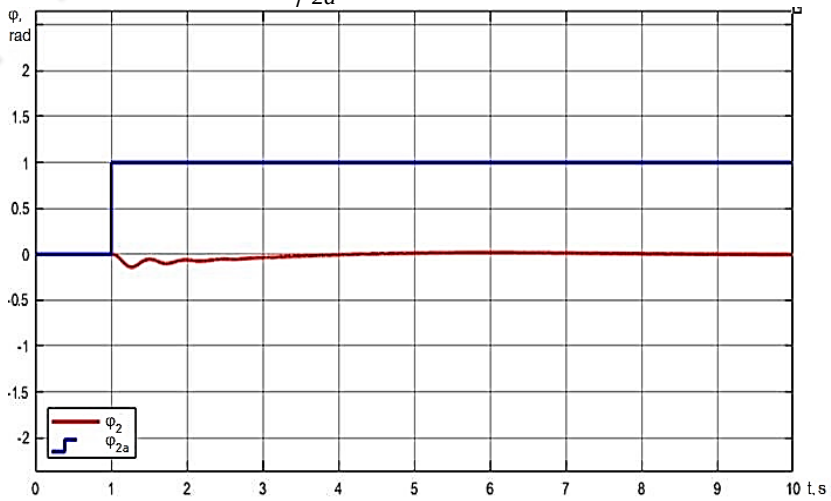


Figure 6. Transients in a stepwise positional task φ_{2a}

Where 1 - position assignment of φ_{2a}, 2 - position of the second mass φ_2.

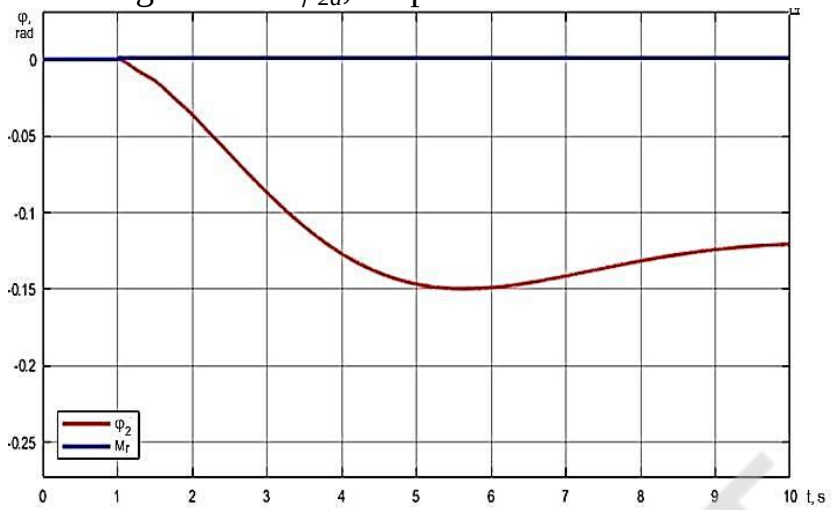


Figure 7. Transients when applying the moment resistance M_r

Where 1 - moment of resistance M_r, 2 -position of the second mass φ_2.

This regulator is difficult to implement, does not cope with either the moment of resistance M_r, or position assignment of φ_{2a}, and therefore its use is not advisable.

Development of a discrete filter

Before developing the PID controller, it was decided to create a discrete filter for the position assignment signal of the second mass φ_{2a}, due to which the input of the regulator will not get a stepwise signal, but a little smoothed, which will allow eliminating abrupt jumps and strong rocking of the second mass.

Discrete filter can be described by the first-order factor and software implementation by the following formulas:

$$FM = FM + \varphi_{2a} - OF, \tag{9}$$

where FM - filter memory;

φ_{2a}- position assignment of the second mass;

OF - output of the filter is equal to:

$$OF = FM/KF, \tag{10}$$

where KF- coefficient of the filter, $KF = 512$.

This filter was software-implemented by C programming language.

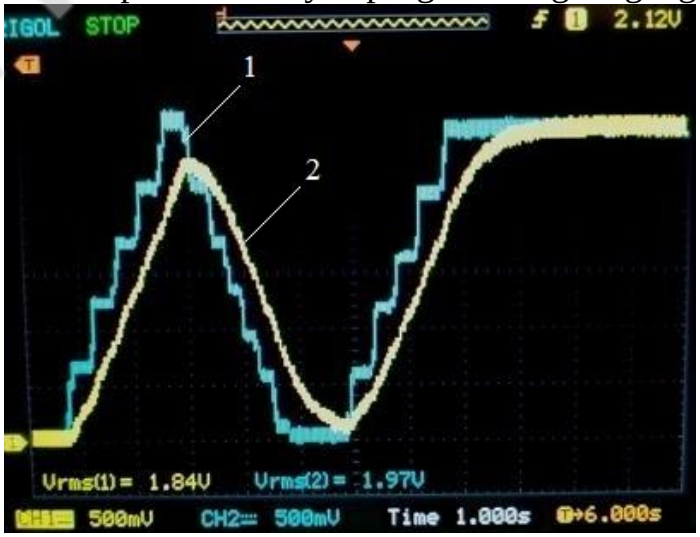


Figure 8. Discrete filter flow chart

Where 1 - input signal, 2 - output signal.

The figure shows a chart of a discrete filter taken by an oscillograph.

Development of PID controller

A PID controller is a device used in control circuits equipped with feedback circuits. These controllers are used in order to generate a control signal in automatic systems where high quality and precision of transients are required [19].

The control signal of the PID controller is obtained as a result of the summation of three components: the first is proportional to the value of the deviation signal, the second is the integral of the deviation signal, and the third is its derivative [20].

The PID controller is described by the following formula [21]:

$$u(t) = P + I + D = K_p e(t) + K_i \int_0^{\tau} e(t)dt + K_d \frac{de(t)}{dt}, \quad (11)$$

where $u(t)$ - output;

P - proportional component;

I - integral component;

D - derivative component;

$e(t)$ - current error;

K_p - proportional coefficient;

K_i - integral coefficient;

K_d - differential coefficient;

For C software implementation, this formula has been converted to the following:

$$u(t) = P(t) + I(t) + D(t) \quad (12)$$

$$P(t) = K_p \cdot e(t) \quad (13)$$

$$I(t) = I(t-1) + K_i \cdot e(t) \quad (14)$$

$$D(t) = K_d \cdot [e(t) - e(t-1)] \quad (15)$$

Setting the PID controller using a mathematical model

The mathematical model shown in Figure 4 was transformed in the following way. The discrete filter described by the first-order factor:$\frac{1}{0,25s+1}$, PID controller and an aperiodic link that takes into account the discreteness of the physical controller $\frac{1}{0,05s+1}$ were added. In addition the factor that allows usage of the programmable PID controller settings on a physical object in a controller created in MatLab Simulink was calculated.

The coefficient is equal: K = 2000/1080,

where 2000 - number of impulses of the encoder of the second mass half-turn;

1080 - number of impulses of the encoder of the first mass half-turn, including the gearbox.

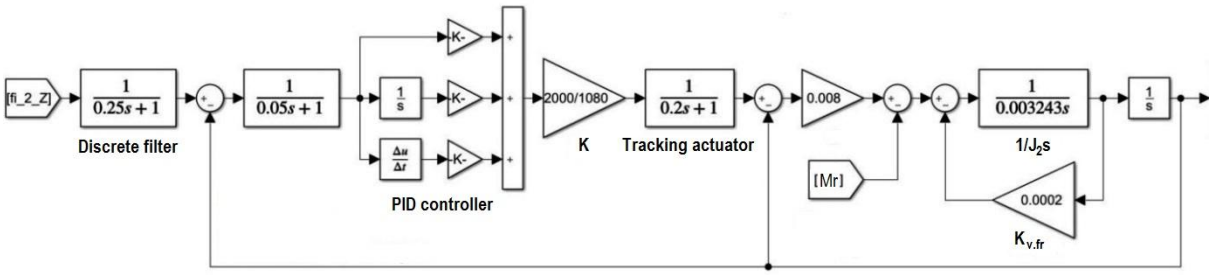
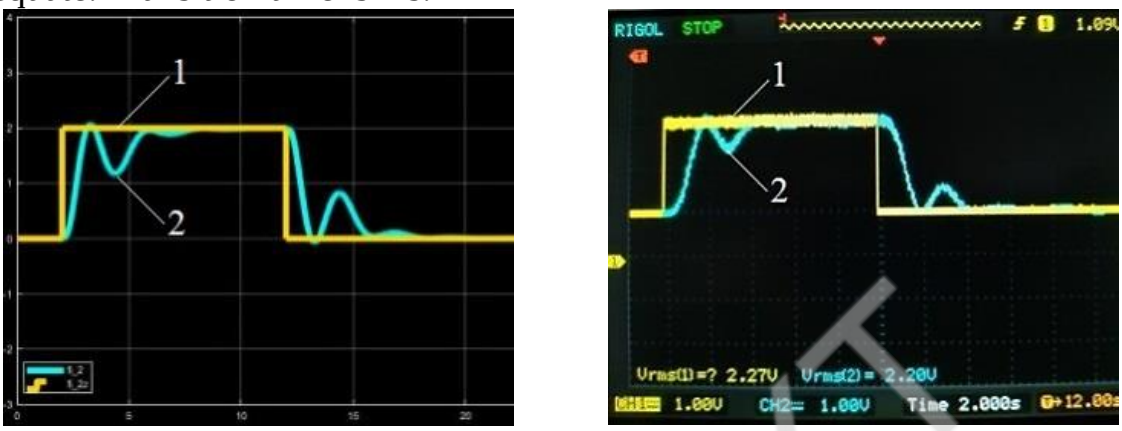


Figure 9. The updated mathematical model of the positioning electric drive of the two-mass system.

Using this mathematical model, the coefficients of the PID controller were found: $K_p = 1/2$, $K_i = 1/37$, $K_d = 10$ and were implemented into the physical model. Figure 10 shows the charts of working out the assignment signal by positioning drive.

The graphs of transients are very similar, and therefore this developed mathematical model is adequate. Transition time is 4 s.



a b

Figure 10. The charts of the signal of the second mass position φ_2 and the position assignment φ_{2a}: a - mathematical model, b - physical model.

Where 1 - position assignment, 2 - position of the second mass.

Figure 11 shows the charts of the transients of the position of the first φ_1 and the second φ_2 mass. They describe how the motor implements the assignment of the PID controller φ_{1a}.

a b

Figure 11. The charts of the transients of the position of the first φ_1 and the second φ_2 mass: a - mathematical model, b - physical model.

Where 1 -position of the first mass, 2 - position of the second mass.

The charts show that the motor of a physical object has certain limitations and doesn't have time to complete the assignment of the PID controller φ_{1a}, as the motor of the mathematical model.

The following was tested for the ability of the system to withstand disturbing effects in the form of 4 fans, which are shown in Figure 1, item 5.

To show the effect of the moment of resistance M_r on the system, Figure 12 shows the chart of the output signal of the physical object second mass φ_2 position when the motor is switched off and when M_r is applied:

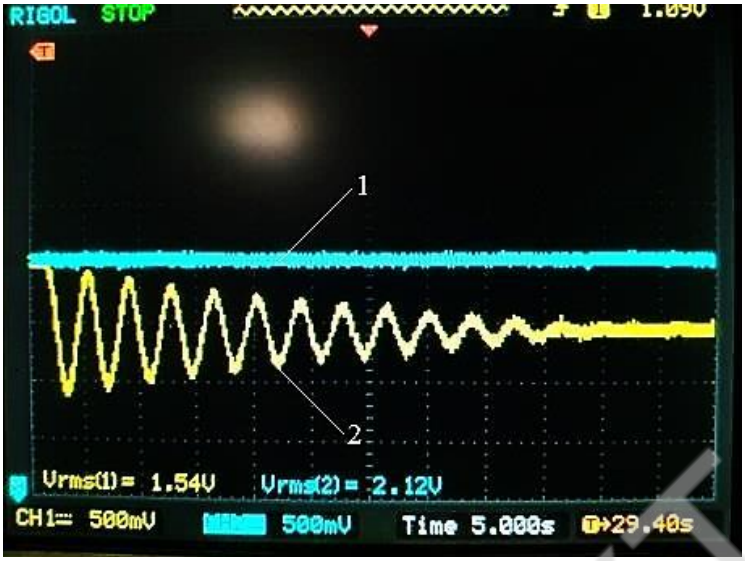


Figure 12. The chart of the second mass φ_2 position signal when the motor is switched off and when the moment of resistance M_r is applied.

Where 1 - position of the first mass, 2 - position of the second mass

Figure 12 defines the moment of resistance M_r forming by the fans according to the formula:

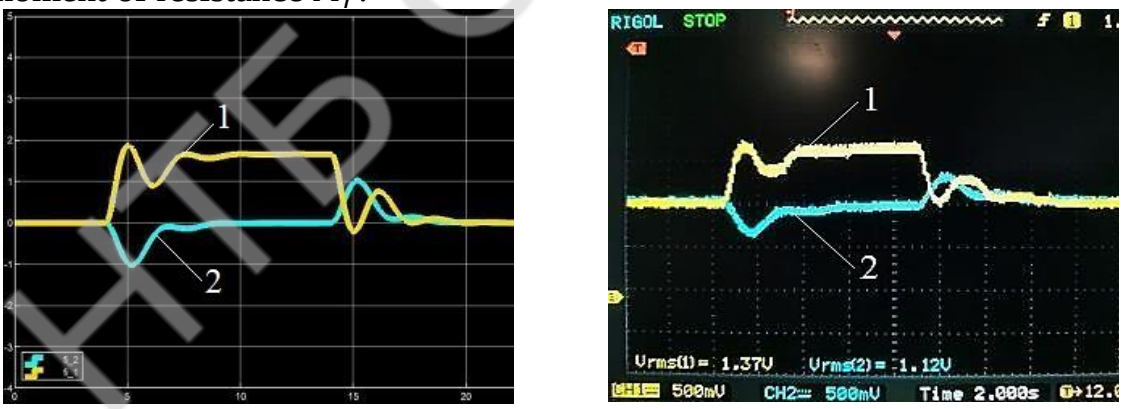
$$M_r = c \cdot 1{,}658, \quad (16)$$

where c - the stiffness of the elastic linkage, c = 0,008

1,658 rad. - deviation 95º of φ_1 from φ_2 when applying a moment of resistance M_r.

M_r = 0,0133

Figure 13 shows the charts of the transients with the motor running and when applying a moment of resistance M_r.



a b

Figure 13. Graphs of the transients of the position of the first φ_1 and second φ_2 masses with the motor running and when applying M_r: a - mathematical model, b - physical model.

Where 1 - the position of the first mass, 2 - the position of the second mass.

As can be seen from the charts, the set position is restored in about 2 s.

V. Conclusions

1. The usage of the single-mass electric drive in the internal circuit of the positioning dual-mass electric drive allows the simplifying of the controller synthesis and reducing the required computational power in the simulation by presenting the tracking actuator with a first-order factor.

2. The simulation model of positioning actuator, the adequacy of which is confirmed by a physical experiment, together with the stand can be used in the study of closed-loop dual-mass systems of DC electric drive with microprocessor control.

3. The controller synthesized by the classical method has a low practical value due to the complexity of its implementation, which is conditioned by the high polynomial degree of the transfer function.

4. The usage of mathematical model in the practical method of finding the values of PID coefficients provides the desired static and dynamic characteristics of the system, reduces the searching time and decreases the risk of real equipment damage during debugging.

5. Further research is planned to be led in the direction of increasing the system performance both by improving the dynamic characteristics of the tracking actuator and by refining the mathematical model that will allow obtaining more accurate values of the PID coefficients.

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3D-MODELING OF THE INTERIOR OF THE ROOMS BY CLOUD TECHNOLOGIES

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Abstract. *The work considers the possibility of using 3D-modeling technology for interior design of restaurant premises; criteria were determined and on-line applications designed for 3D interior design were compared, their advantages and disadvantages are defined. The example of one of the on-line services describes how to design an interior project for a pop art youth café.*

Keywords: *cloud technologies, 3D-modeling, room interior, design, visualization.*

Introduction

In the research of current conditions of economic development of Ukraine, an important place given to small and medium-sized businesses, which play a significant role in the formation of enterprise. Foreign experience of doing business shows that it is the medium and small business sector that is the most widespread, flexible and dynamic form of business [10, 15]. However, despite the fact that the effective activity of small and medium-sized enterprises has a significant impact on the economic growth of the country, provides employment and directly improves living standards, Ukrainian entrepreneurship faces a number of problems the hinder its development.

Along with such problems as the general state of the Ukrainian economy monopolization of business, imperfection of the tax system, instability of business conditions, etc. – there is a problem of lack of sufficient starting capital, own financial resources, raw materials, premises and equipment for starting a business [10, 15]. To solve this problem, entrepreneurs usually try to save money on attracting specialists of a certain profile – independently search for professional information, personally perform job responsibilities in several positions, and even perform the selection of premises and develop their design.

Small and medium-sized service businesses are owners of small cafes, coffee shops, bars, and the like. Designing a room is one of the main expense items in organizing their business. An important factor that will save on this article is the current state of information technology development, and especially – the emergence of professional cloud services in the field of room design. Architects and designers have long been using paper, ruler and pencil to make plans. This process has become easier and more productive with the help of computer software for interior design.

The purpose of the work is software modeling of the interior of the youth café and its elements in the style of pop art, as well as visualization of the developed model.

Therefore, as a ***research object*** in our work, we will choose the process of 3D modeling of the interior of the premises.

The subject of the research is the possibilities of on-line programs for the development of 3D project of the room design.

The objectives of the research will be:

1. Exploring the features of 3D interior modeling technology.
2. Comparison of on-line applications designed for 3D interior design, identifying their advantages and disadvantages.
3. Design of the project of the youth café hall with the help of on-line program for 3D modeling of the interior of the premises.

The methods of research will be literature study, analysis, comparison and modeling.

1 Analytical review of literature

In the 21st century, the development of modern information technology is gaining momentum – no field of activity can do without information technology, and architecture is no exception. Interior designers, as representatives of this field, usually use serious software to create their projects, which uses sophisticates graphical data analysis algorithms and requires powerful computers with advanced input and output devices.

A review of contemporary literature on 3D interior design shows that AutoCAD and Autodesk 3D-MAX are the most sought after in the industry. These software products provide a complete cycle of designing buildings – from the drawing of the foundation, the floors, walls and engineering communications to the furnishing of premises and their filling with design elements. In the works of S. R. Dundyak [11], I. N. Egorova, A. V. Gaidamashchuk [12], I. O. Kuznetsova [13] and other scientists who research the possibilities of architectural CAD for interior design of premises, there is a clear argument that working with these packages requires a high level of user training. However, the use of high-grade CAD is not always justified – in cases where architectural tasks are not systematic or there are no computers with the necessary power or equipment – there is no need to spend money on the purchase of CAD systems, their installation and maintenance. A research of three-dimensional interior and exterior modeling environments using the Lee J. research [4] shows that there are many on-line services that do not need to be downloaded in today's Internet environment and storage of gigabytes of data. According to RBC-Ukraine, in 2017, almost half of Ukrainian companies used cloud technologies [1], and Forbes estimates that almost 83% of companies worldwide will use clouds in 2020 anyway [14]. The current state of development of cloud services gives the business powerful enough opportunities to modernize its work. First, the use of cloud technology can significantly reduce the operating costs of equipment and software, and secondly – if you have access to the Internet access to work information from anywhere in the world [1; 14].

2 Comparative features of on-line services for modeling interiors of rooms

To analyze the services that allow you to model the interior of the premises on-line, the following programs have been selected:

– *Roomstyler* is a free-of-charge on-line interior design service that allows you to choose your modeling accessories (furniture, flooring, walls, décor, etc.) without limitation. In addition, you can add to the benefits that the program can not only design and style a room, but also look for inspiration, because Roomstyler also functions as a book viewer with tens of thousands of designed rooms already on the net. The application's interface is easy to use and allows you to view both plan and 3D images. To

get started, you need to sign up; you can do this with a Facebook account, because the program is closely link with social networks [8];

– *Planer 5D* is a free web application designed for the design of premises. The design can be show in 2D and 3D. Now the user has the opportunity to erect walls from scratch and fill the premises as they wish, or edit the finished works, which can be select from the existing gallery. Planner 5D has a Russian-language interface and is very easy to use. A significant drawback of the program is that not all furniture is free. Most furniture is pay, so choice of filling for the room is very limited for the average user [6];

– *Sweet Home 3D* is a freeware computer program designed to simulate and visualize different purpose spaces. The program interface has a large number of languages, including Russian. It is quite easy to work in the program, in the main window there are several fields: the current project in the form of a plan, 3D visualization and elements for interior design [9];

– *Homestyler* – a free room modeling software. You need to sign up before you go to work. From this resource, you can be acquainted with the works of other users and professional designers, thus finding inspiration for your own project. The program has an English interface; it is quite easy to use. With Homestyler you can easily create a floor plan of the project and fill the room with any furniture and décor, because in addition to the material offered by the program, users have the opportunity to download their own textures and furniture [2];

– *Roomle* – an on-line service for the design of premises. The program has an English interface, but in is easy to use, so there should be no difficulty with translation. A large number of “icons” guide users in the process of creating their own project. The disadvantage of the service is the low quality of 3D rendering [7];

– *Floorplanner* – a freeware application for designing floor plans for a future building. The program has an English interface. First, the user should replace the measurement system with a metric using the option at the bottom of the screen. With the program, you can design any room, save or print the project, having previously passed a free registration. The major disadvantages of the program are the ability to consider only the first floor, not the frame structure and the ability to create only a general scheme of the house, and for the drawings of the frame building need to use other programs [3];

– *Plan Your Room* – a free application for on-line design of the room. The interface is English and easy to use. User registration is only required if you want to save the project. The major disadvantages of the program are that the choice of furniture is limited and the tools of the program can be difficult to use. Plan Your Room is quite poor in function: it is impossible to change the style of the floor in the design, there is no choice of color for the objects, and there is no "cancel" button [5].

The following were the main criteria against which the functionality of the software was compared:

– basic requirements for the hardware of the computer on which the simulation will take place;
– equipment for modeling;
– possibility to download external textures;
– possibility to download external models (furniture, décor, etc.);
– the presence of built-in visualization tools (rendering);

- format conversion (import and export files from other applications);
- access from mobile devices;
- trial version and its limitations;
- availability of training materials (tutorials);
- providing feedback, technical and service support to users.

A detailed analysis and results of an on-line services study of the 3D interior design of the room are present in Table 1.

The analysis found that the most convenient and advanced on-line services for interior design is a cloud environment Homestyler. Its complete range of modeling tools is the most comprehensive and versatile: unlike other services that allow only floor and wall modeling, Homestyler has designed tools for designing arches, ledges, niches, and more. Window and door model kits are consistent in style and color.

The design of the rooms is done through wallpaper libraries, ceramic tiles, wood elements, painting elements and friezes. The library of furniture and decor is sufficiently extensive and logically structured – there are separate directories for the design of the kitchen, bedroom, living room, office and other premises. A library of decor and art materials has been develop separately, with a large number of design elements (window accessories, paintings, photo frames, statuettes, houseplants, etc.). The collection of lamps, sconces and floor lamps is quite harmonious and at the same time diverse.

The great advantage of this program is the ability to download and save in the library user external (developed in other applications or downloaded from the Internet) textures and 3D models (furniture, decor, etc.).

Built-in rendering tools allow you to create high-quality renderings and a virtual 3D tour of the developed project (in HD format with a resolution of up to 2560x1440 pixels).

Table 1 – Comparative characteristics of cloud services for 3D interior design

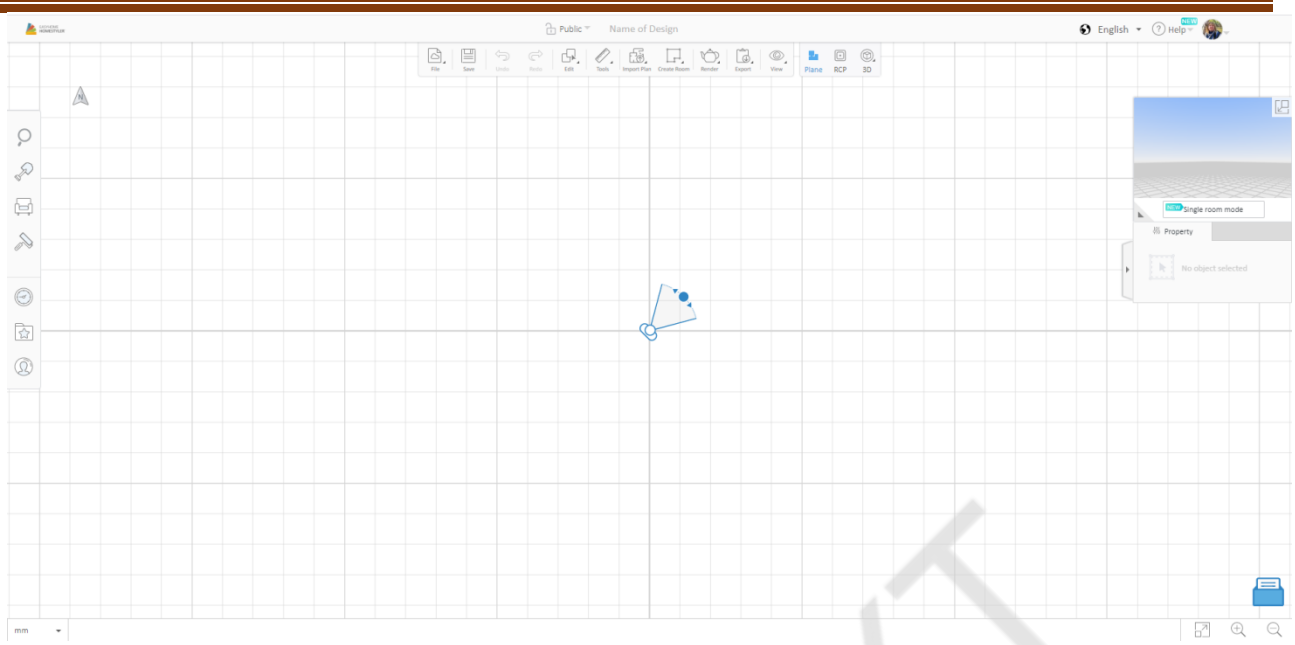
Criteria	Programs						
	Planner5D	Roomstyler	Sweet Home 3D	HomeStyler	Roomle	Floorplanner	Plan Your Room
1	2	3	4	5	6	7	8
Access to the program (links)	https://planner5d.com/ru/	https://roomstyler.com/3dplanner	http://www.sweethome3d.com/	https://www.homestyler.com	https://www.roomle.com/	https://floorplanner.com/	http://www.planyourroom.com/
Developer	Planner 5D LLC, Russia	Floorplanner, Netherlands	eTeks, France	EasyHome, China	Austria	Floorplanner, Netherlands	No information available
Interface language	Russian	English	Russian	English	English	English	English
Trial version and its limitations	+ Limited selection of equipment for modeling, it is impossible to make a project renderer	-	-	+	-	+ The inability to make multiple floors in one project, the choice of equipment is not wide enough, the lack of 3D-tour, the image quality is not high	-
Basic requirements for the hardware of the computer	RAM is at least 2GB (better than 4GB), processor not less than 2 GHz, video card availability						
Tariff packages	269,14 – 1346,77 UAH/month	-	No information available	-	-	606,06 UAH/month	-
Format conversion (import and export files from other applications)	There is no export in the free version	Export: 2D image (jpg)	No information available	Export: DWG project, floor plan	Export: 2D image (png)	Export: 2D image (jpg, png)	No export
Access from mobile devices	+	-	-	+	+	+	-
Availability of training materials (tutorials)	+	+	+	+	+	+	-
Providing feedback, technical and service support to users	+	+	+	+	+	+	+

1	2	3	4	5	6	7	8
Equipment for modeling:							
floors of rooms	+	+	+	+	+	+	+
walls of rooms	+	+	+	+	+	+	+
arches, speeches, niches, etc.	+	+	No information available	+	+	-	-
interior of the premises with the help of furniture	In the free version, not all furniture is free	+	+	+	+	+	+
interior with decor	In the free version, not all décor items are free	+	+	+	+	+	-
Possibility to download external textures	+	-	No information available	+	+	-	-
Possibility to download external models (furniture, décor, etc.)	-	-	No information available	+	-	-	-
The presence of built-in visualization tools:							
rendering	In the free version its missing	+	+	+	+	+	-
creating a 3D-tour	In the free version its missing	-	-	+	+	In the free version its missing	-

3 Interior development of youth café in pop-art style at homestyler

The design environment is download at https://www.homestyler.com. The environment requires authorization for the development of the project; the authorization is not required to familiarize with the gallery of works and video instruction on working with the environment.

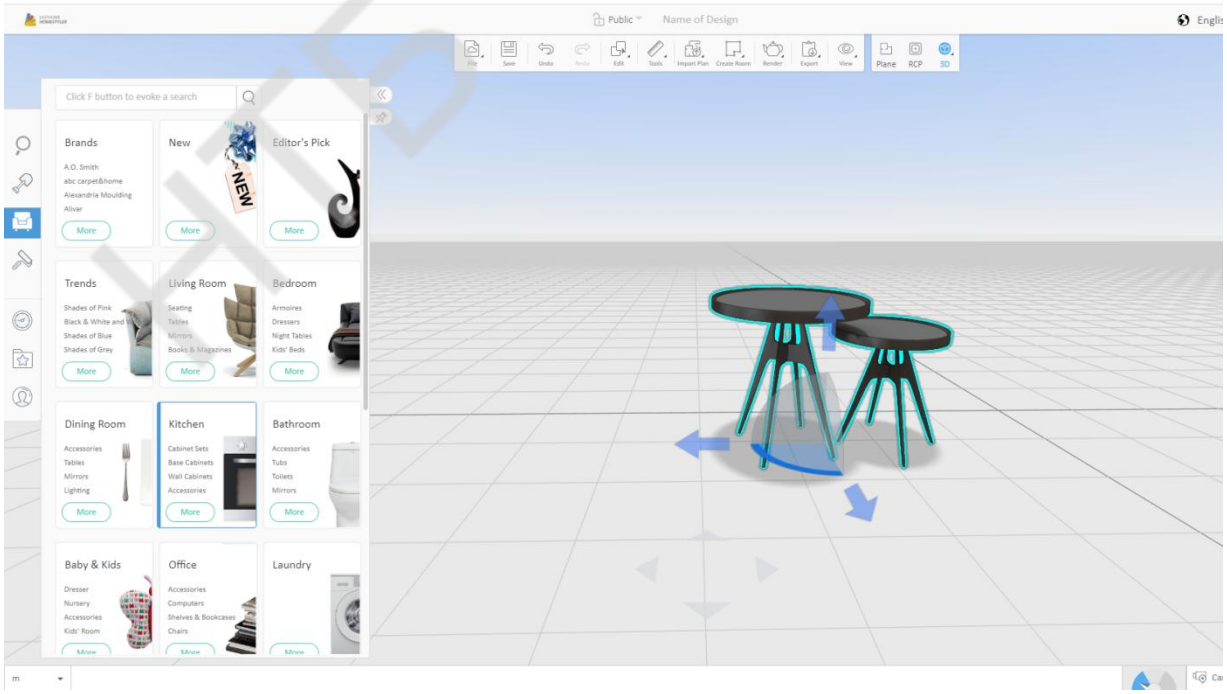
The working field is an unlimited plane, which for convenience has a virtual dimensional grid (Pic. 1). The toolbar contains commands for working with project files (download, save, customize, etc.), to build walls of future premises, to export and import a project, to render and view it.



Pic. 1 – Homestyler workspace

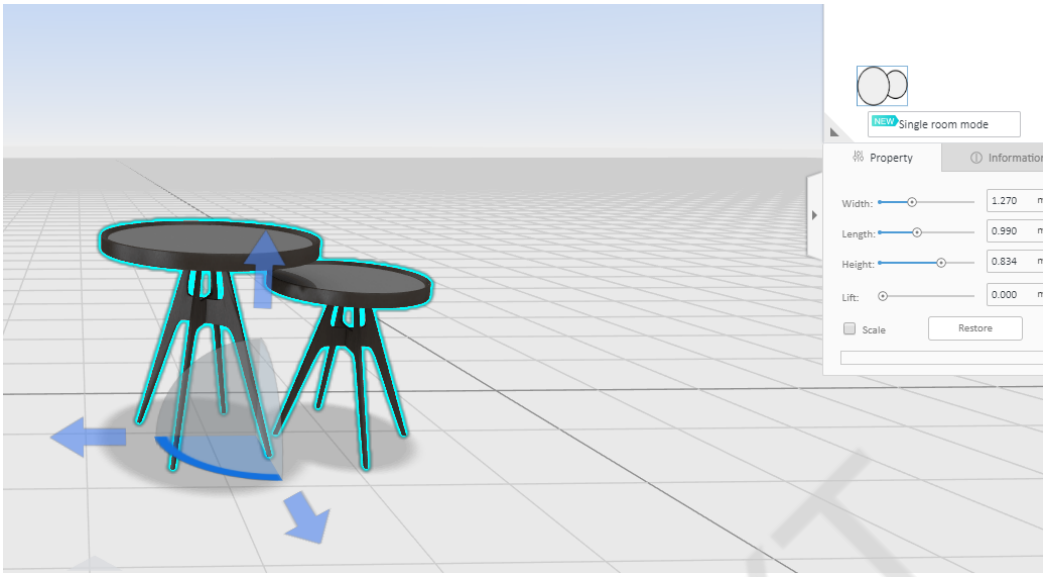
In the center of the worksheet is a visualization tool (in the form of a camera) that allows you to see the simulation results in 3D at once. It is enough to move the camera along the lines of the project with the mouse (the corresponding window is located in the upper right corner of the worksheet). The button  is switch between the display modes of the room layout and its 3D model.

The library (catalog) of models of building elements (doors, windows, arches, etc.), furniture and style design of the room is located on the left edge of the worksheet (Pic. 2). This library also has a directory where the user can store external textures and elements.



Pic. 2 – Catalog of Homestyler built-in models

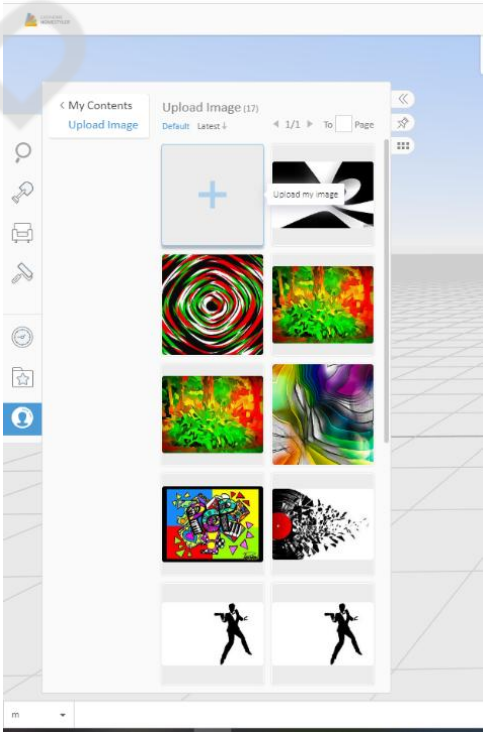
Each built-in model has properties that can be change at the user's request (Pic. 3).



Pic. 3 – Setting element properties

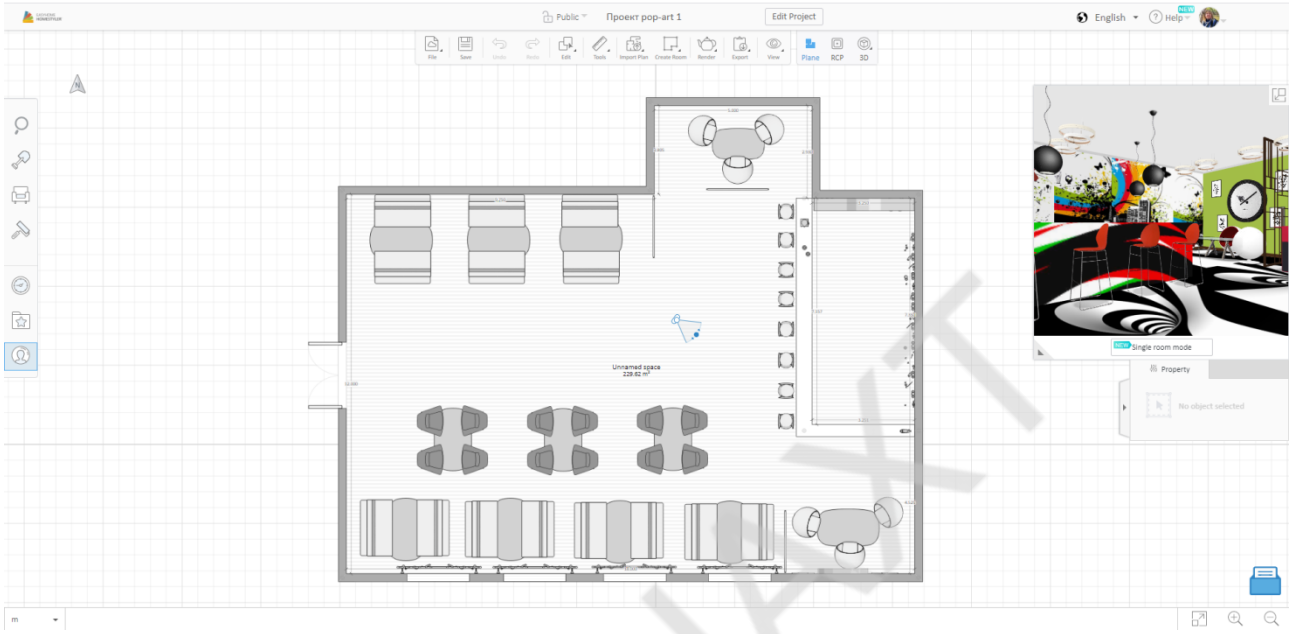
The modeling of a youth café room begins with the establishment of its properties (ceiling height, wall thickness) with the *File → Preferences* tool. The next step is to build the exterior and install the interior walls. Doors and windows of the future room are select from the *Building →Doors* and *Building → Windows* directory respectively. Their properties (width, height. Level relative to the floor), the direction of opening are set using the appropriate menu.

The next stage of modeling is the choice of wall, ceiling and floor coverings. A set of matching textures is located in the *Style* directory. Unfortunately, for pop-art design, the embedded textures were not enough. Therefore, the necessary textures were downloaded with the help of the *My contents → Upload image* (Pic. 4).



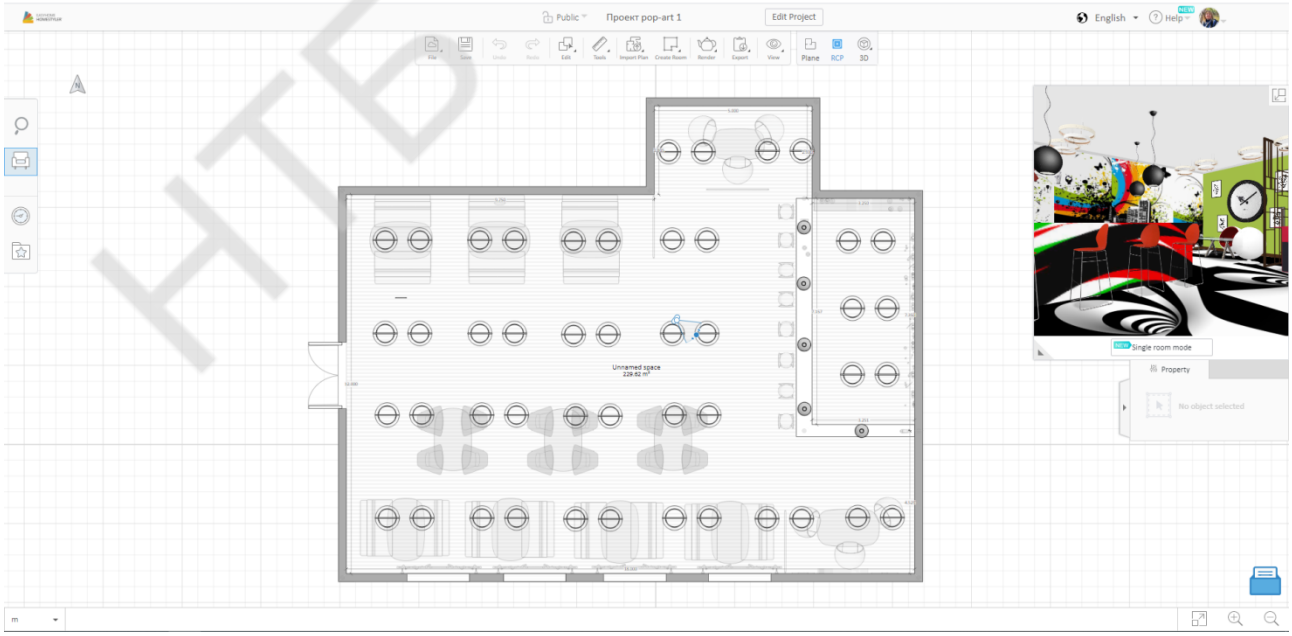
Pic. 4 – Loading external textures

The selection and installation of furniture and accessories, as well as the construction of the composition of the future room is done using the tools (commands) of the *Catalog* menu. This is a painstaking, time-consuming job, so the user must periodically save the project (*File* → *Save*...). The result of planning and furnishing a 2D room is show in pic. 5.



Pic. 5 – General view of the project (in 2D mode)

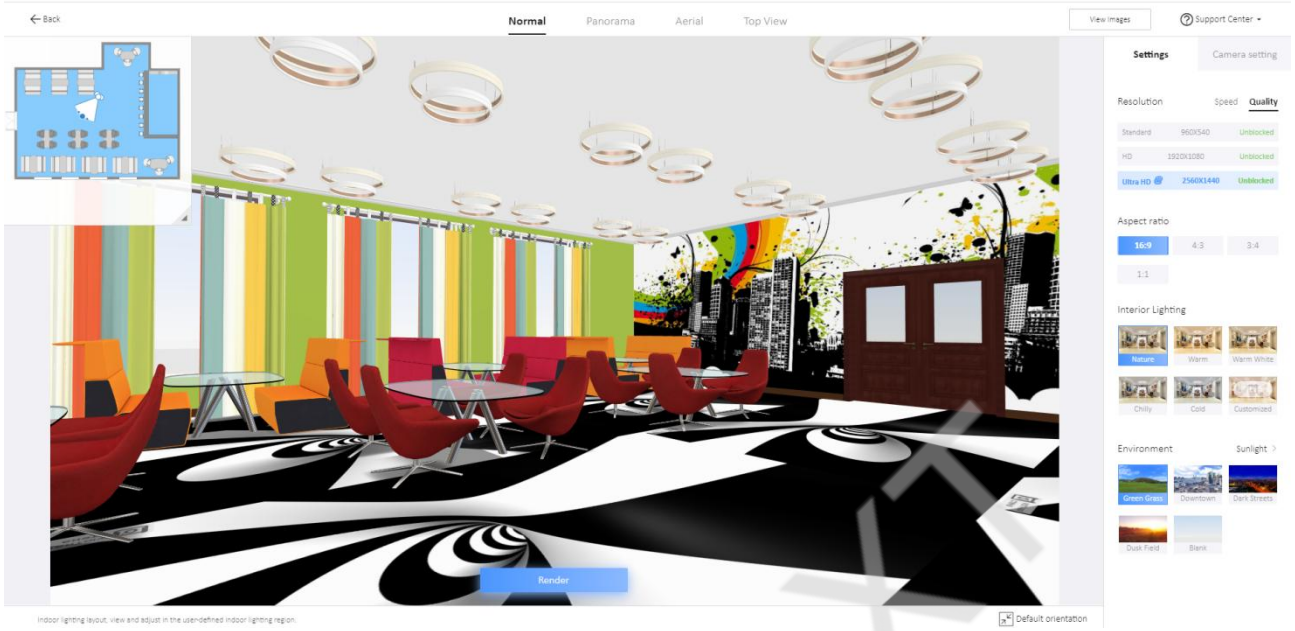
For ease of adjustment of the room lighting parameters, it is necessary to translate the project worksheet into RCP mode (Pic. 6) – in this mode, it is possible to place light fixtures with appropriate precision and scaling.



Pic. 6 – RCP mode to adjust the room lighting

3D project rendering is done using built-in rendering tools. To provide quality visualization, the user can choose from four modes of image quality (800x600… 2650x1440), one of six Interior Lighting (Nature… Customized) modes and one of five Environment (Green Grass… Dusk Field) modes. In addition, due to the flexible settings

of the camera (change of height, angle of view, radius of coverage of the room), it is possible to realize the highest quality of visualization (Pic. 7 and Pic. 8).



Pic. 7 – Visualization tools configuration menu

Pic. 8 – Camera settings panel

The result of rendering a 3D model of a room is stored in the user's personal account on-line and can be download from it to any media in .png format.

The development of a virtual 3D tour of the project takes place in two stages – first, it is necessary to form panoramic images, which will later become the basis for the 3D tour. To create panoramic images, you must place the camera where it will rotate and take steps to adjust the image quality. Panoramic images are combine into a 3D tour using the *Render → Create 720° Virtual Tour* command.

The result of modeling a pop-art hall in a youth café is show in Pic. 9 and at the link: https://www.homestyler.com/floorplan/?assetId=2709272b-bb15-414a-bf83-5c9c809d85d3

Pic. 9 – The result of the interior design of a pop-art youth café

Conclusions

In the general term, 3D modeling is the process of converting any surface of a 3D object from drawings, drawings, photographs, or imaginations into digital electronic representation through mathematical operations. The ultimate goal of interior design is to develop a virtual three-dimensional model that can be view from all sides to have a realistic picture of the future object, to predict the quality of the changes made (reconstruction) to the future design, to select furniture and design, and so on. Modern information technologies allow you to perform 3D modeling of the interior of the premises without the involvement of expensive resources.

To this end, approaches to building 3D models of premises have been consider during the work, features of 3D interior modeling technology have been studied, and applications have been selected to enable this task to be accomplished through a cloud-based online environment.

As a result of a comparative analysis of selected on-line programs designed for 3D modeling of the interior of the premises, exploring their advantages and disadvantages, it was determined that the most modern, sophisticated, convenient and containing the largest model libraries for interior design, as well as meeting modern 3D modeling requirements, is the https://www.homestyler.com, software product developed by China's EasyNome campaign. Homestyler.com tools have implemented a pop art interior design for a youth cafe.

Today, architectural visualization is an emerging area of 3D modeling. Creating a photorealistic image of a project is a time requirement that must ensure a modern level of presentation of the design results, and to which reasonably high criteria are applied. Therefore, the software environment used in this field should ensure the effectiveness of the developer's actions by being able to draw attention to many of the smallest details.

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RESEARCH AND IMPROVEMENT OF 3D PRINTING WITH ABS PLASTIC USING FDM TECHNOLOGY

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Abstract*. The paper describes the main problems that may occur when 3D printing on printers using FDM technology. A literature analysis of the effectiveness of the use of volume printing in various industries is carried out, the sources of the difficulties encountered in printing with plastic are shown, the main difficulties of the process are listed.*

Various solutions to emerging problems have been proposed, based on the operating experience of the Smartprint HB-8 household 3D printer, implemented on the basis of the common Arduino Mega board. Various cases of ineffective 3D printing are considered, recommendations for its elimination are developed. The presentation is accompanied by original photographs of problem cases and scans of the slicer operation screen when solving such problems.

Keywords*: 3d model, 3d printer, ABS-plastic, PLA-plastic, G-code, Slicer, FDM technology, .STL format, Arduino, Rep-Rap, Raft substrate*

1. Introduction

3D printing and 3D printers in our lives have already moved from the category of fiction to the category of domestic use. Indeed, quite a few companies offer to make an original birthday present in the form of a birthday bust, a broken plastic part in a car is much cheaper to make on a 3D printer made of plastic than ordered from a manufacturer or in a parts store.

Three-dimensional or 3D printing is a layer-by-layer creation of a physical object based on a virtual three-dimensional computer model. This is the ideal solution for creating models for design, architectural concepts, as well as products needed in the fields of education, art, medicine, cartography, etc.

FDM 3D printing technology involves the creation of three-dimensional objects by applying successive layers of material that follow the contours of a digital model. As a rule, thermoplastics supplied in the form of spools of thread or rods are used as printing materials.

The process of creating 3D models, even on modern printers using FDM technology, does not always go smoothly and flawlessly. This is to blame for both the design of 3D printers simplified for cheapness, the flaws of poor-quality plastic, incorrect settings for printing, and the mistakes made when creating models in a computer program.

This work is devoted to the analysis, research and solution of some problems that arise in the process of functioning of a 3D printer operating on the common FDM technology [7, 9].

2. Analytical review of literature

A 3D printer is a device that creates a three-dimensional object based on a virtual 3D model. Unlike a conventional printer, which displays information on a sheet of paper, a 3D printer allows you to display three-dimensional information, that is, to create certain physical objects. The technology of 3D printing is based on the principle of layer-by-layer creation (growing) of a solid model [1, 2, 3, 6, 7, 11, 12, 19]. 3D printing is performed using various materials (silicone, concrete, plastic, acrylic, hydrogel, paper, wood fibers, gypsum, metal, nylon, polymer or stone chips, etc.).

The use of three-dimensional printing is a serious alternative to traditional methods of prototyping and small-scale production. For example, to create any part manually, it can take quite a lot of time - from several days to months. After all, this includes not only the manufacturing process itself, but also previous work - drawings and schemes of the future product, which still do not give a complete vision of the final result. As a result, development costs increase significantly, the time period from product development to serial production increases [7, 11, 8].

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3D technologies can completely eliminate manual labor and the need to make drawings and calculations on paper - after all, the program allows you to see the model in all angles already on the screen, and you can eliminate the identified shortcomings not during the creation process, as happens with manual manufacturing, but directly during development and create a model in a few hours [1, 5, 11, 18].

3D printing has opened up great opportunities for experiments in such fields as architecture, construction, medicine, education, clothing modeling, small-scale production, jewelry, as well as in the food industry [4, 6, 8, 12].

Since the construction and modeling using 3D technology has become very common, many specialized software tools have been developed. The software that manages 3D printers accepts all major formats of files containing 3D geometry, including .stl .wrl .ply, and .sfx files; they can export all major 3D modeling packages [11, 12, 10, 19].

We should also dwell on the use of 3D-technologies in education. 3D printing technology is quite new, but it is developing really fast. More recently, rapid prototyping has been limited in schools, colleges, universities due to the high cost of equipment, supplies. But the technology of layer-by-layer build-up appeared, and designers are happy to use this technology for rapid prototyping and small-scale production [4, 6, 8, 19].

Using a 3D printer for students, it becomes possible to design objects that cannot be made even with 4-axis milling machines. In the past, students were limited in modeling and manufacturing things, since they had only hands and simple processing machines from production tools. Now, these restrictions are practically overcome. Almost everything that can be drawn on a computer in a 3D program can be implemented [5, 19].

Using a 3D printer in a classroom dramatically increases the effectiveness of training. Using 3D printing paves the way for iterative modeling. Students can design 3D parts, print, test and evaluate them. The use of 3D technologies inevitably leads to an increase in the share of innovation in student projects [5, 6, 8, 11, 18].

However, printing of volume models previously developed on a computer encounters numerous problems that are caused by the relative imperfection of the technology used, poor-quality plastic, and poor-quality three-dimensional models. This work is devoted to the analysis and solution of some problems that arise in the process of functioning of a 3D printer operating on the common FDM technology [13, 14, 15, 18, 20].

3. Object, subject and research methods

The purpose of the study: to experimentally investigate and improve the technology for printing models on household 3D printers that print with plastic using FDM technology, to develop recommendations for solving the most common printing problems.

Object of study: FDM technology for printing models using 3D technology.

Subject of research: development and printing of a 3D model using the Smartprint HB-8 consumer printer.

The Smartprint HB-8 3D printer, along with the Prusa i3 model, is a household representative of the Rep-Rap family of printers, developed as a project for open and cheap DIY products. For research, we used a 3D printer assembled on the basis of the common Arduino Mega board (Fig. 1).

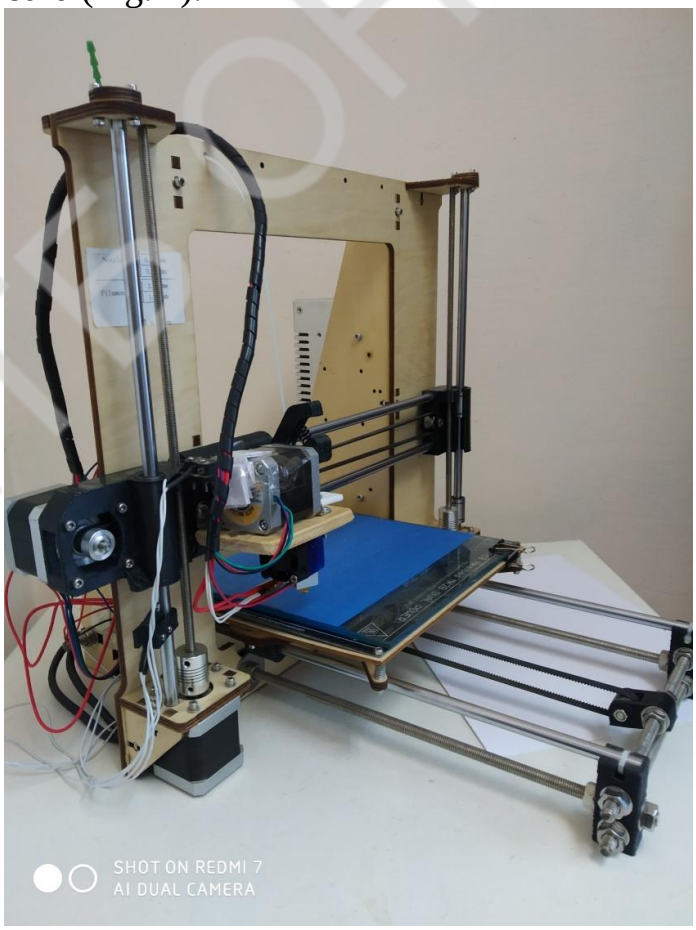

Fig. 1. - General view of the household 3D-printer Smartprint HB-8

4. Results of work

For the correct analysis of printing imperfections, it is necessary to clearly know the technology of model preparation. First, the volume model is created in one of the specialized programs that take into account the specifics of their further use (the most common ones are Rhino, Blender, 3D Max or SketchUp), after which its image in the form of a file with the .STL extension is transferred to a special slicer program.

Slicer is a program for translating 3D models into a control G-code for a 3D printer (the Repetier-Host program was used in research). In this case, the model is cut into layers, each layer consists of a perimeter and / or fill. The model may have a different percentage of filling with a fill, and there may also not be a fill (hollow model). On each layer, the printer extruder moves along the XY axes with the application of plastic melt. After printing one layer, the Z axis moves to the layer above, the next layer is printed, and so on [1, 2, 9].

It should be noted that today the .STL file format is widely used for printing, which contains the model by writing it in separate triangles (Fig. 2) [19]. At the same time, there are no curved surfaces, regions, and tori; all objects are approximated into figures consisting of many triangles. Slicer reads triangles from the STL file, cuts this set into thin layers, which eventually turn into separate movements of the printing carriage.

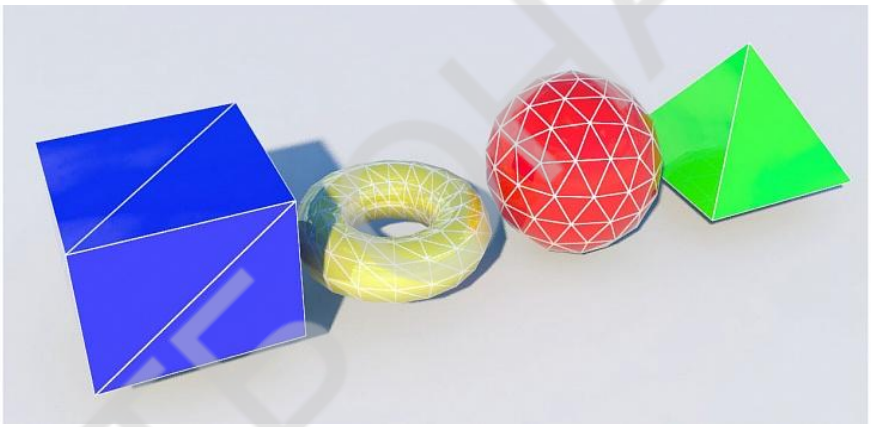

Fig. 2. - Illustration of saving a volumetric figure in STL format [19]

In studies, a 3D printer Smartprint HB-8 was used, which has the following main characteristics: printing dimensions 200 * 200 * 200 mm; interface - USB; printing material - ABS, PLA, PVA; filament diameter 1.75 mm; printing accuracy 0.1 - 0.2 mm; layer thickness 0.2 - 0.4 mm; number of nozzles - 1; nozzle diameter 0.4 mm; temperature of the support stand 110-120^{o}C; extruder temperature 210°C for PLA, 230°C for ABS; spindle speed 40 mm / s; nozzle flow rate 24 cm3 / hour.

FDM technology is highly flexible but has certain limitations. Although the creation of overhanging structures is possible at small angles of inclination, in the case of large angles, the use of artificial additional supports. These supports are typically created in the process of slicing and printing, and are separated from the model at the end of the process.

In addition, various problems may arise during the printing process itself. They can be caused by incorrect print settings, hardware problems, lack of practical experience with a 3D printer. Basically, such complications include the following: insufficient adhesion, displacement or absence of some layers in the model, holes and slits on the upper surface

of the printout, displacement of layers, formation of spider webs between model elements, absence or poor printing of the internal structure of the model, gaps between filling and walls.

Most of these problems can be corrected with the appropriate model location and the correct settings for printing and slicing in the Repetier-Host program (setting the correct temperature, starting point, printing speed, separation of the technology for passing individual layers, etc.). The recommendations described below were obtained during experiments when printing 3D models with the Smartprint HB-8 printer using ABS and PLA plastic.

The list of printing problems and recommendations for solving them:

1. Inadequate adhesion (the model does not adhere well to the 3D printer table (Fig. 3). The deformation of the base of the printout is due to the characteristics of the plastic, as the ABS and PLA plastic cools very quickly, which leads to the sticking of the first layer. Solution : recalibrate the working platform, reduce the gap between the nozzle and the 3D printer table; apply special materials on the platform for better adhesion: kapton, blue adhesive tape or special glue; use an additional Raft substrate (removable layer); reduce the print speed first layer to 30% (Fig. 4), set the initial temperature of the heated platform to about 100 ° C - 110 ° C.

Fig. 3. - Illustration of poor adhesion of the first layer to the platform

In general, experiments showed that the temperature of the platform when printing should be about 100 ° C (the model adheres well to it), and after the end of the process - about 70 ° C (otherwise the model cannot be removed without damage from the platform). It is also effective to turn off the cooling fan at the beginning of printing, for the first 3-4 layers.

You also need to choose the correct height of the first layer of printing (First layer height), which should be less than the height of the other layers, because the first layer should be distributed horizontally, if it is too high, it can affect the print quality of subsequent layers (Fig. 5). In general, the Layer height value should not be larger than the nozzle diameter of your printer, otherwise the print quality will be rough.

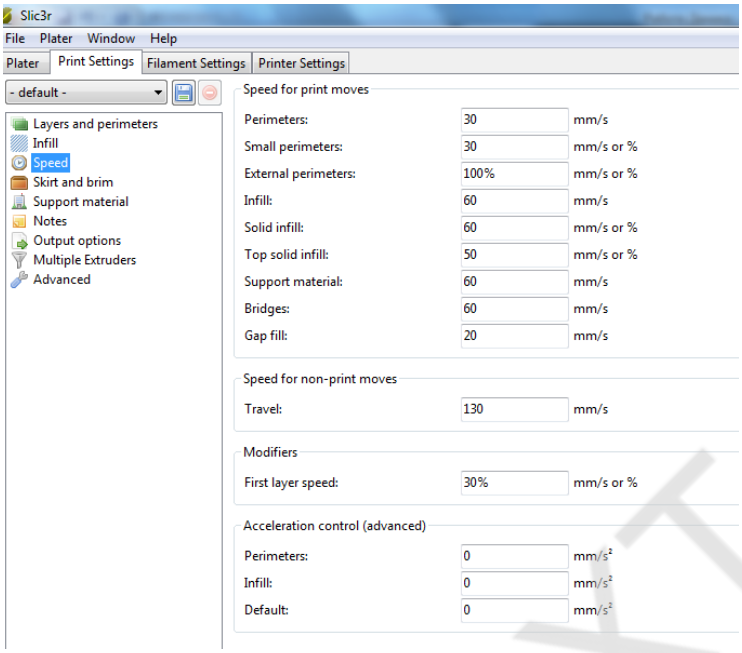

Fig. 4. - Print speed settings in the Slic3r slicer (Repetier-Host program)

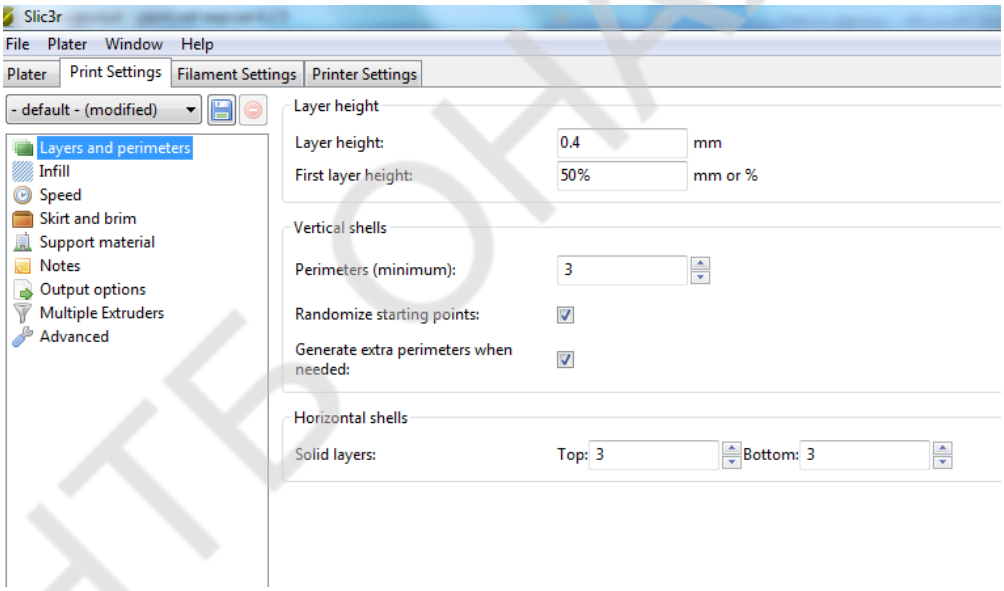

Fig. 5. - Illustration of setting layer heights when printing

2. Displacement or absence of some layers in the model (Fig. 6) - insufficient extrusion. In this case, it is necessary to check the tension of the belts (Fig. 1), moving both the extruder along the X axis and the platform along the Y axis: they should not hang freely, but also should not be too tight. It is also necessary to check the oil lubrication of all rubbing parts of the printer. Checking the extrusion coefficient in the slicer (or flow rate) may help, it may be too small. It is also necessary to check the correspondence of the diameter of the thread to the characteristics of the printer (there were cases when the set diameter of the thread did not correspond to the diameter set in the slicer). Also, insufficient extrusion can provoke a clogged nozzle.

Fig. 6. - Illustration of offset layers in the middle of the printout

3.Holes and crevices on the upper surface of the printout (Fig. 7). The two most common causes of this problem are improper cooling of the top layer and an insufficiently thick top layer. The solution is to increase the thickness of the top layer, which can be adjusted in the slicer using the advanced settings 'Bottom / Top Thickness setting'. It is necessary to increase the thickness of the upper and lower layers up to 6 times in comparison with other layers and up to 8 for smaller nozzles and plastic. If the layer height is 0. 1mm, then the height of the upper and lower layers should be 0.6 mm. If you still have holes and bald spots in the top layer, you need to increase the thickness to 0.8mm.

Fig. 7. - Illustration of holes on the top of the printout

4. Offset layers. The upper and lower layers are shifted, creating the effect of a step in the printout (Fig. 8). There can be many reasons for the shifting of the layers - even a jolt of the printer during printing can provoke this. Also, this may be affected by bent or incorrectly aligned studs, a nozzle that touches the printout and moves it on the platform,

etc. Solution: the printer should be on a stable stand; the printer platform must be securely fixed and placed in a place safe from shock; it is necessary to reduce the print speed in the slicer (Fig. 3). Printing time can be increased by increasing the temperature and flow rate, this can affect the amount of filament released. If you hear tapping while printing, it means the printer is working too fast.

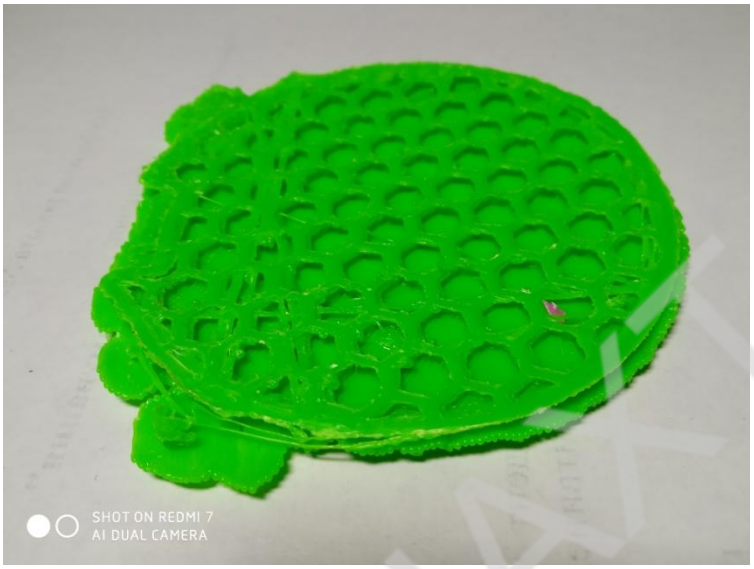

Fig. 8. - Illustration of offset layers when printing

4. **The formation of "cobwebs" or "hairs" between the elements of the model** (Fig. 9). This problem occurs when the printer head moves on an open surface (without extrusion), that is, it moves from one object to another, while the plastic continues to drain from the nozzle. In this case, it is necessary to activate the retraction mode in the slicer (rollback / retract). It functions quite simply and works on the principle of drawing the thread back into the nozzle before the head begins to move. The bottom line is that it prevents the leakage of plastic from the nozzle during the movement of the extruder above the layers where clearance is needed.
5.

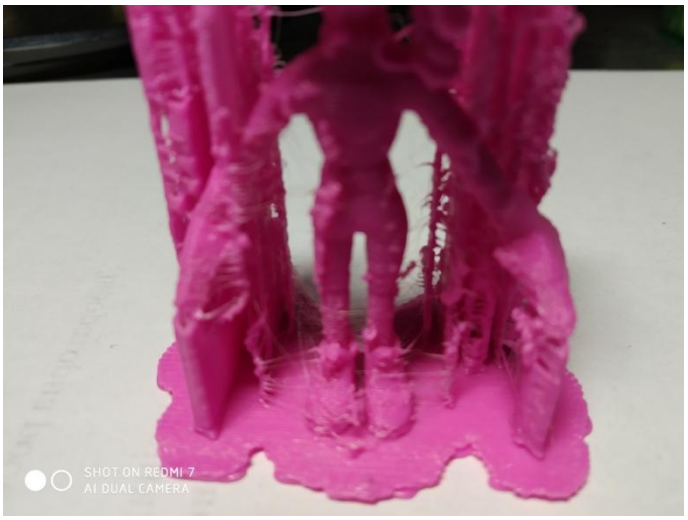

Fig. 9. - Illustration of the formation of "cobwebs" when printing

6. The internal structure of the model is missing or poorly printed (Fig. 10). It is necessary to check the percentage of filling in the slicer. Performance in the region of 20% is considered normal, if less - there may be problems with printing. Also, when the model is not full, you can reduce the print speed (Fig. 3). The internal structure is affected by the structure of the filling (it can be mesh, triangular, honeycomb or other filling). For the Smartprint HB-8 printer, experiments showed that cellular filling is optimal; the models are light and durable (Fig. 11).

Fig. 10. - Illustration of the poor internal structure of the model

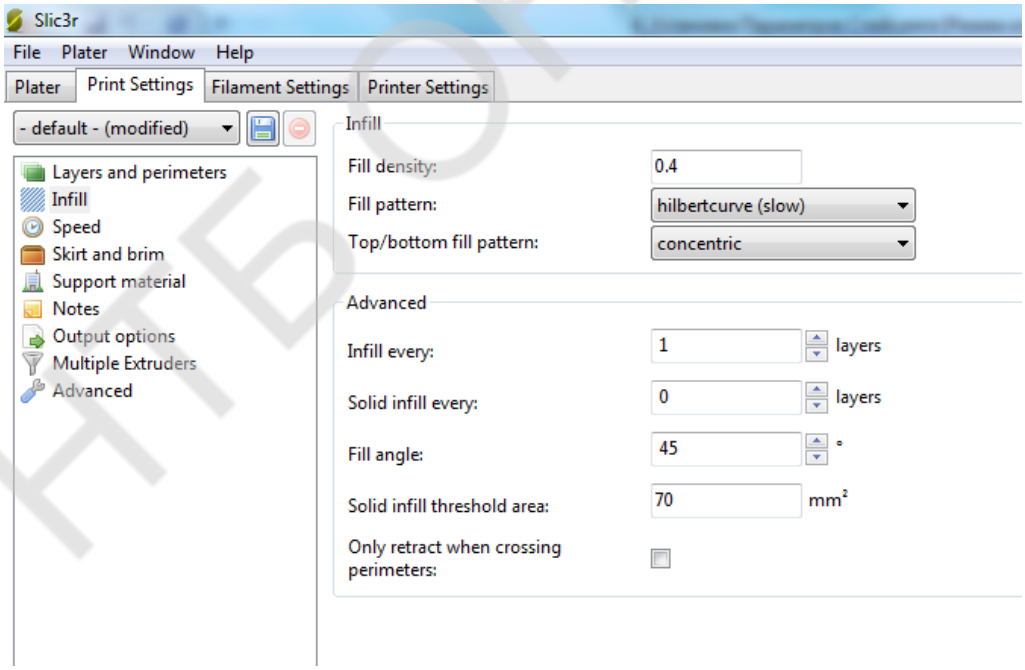

Fig. 11. Illustration of filling changes in slicer

7.The gap between the filling and the walls (Fig. 12). Slots appear due to the fact that the plastic used to print the filling and contour does not bind. Solution - in the slicer you need to select the Infill Overlap parameter and increase the values to 30%. Changing the print order of the outline and fill can also help. If you first print the outline and then the filler, this should not be a problem. You can change the order in the slicer by checking the "Infill prints after perimeters" option. Increasing the hotend temperature by 5-10 degrees and slowing the print speed by 10-20% can also help.

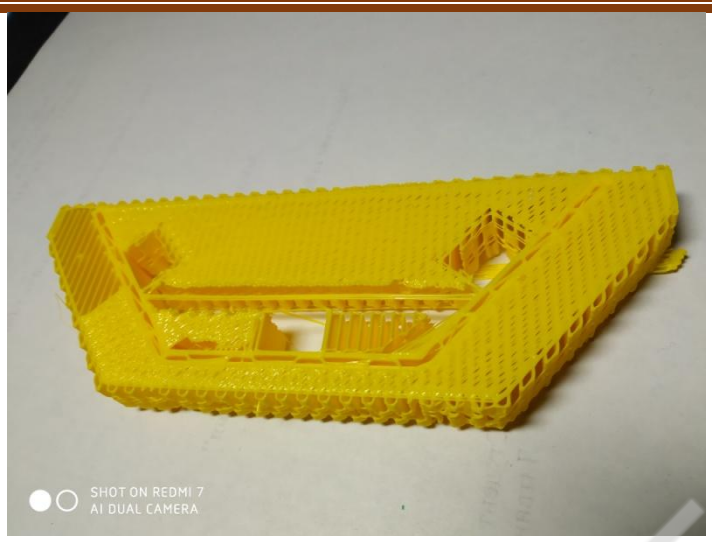

Fig. 12. - Illustration of the gaps between the filling and the walls

5. Conclusions

The paper describes the main problems that may occur when 3D printing on printers using FDM technology. A literature analysis of the effectiveness of the use of volume printing in various industries is carried out, the sources of the difficulties encountered in printing with plastic are shown, the main difficulties of the process are listed.

Various solutions to emerging problems have been proposed, based on the operating experience of the Smartprint HB-8 household 3D printer, implemented on the basis of the common Arduino Mega board. Various cases of ineffective 3D printing are considered, recommendations for its elimination are developed. The presentation is accompanied by original photographs of problem cases and scans of the slicer operation screen when solving such problems.

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ANALYSIS OF RELEVANCE OF DEVELOPMENT OF INFORMATION RESOURCE OF WORKFLOW PLANNING FOR BUSINESS ADMINISTRATORS

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Abstract.*This paper examines the relevance of creating a new workflow planning product for business administrators.*

In time when time management is an important part of our lives, there are many programs that help to organize the time, but all programs have their pros and cons. We will carry out the analysis of time planning on several currently relevant programs for planning the time, will consider the advantages and disadvantages, and on the basis of

these data we will consider whether the creation of a new program is relevant and what functionality is needed in it.

Keywords: *time management, business organization*

Introduction

"We cannot go back. That's why it's hard to choose…" - (Mr. Nobody)

The modern pace of life cannot be called deliberate; to say - «I have time to make all the plans of the day» almost impossible, after all, it is difficult and it takes pains to choose which work to do right now. This has a negative impact on productivity both in personal life and at work.

Principles and tasks of time management

Time management — is a time management technique that includes rules and principles that help a person to organize their time properly and maximize efficiency in any business.[1]

If it is possible to implement a time management program in your personal life, if you want it yourself, then it is very difficult for a staff of employees. People treat their time differently: someone already adheres to their own plan for the day, and someone lives aimlessly and does not want to have time to make his working norm, and this can delay the development of the whole company. However, the employee from the second group, unwilling to perform the work, according to introduced norms of work and / or work functions that he should perform, and the threat of dismissal still forces him to carry out his work almost in time.

Time management or time management processes are based on the following basic principles[2]:

— *correct goal setting* (the main thing is that it is clearly defined and achievable);

— *motivation* (the desire to save time must be conscious and connected to meeting any important needs);

— *performance* (time management is necessary to eliminate or at least reduce the time deficit by performing certain tasks in a shorter period).

Some people have a habit of managing their own time, others need help from outsiders: a friend, an expert, a leader, or in the modern world, it can be a program on your phone or computer.

No matter in what way, but in the case of competent distribution of their time resources, allocating important and minor tasks, the person begins to control his time completely, and problems with «rush job» disappear on their own.

Time management tasks allow the employee:

— to achieve the set goals, spending the minimum amount of time;

— achieve high results in anything (both in work and in personal life);

— rationally allocate your working time without overtime work and, accordingly, be able to rest fully, leaving time for leisure and socializing with loved ones;

— increase your financial position in case you do additional work;

— get rid of stress and fatigue from the constant workload;

— have a clear career plan for the future;

— to control your own life completely.

Now there are two main directions of time management: corporate and personal.

Corporate time management is relevant in large enterprises and is important, above all, for managers who plan the working schedule of a particular structural unit or enterprise as a whole. In this direction, the manager distributes the priority of current tasks and determines the timing of tasks, and then, depending on the results obtained, decides how many tasks to be put for a certain period of time before each of his subordinates and, of course, controls their performance.

Personal time management applied to an individual may affect both his or her professional activity and the sphere of private time, development, relationships. Personal time management is relevant when a person has «nothing to do» - neither at work nor in personal affairs. If the employee constantly feels tired, works hard every day, and the «light» is not visible, it means that it is simply necessary to pay attention to his interaction with time. You can help him or her to make good use of time, but this requires that the employee first expresses his / her desire (at least he / she agrees to help) and secondly that he / she clearly understands why he / she needs it (because in the lack of motivation, it is difficult to achieve a positive result).[7]

Time management is not about working more intensively - it is a way to work efficiently and reduce the depletion of physical and moral resources and increase productivity, not through increased efforts, but through their proper distribution.

Analysis of existing time management programs

Several popular programs in this field have been selected for analysis and I will say in advance - they are all very different, each with its own unique features and advantages and disadvantages:[3]

1. «Trello»

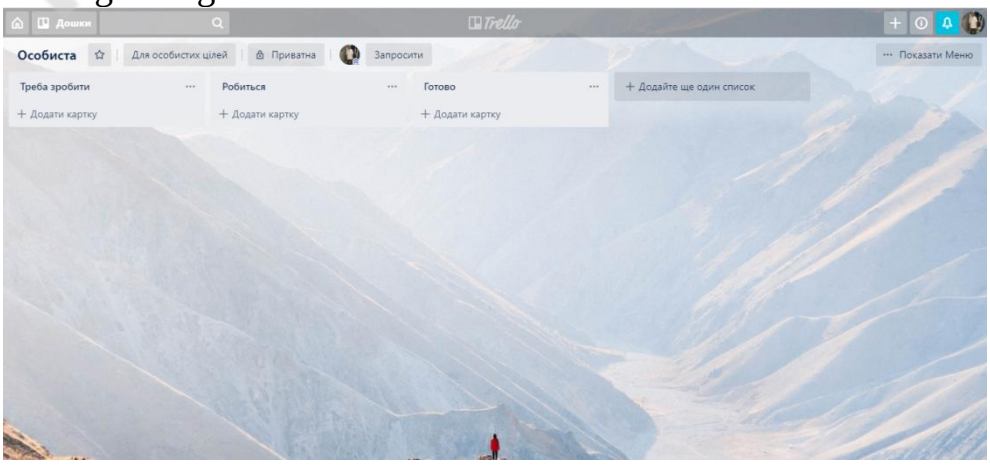
Trello is a service for organizing projects of any size. It splits tasks by special boards so you don't get confused in different projects and your staff can have access to individual tasks. It can be used for both personal and corporate use.

Pros:

1. User-friendly interface;
2. Mobile version;
3. Corporate and personal use.

Cons:

1. Very simple for some tasks;
2. It is difficult to navigate a large number of boards;
3. Not enough integration with other services.



Drawing 1 – Web resource board «Trello»

2. «Wunderlist»

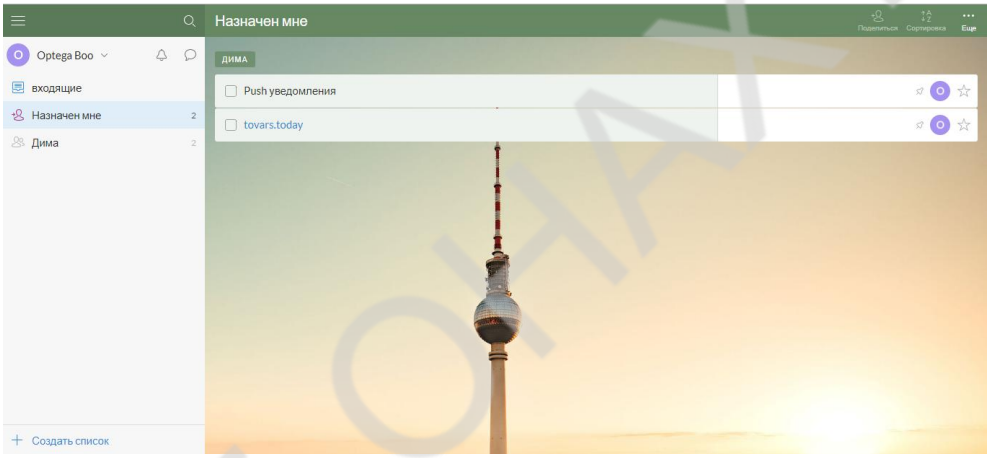
Wunderlist is based on a to-do list. This is a project within which separate tasks are created. Each of these sets the time of performing and the notification time. Set reminders for repeated events: once a day, a week, a month and a year. You can set a reminder in a few days.[4]

Pros:

1. Wunderlist is easy to learn;
2. Mobile version;
3. Delegations and collaboration on lists.

Cons:

1. You cannot postpone the task for an hour or for another day;
2. You cannot schedule multiple messages on a single task in one day;
3. The timing of the beginning and completion of the task cannot be noted;
4. Not enough integration with other services.



Drawing 2 – Web resource task page «Wunderlist»

3. «Google Calendar»

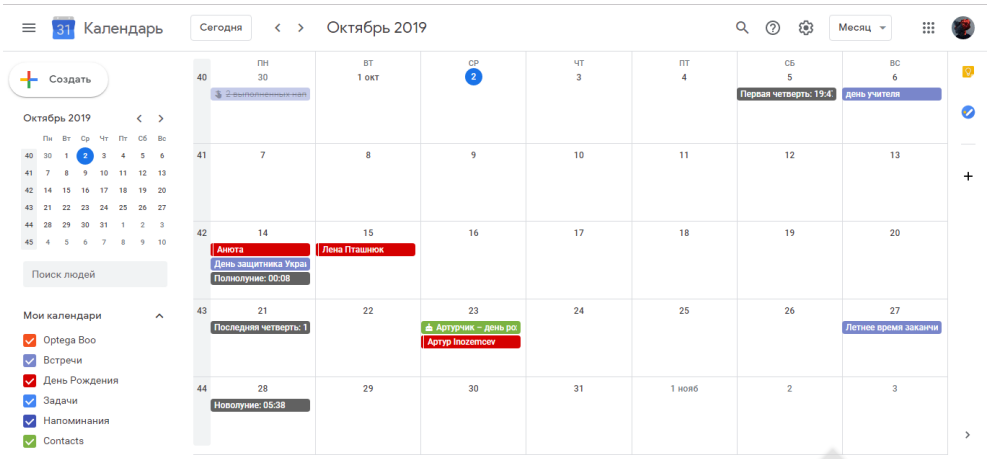
A classic and understandable service for scheduling meetings, events and chores. It allows not only to set the date and place of the meeting, but also invites participants by e-mail. Event reminders come, depending on the setting, by mail and / or as messages. [5]

Pros:

1. You can create multiple calendars and share them with other users;
2. The presence of simple «reminders» that will pop up on the screen at a given time;
3. Export and import calendars;
4. Mobile version;
5. Integration with Google services.

Cons:

1. You spend a lot of time setting one day planning;
2. More suits for reminding important tasks than scheduling;
3. Not enough integration with other services.



Drawing 3 – Home page of the web-resource «Google Calendar»

4. «Microsoft To Do»

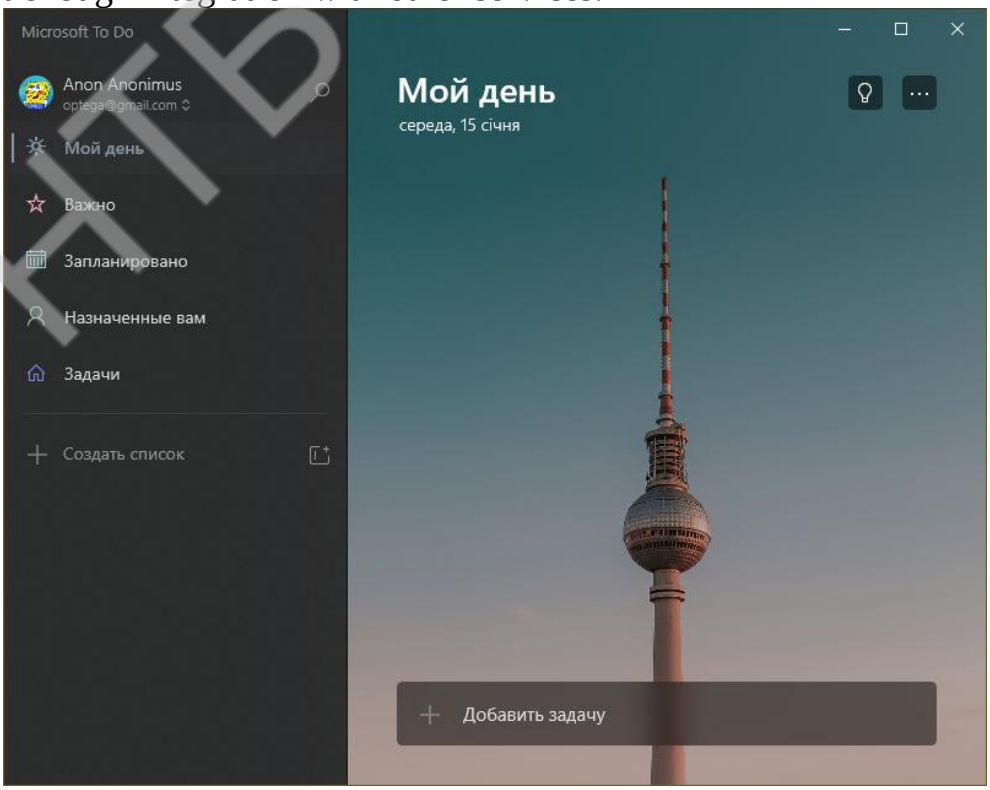
Enhanced version of Wunderlist - to-do list for the day. Unlike Wunderlist, it has an individual plan for the day, reminders of important plans for today, and lets you customize your plans visually - sets color, themes, etc. [6]

Pros:

1. Easy to master;
2. Mobile version;
3. Delegations and collaboration on lists;
4. Individual plan for the day.

Cons:

1. You cannot schedule multiple messages of a single task in one day;
2. The timing of the beginning and completion of the task cannot be noted;
3. Not enough integration with other services.



Drawing 2 – The computer version window «Microsoft To Do»

Object, subject matter and tasks of analysis

The object of study of this paper is the relevance of creating a new workflow planning product for business administrators and what functionality is important for such programs.

The subject of the study of this work are the programs that allow you to manage your time and why there is no perfect program for time management.

The task of the analysis:

1. To highlight the popular programs used to plan personal time;
2. To carry out analysis of these programs, highlight their advantages and disadvantages;
3. To find out the relevance of creating a new product in this area and what functionality should be in the program in order to be a rival in the market.

Analysis result

The analysis of the programs revealed the main features of the program and their presence in each of the products viewed.

Comparative characteristics of analogues:

Features	**Trello**	**Wunderlist**	**Google Calendar**	**Microsoft To Do**
User-friendly interface	+	+	+	+
Work offline	+	+	+	+
Deprecated interface	-	+	+	-
Group work	+	+	+	+
Connection of other services	-	-	+	-
Out-of-program messages	-	-	+	+

There are many other programs and web-resources for planning personal time or work of the staff. For some the features which this programs provide are sufficient, but as for me they are very limited as they are «local», that is, they work only in their midst and do not use the ability to connect modules, other services with API technologies, which can open broadly the functionality of any application and attract a larger audience of users.

My analysis is aimed primarily at the administrator of any enterprise, which, through my program, will mainly be able to create tasks for each individual employee and group staff with clear parameters (start date, term, deadline, notifications, etc.), control the progress task execution, ability to chat for each task separately. In their turn, the employees responsible for the task assigned to him by the manager can monitor changes in the task, change it himself (perform or add minor tasks), participate directly in the chat of a task.

Furthermore, each user of the program will have his own personal page where he will be able to create his personal plan and tasks for himself, which will not intersect with working tasks.

Program notifications can be configured as regular push messages from the browser, to the mailbox, or to various modern messengers.

Due to integration with a separate services, some already have an API that will allow you to connect to them and perform some actions without using the services directly; for example: send a reminder to any user with a regular message, the desired messenger, or by e-mail in due time, or after some action was taken; to publish any post on your social network page, also under certain conditions, time or action; automatic creation of tasks / reminders from mailboxes; etc. It is also possible to automate such processes as: food delivery order; order office supplies such as water, coffee, hygiene products, etc.; employee's birthday reminder and ordering a present or flowers; etc. The problem with the automation of some processes is that there are no services for many needs that provide API connection, or they are not enough functional, or there is no such function. To solve this need, one needs to interact with the services themselves and, or provide them with our facilities to create a connection, or they create such opportunity and to connect to them.

Several small business owners with a staff of 10 to 50 were interviewed during my analysis, all of whom have identified the needs for such a program and are willing to cooperate in creation and implementation of such a product.

Conclusion

Nowadays, people pay attention to programs that provide a wide range of services, not just the usual day planning. The product should fully meet the demands of the modern person, as well as the main functions of workflow planning and the ability to control the workflow of each member of the staff quicker and more efficient. It should involve not only the usual time manager, but also to be able to interact with other services from different fields.

As small business owners are interested in the program, you can find investors to sell this product, and in this case, users.

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IMPROVEMENT OF THE METHOD OF IMPROVING THE INFORMATION SECURITY OF THE INFORMATION AND TELECOMMUNICATION SYSTEM

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Abstract*.The relevance of the topic of identification of a person due to the active informatization of society and an increase in the flow of confidential information. The analysis of modern methods of improving information security shows the obvious movement towards biometric methods due to their convenience, reliability and reliability.*

The task of scientific work is to investigate methods of improving information security.

The research methodology was used. The methods of text analysis based on semantic differential and the method of phonetic analysis of semantic component were used.

It is revealed that the creation of an information security system using biometric methods of user identification will reduce the impact of the "human" factor, which will increase the efficiency of identification and authentication procedures. It is proposed to increase the efficiency of the system to protect information using a steganographic method.

Keywords*: biotechnology, identification, authentication, verification, access systems, template, mapping, data warehouse.*

I Introduction

Enterprises of different industries have to operate in conditions of high complexity, uncertainty and dynamic environment. There is an urgent need to create not only a single information space, but also an adequate mechanism for organizing information security. This activity is of particular relevance at the present stage, when various forms of hostile competitive influence are being disseminated. Equally important is the provision of information security at the country level.

In today's society, information has become one of the most important strategic resources for further development of the enterprise. That is why information, like other resources, needs special protection. The problem of information security has become especially important in the current context of the widespread use of automated information systems. In view of the growing role of information resources in the life of modern society, as well as the reality of numerous threats, the problem of information security requires constant and considerable attention. The implementation of the latest automation and communication tools require faster and more reliable means and methods of protecting information. Therefore, the use of steganography techniques is necessary to protect information in today's world.

In this paper, information security enhancement methods will be discussed and compared. An analysis of their advantages and disadvantages, the principle of operation, the main characteristics and the best method will be highlighted.

II Analitic reviev of literature

BIOMETRICS. BASIC METHODS OF DATA RECOGNITION

Biometrics is a collection of automated methods and means of identifying a person based on their physiological or behavioral characteristics.

There are two methods of data recognition: static and dynamic methods.

Static methods:

- fingerprint;
- in the form of a palm;
- the location of the veins on the back of the palm;
- behind the retina;
- behind the iris;
- by face shape;
- by the thermogram of the person;
- DNA;
- using other methods.

Dynamic methods:

- take into account the peculiarities of subconscious movements;
- in handwriting;
- by keyboard handwriting;
- by voice;
- other methods.

To evaluate the performance of a biometric system, there are characteristics that can be easily quantified to determine the reliability of the systems created [1].

These characteristics are accompanied by the presence of errors of the first and second kind. Denoted as FRR (False Rejection Rate) - the probability of a mistake of the first kind, that is, the probability of rejecting "one's own".

$$\mathrm{FRR} = \frac{\mathrm{NFR}}{\mathrm{NAA}} \mathrm{x}100\% , \qquad (1.1)$$

where NFR is the number of false deviations;

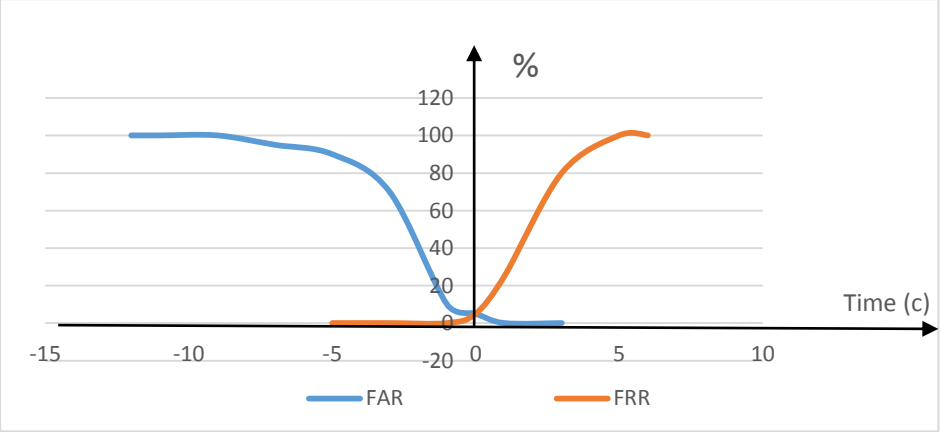
NAA is the time of false deviation.

A second kind of error occurs when comparing "alien" to "alien" when "alien" recognizes "own". Denoted as FAR (False Acceptance Rate) - the probability of a second kind of error, that is, the probability of missing another.

$$\mathrm{FAR} = \frac{\mathrm{NFA}}{\mathrm{NIA}} \mathrm{x}100\% , \qquad (1.2)$$

where NFA is the false approval number;

the NIA is a time of false rejection.



To determine the efficiency of the biometric system is a graph FAR, FRR.

For example, to obtain first-order error statistics, it is necessary to compare pairs of patterns in a single row in order to provide one-to-one comparisons. If the first pattern in a row is compared with all other prints of a row, it turns out $(m-1)$ comparisons; compare the second pattern in a row with all the patterns that follow it, since it has already been compared to the first pattern, we get a $(m-2)$ comparison, etc. The penultimate pattern is only compared to the last pattern, one comparison is obtained. Thus, the number of comparisons in the series will be:

$$V_i = \frac{m(m-1)}{2}, \quad (1.3)$$

where m is the number of templates in the database.

To obtain second-order error statistics, comparisons are made in pairs between templates of different rows, to provide comparisons of type "alien" to "alien." the second row of the first row is also compared and more $(n-1) \times m$ comparisons are obtained. After comparing the first row m patterns with all the other row patterns, we get m^2 $(n-1)$ comparisons.

The second row templates are compared to the patterns of all $(n-2)$ rows after it, since they have already been compared to the first row prints, there are still m^2 $(n-1)$ comparisons. This procedure is carried out to the penultimate row, which is compared only with the only one, the last, close, and there are still m^2 comparisons. This means that the number of possible comparisons of "alien" to "alien" in the base of n samples of m templates each will be:

$$VFAR = \frac{m^2 n(n-1)}{2}, \quad (1.4)$$

where n is the row number.

The use of this method allows to obtain a sufficiently large number of variants of comparisons needed to build characteristics with incomparably smaller amounts of templates in the database [2].

PROSPECTS FOR THE DEVELOPMENT OF BIOMETRIC MARKET AND DIFFERENT TYPES OF BIOMETRIC AUTHENTICATION AND IDENTIFICATION TECHNOLOGY

Biometrics are rapidly acquiring industrial features. The need for standardization and unification is increasing in the world market; Competition is intensifying, mergers and acquisitions are being activated. However, despite the existing differences in the prospective estimation of the volume of the world biometric market, all research and consulting firms believe that the general tendency for further growth of the biometric market will be maintained.

Recent developments in new biometric technologies may have very accurate recognition properties, but at the same time they will require additional data to confirm their uniqueness.

Another fairly significant aspect is how simple ("comfortable") each technology is. The process should be quick and easy, such as standing in front of your camcorder, saying a few words into the microphone, or touching the space in the fingerprint scanner. The main requirement for biometric technologies, which is their major advantage, is quick and easy identification without causing any inconvenience to humans.

Regarding segmentation of the industry market, experts were unanimous in their conclusions that the most popular were and remain systems that implement fingerprint and face identification technologies; third and fourth places share solutions based on the recognition of users by vein pattern and voice.

In the coming years, three major biometrics (fingerprint, face, iris) technologies will retain dominant positions, but overall their share will decline. However, it is assumed that the popularity of rainbow technology will give way only to the popularity of fingerprint identification, and third or fourth place in popularity may come methods of identification of a person by voice.

But the question is: what kind of biometric identification technology is better? It all depends on the specific scope of its application. For example, identification of a person in complete darkness (if necessary) is better done by voice, and techniques using fingerprints are used [3].

The dynamics of growth of the world biometric market, from 2007 to 2018, is shown in Fig. 2.1.

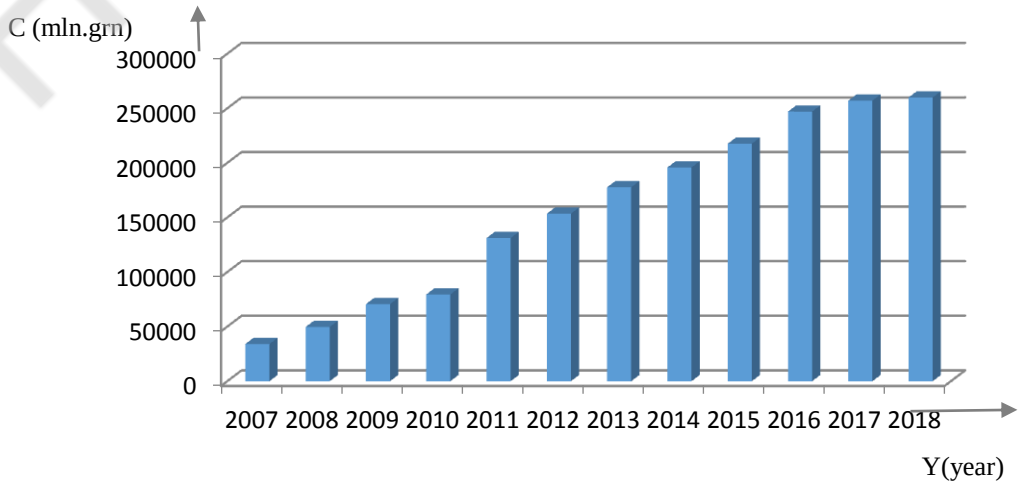


Figure 2.1 - Dynamics of the global biometric market

III Object, subject and methods of research

The scientific and applied task is to increase information security with respect to demarcated access to information resources.

The purpose of the work is to develop an identification method using image hiding methods.

The object of the study - methods of improving information security.

Research Methods - Determine the most effective method of enhancing information security.

IV Work results

PROBLEMS OF FACE IDENTIFICATION BASED ON THE IRISIris Identity has a very high degree of reliability and accuracy, but there are a number of problems. First of all, it is the change in the size of the pupil as the lighting level changes. The rest of the problems are related to the features of the human eye structure and are shown in Fig. 3.1.

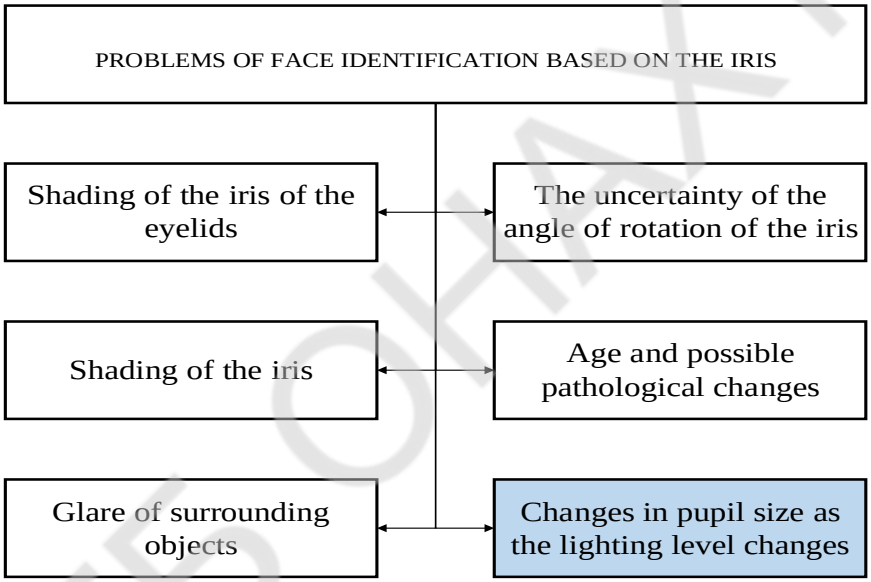


Figure 3.1 - Iris-based identification problems

– shading of the cornea eyelids. This problem can be solved with a special algorithm for searching the eyelids or rejecting parts of the image when comparing consecutive frames;

– shading of the cornea with lashes sticking down. The algorithm of search of eyelids on such pictures works successfully and with great confidence, the area allocated to it, is not suitable for recognition. The problem can be solved by the algorithm of rejecting the sequence of images. The cornea and eyelids with the eyelashes move relative to each other, so those parts of the image where the eyelashes and eyelids hang over the cornea are constantly changing (the eyelashes alternately close different parts of the cornea). On the contrary, the corneal open areas in the normalized image are relatively stable;

– glare from surrounding objects on the cornea. The cornea acts as a spherical mirror, reflecting the outside world. These reflections (especially reflections of light sources, patches of sunlight and areas of the daytime sky) can be several times brighter and more completely suppress corneal details. To solve this problem, high intensity in the narrow area of the illumination spectrum is used (far exceeding the solar illumination, most often use infrared radiation) and image registration in the same area of the spectrum;

– different size of pupil under variable shooting conditions. As noted above, the affine transformation of the corneal image to a standard size solves this problem only in the first approximation, since the corneal stretch obeys a nonlinear, too complicated law. To solve this problem, it is suggested, for example, to remember the size of the human pupils when registering in the system, and to recognize the accommodation (expansion or narrowing) of the pupils to this size by manipulating the brightness of a special visible light source;

– pathological and age-related changes. The cornea very clearly reflects the state of the body, including various pathologies (diseases, injuries, poisoning). In this regard, the question arises about the stability (over time) of the recognition of the object subject to these changes. However, there are a significant number of birthmarks and signs that remain unchanged throughout the life of the cornea. It is almost impossible to separate congenital and acquired traits, but even a small number of traits can be recognized by a person. The required minimum is 30%, and even so, the probability of a false tolerance does not exceed 10-64;

– uncertainty of corneal angle of rotation. There is no problem with the corneal registration system or the corneal-face combination system. For the so-called "one-eyed" system, you can determine the angle on the configuration of the eyelids, the pupil decentralization or on some important characteristic of the cornea. All of these signs may change over time. In this case, it is necessary to iterate over the angles of rotation (significantly increases the operating time of the system) or to calculate signs that are invariant to rotation (such signs are ten times less, therefore, greatly reduces the reliability of the system). In addition to all of the above biometric identification systems should be resistant to the use of fakes. For iris-based identification systems, either a corneal volumetric photograph or a mockup of the eye can be used as a fake, as well as the alienation of biometric features (in this case, a "torn" eye) [4].

There are two ways to solve this problem:

Method 1 - Corneal Reflection Spectrum. The cornea of the "living" eye is constantly moisturized, the "dead" eye quickly dries. The reflectance spectra of wet and dry corneas differ.

Method 2 is by the reaction of the eye to illumination. The pupil reacts to external stimuli (flash of light, loud sound, etc.) in a certain way and with some delay, and this reaction is controlled by the brain.

Iris scanning, electronic fingerprints and signature recognition are definitely better than the password on a piece of paper attached to the monitor. However, according to researchers, biometric information is easy to steal or copy. "In this regard, it is desirable to develop such an identification device, when working with which you would not need to make a secret of biometric data," - they say.

In an article in the International Journal of Biometrics, scientists led by Masakutsu Nishigaki and Daisuki Arai of the University of Shizuoka write that they have been able to develop an alternative method of authentication based on the unique reflex response of the human eyeball. Nishigaki and Arai use as a biometric identifier the unintentional reaction of the eyeball to an external action, measured in conjunction with the calculation of its dead zones, also called blind zones.

Blind spot is a visual projection of the optic disc. This rounded eye area of about 1.9 mm in size cannot form a visual image. Human eyes have an area of blind spot, however, due to binocular vision, the blind spot remains unnoticed, as these areas are superimposed when comparing images of the right and left eyes. Even with one eye closed, seeing a blind spot is not easy. The brain compensates for the missing visual information and the blind spot goes unnoticed. Increasing the size of the blind spot can indicate a number of eye diseases and is a diagnostic criterion in ophthalmology.

Each vertebrate eye has a dead zone where the optic nerve moves away from the retina. This visual gap is not perceived visually as the field of view of the other eye overlaps this dead zone. Scientists use this dead zone to detect eye movement. A person is shown a visual image, both within and beyond, and measures the reaction time of the eye until the moment of movement of the eyeball. Other options for using this method, such as dead man positions and pupil constriction time, are also offered.

Nishigaki especially draws attention to the fact that using only the dead zone position as an identifier is by no means safer than using a scan of the iris, since in this case it is possible to use contact lenses or even surgery.

DEVELOPMENT OF PERSONAL IDENTIFICATION METHOD USING STEGANOGRAPHIC TRANSFORMATION

The method of face recognition by iris and human eyeball response to stimuli consists of the following steps:

a) a request for an identification process, that is, to determine the identity of a person and determine his or her rights to perform certain actions. The person who wants to access the data should bring the face closer to the scanner, fix its position and look at the special mark on the scanner display. Then the camera takes pictures at a rate of ten frames per second, and the resulting images are processed by a special program. The beam incident on the curved surface is bent - the greater the curvature of the surface, the stronger the bend of the beam. Initially, a visible light source was used. Then visible light will be replaced by infrared.

b) the input of the key (password) by the person. The key is the rule for steganographic conversion of a snapshot taken by the system. The key is a certain sequence of letters / numbers known to the system, the person requesting identification, and the system administrator. With this system, the system places data on the container, so that the attacker will not know which blocks of the container are steganographically changed. User must enter 2 keys:

– the first to close information;
– second for steganographic placement in the container.

This increases the complexity of accessing the system for unauthorized users [5].

c) forming a template based on the shot. In the first stage of processing, the image is deleted, where the face is not visible at all or there are foreign objects that interfere with identification. The resulting images restores a 3-D model of the person, which stands out and removes unnecessary obstacles (hairstyle, beard, mustache and glasses). Then the model is analyzed - anthropometric features are distinguished. The pupil "circle" is selected from the general image of the eyeball and the blind areas are selected. Measures the reaction time of the human eyeball to stimuli.

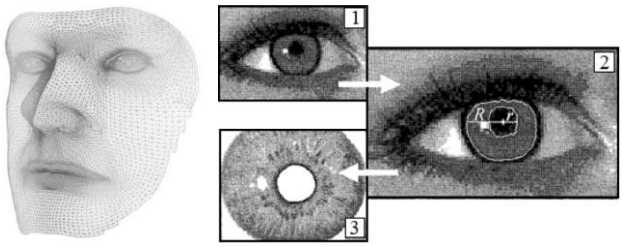


Figure 3.1 - Forming a 3-D pattern for face recognition and getting a "pupil" circle

d) forming the contour of the image. Contours are lines that extend across homogeneous areas. The elements zi, j of the space-time representation of the image, the values of which do not exceed a certain threshold, form homogeneous regions. This is determined by the following condition:

$$|z_{max} - z_{min} \leq 1|, \tag{3.1}$$

where z_{max} is the element of the largest image area that is defined based on the following expression:

$$z_{max} = \max_{1 \leq i \leq x}\{z_{i,j}\} \text{ при } j = \overline{1, y}\ , \tag{3.2}$$

where y the allowed number of elements of the image;

z_{min} is the element of the smallest value image area is determined by the formula:

$$z_{min} = \min_{1 \leq i \leq x}\{z_{i,j}\} \text{ при } j = \overline{1, y}\ , \tag{3.3}$$

where 1 is the threshold for the detection of homogeneous regions.

The most common and practically applied approaches for contour detection are gradient methods. Gradient methods are based on the determination at each point of an array of values of brightness increase (gradient) and the directions of their greatest change, with further determination of maximum values of brightness gradient, their statistical processing and division into thresholds (levels).

The most common way to find outlines is to process the image with a sliding mask. It is a square matrix with coefficients. The matrix-based image processing process is filtered or masked and is given by the following functional $f(Z, K)$ (Figure 3.1):

$$M = f(Z, K)\ , \tag{3.4}$$

where M is the image obtained by processing the image Z based on the mask K.

The filtering process is based on the gradual spatial movement of the filter mask from element to element of the image. Analysis of Figure 3.1 shows that the value of the element $m_{i,j}$ (filter response) is calculated using the values of the previous and next elements in the two-dimensional plane.

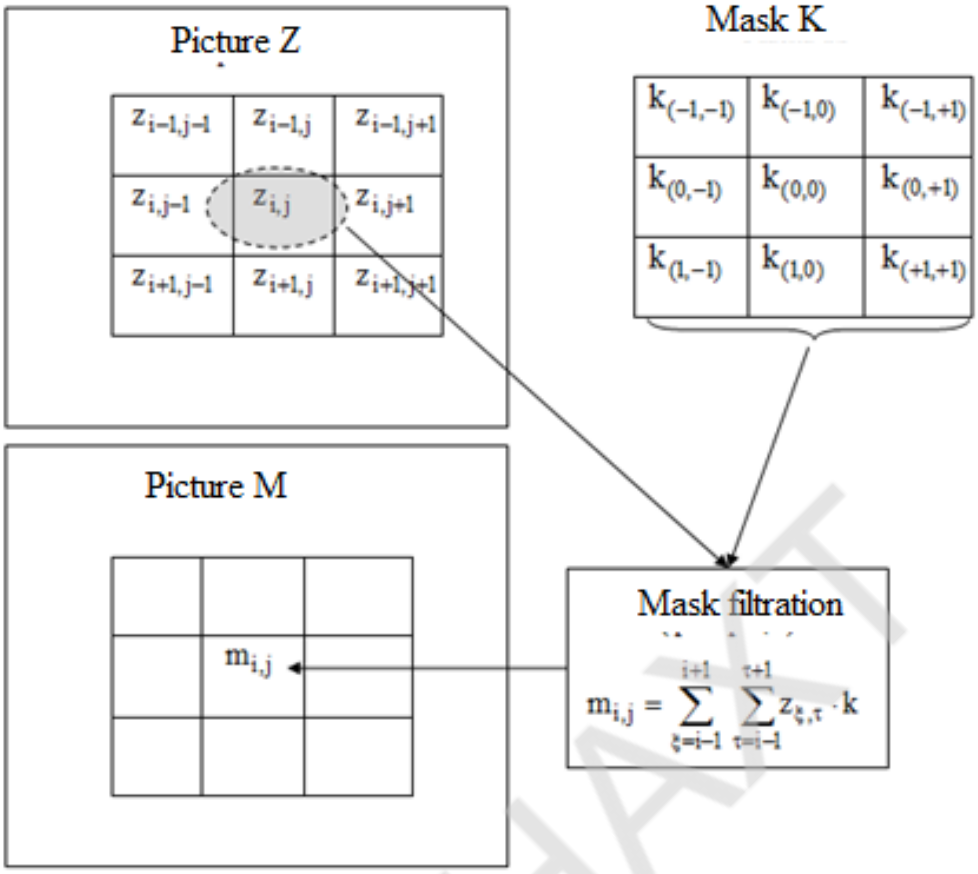


Figure 3.2— Scheme of masking an image based on a variable mask

e) embedding the data in the least significant bits (NZB) of the spatial representation of the image. The NSA is selected with the second key entered by the user in step 2. The embedding of the message occurs in the lower bit of the image, which carries the least information.

In fact, NZB is noise, so it can be used to embed a secret message. In spatial-temporal representation, image embedding is based on the properties of the 24-bit representation of the image.

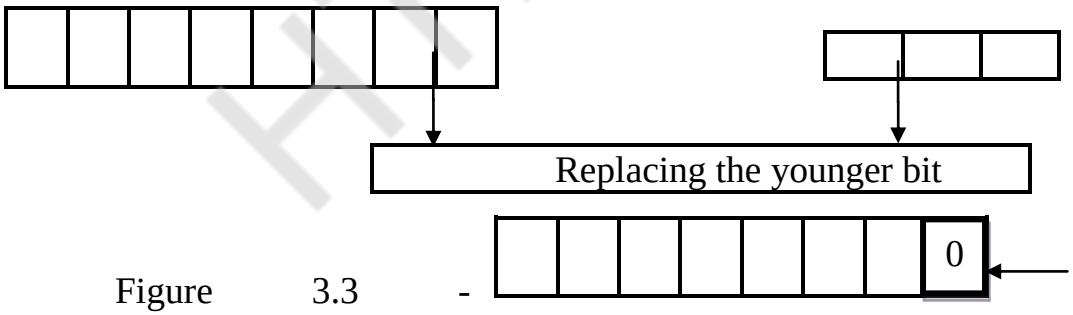


Figure 3.3 - Steganographic embedding in the least significant bit

24-bit color in computer graphics is a method of presenting and saving an image that allows you to display a large number of colors, undertones and tones. Color is represented using 256 levels for each of the three components of the RGB model: red (R), green (G) and blue (B), resulting in 16 777 216 (224) different colors.

Usually, when encoding a pixel, one byte is assigned to each of the channels (red, green, blue channels); the fourth byte (if used) is usually assigned either to store alpha channel data or simply ignored.

The size of the embedded message can be 1/8 of the total volume of the container. For example, a 512x512 image can embed 32kBytes of information. If you modify the two smallest bits, the bandwidth can be doubled.

The method of embedding data in the spectral region is somewhat more complicated than embedding the message in the spatial-temporal region of the image. Embedding information occurs after a discrete-cosine transform (DCT) of the image.

The DCT coefficients (transformants) are ordered according to their importance, for example according to the contribution to information content, so that transformants with small information content can be omitted (discarded). Other transformants are quantized, coded and transmitted or memorized. The importance of coefficients can be compared, for example, visually (subjectively), according to their contribution to the picture of the brightness of the reconstructed image on the display; thus, you can work around the issue of image element correlation and evaluate the result of compression. The archiving is considered to be excellent, in which it is impossible to distinguish between the original and unpacked (restored) image on the eye, good - when the difference is visible only for a number of these images. With further increase in the degree of compression, as a rule, there are noticeable side effects characteristic of the compression algorithm used.

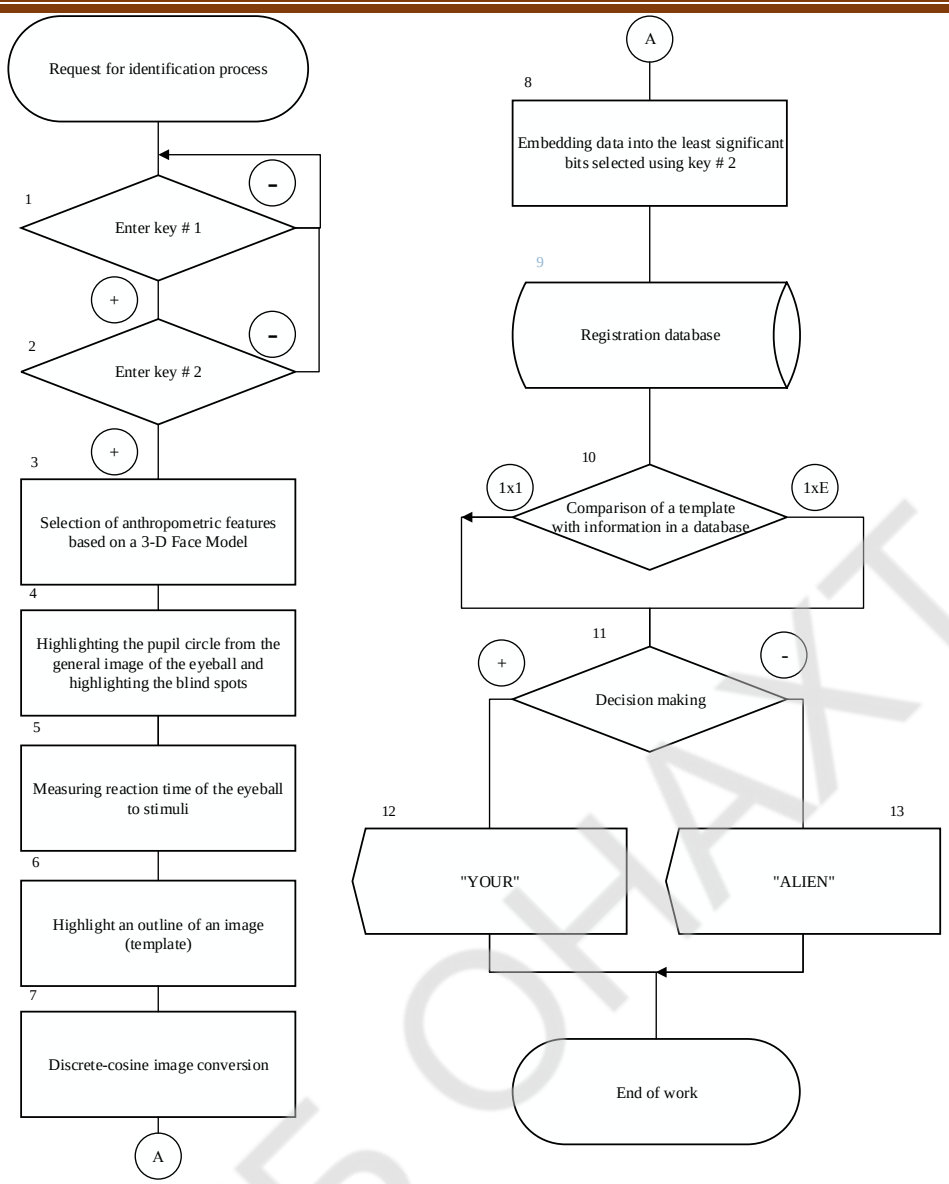
The embedding is done by bit: one bit of information into one value of the low-frequency DCT factor. For this purpose, information bits are transformed into polar form.

e) sending a steganographically converted image to the database. Each biometric system has a storage subsystem - a registration database that serves to store templates.

g) comparison of the template with the information in the registration database. The resulting verification template is compared with the stored one to determine if these patterns match. This technology uses the user's installation data (keys entered by the user) as a pointer to retrieve the stored subscriber's account and verify one-to-one (authentication or verification) between the template or one-to-many received during verification biometric parameters, and a template that already exists for that username. Otherwise (identification procedure), the biometric metric parameter template that is being presented is compared to the entire set of stored templates.

g) decision making by the system ("one's own" / "another's").

Scheme of operation of the iris identification system and the response of the human eyeball to stimuli using steganographic transformation:



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INFORMATION ENTHROPY AND FREEDOM OF CHOICE

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Abstract.*The article proposes a formula for estimating the freedom of choice of a person, similar to the formula for information entropy in information theory. The formula is used to compare the freedom of election in presidential and parliamentary elections in Ukraine and the Russian Federation, as well as in Ukraine, the Russian Federation and EU countries.*

Keywords: *information entropy, information theory, freedom of election, presidential and parliamentary elections in Ukraine.*

Introduction

Statistical physics is steadily gaining new ground in fields that seemingly have nothing to do with it. One of the fundamental concepts of statistical physics is the concept of entropy. In 1877, the ingenious Austrian physicist Ludwig Eduard Boltzmann was the first who understood the connection of the entropy of the physical system with the probability of its being in a macroscopic state, due to the number of microstations that realize this macroscopic state [1, 2]. In 1948, the famous American electrician and mathematician Claude Elwood Shannon proposed to use the concept of entropy to evaluate the uncertainty of information about a particular event [3, 4]. In this way he initiated a new mathematical discipline - information theory, where entropy was called information entropy. The relation of information entropy with the probability of the occurrence of a particular event, he proposed in the same form as the relation of finding the system in a particular macroscopic state, that is, actually used the information entropy Boltzmann formula. Consider the formula for information entropy.

Information entropy or the entropy of choice

Let's have a random experiment with the consequences E_1, E_2, …, E_n, that can be realized with probabilities p_1, p_2, …, p_n . Then the information we get as a result of this experiment is a random variable that assumes value $I(E_i)$ when the experiment results is E_i. With

$$I(E_i) = -\log_2(p_i).$$

The mathematical expectation of this information (information entropy), that is, the average amount of information attributable to one consequence of an experiment, is determined in a standard manner [5]

$$M(I(E_i)) = \sum_{i=1}^{n} p_i I(E_i).$$

The last result can also be written in the form adopted for information theory

$$S = -\sum_{i=1}^{m} p_i \log_2(p_i).$$

Many political processes resemble a random experiment. In particular, in our opinion, such a process is the election of different levels. If the possible consequences of this political process are to consider the victory of a candidate, that is, an event E_1, E_2, …,

E_n with probabilities $p_1, p_2, \ldots, p_n$, then the preceding formula can be used to evaluate the election results.It would now be advisable to use the term entropy of elections, or the index of freedom of elections instead of information entropy term. Election entropy depends on two main factors: the number of candidates and the probabilities election of the candidates. The entropy of elections with a fixed number of candidates reaches a maximum if the votes between the different candidates are distributed equally, that is $p_1 = p_2 = ... = p_n$. This universal property of entropy has also been warned by Ludwig Edward Boltzmann. In this case, the formula for entropy of elections will look like

$$S = \log_2(n).$$

That is, as the number of candidates increases, the entropy of elections increases as the logarithm of their number. It is nothing more than the famous Ralph Hartley formula [6].

Thus, election entropy characterizes the level of uncertainty in election results. Than are more candidates in an elected office and than are more uniform distributed the probability of winning different candidates, so is greater the entropy of the election, or the index of freedom of election. . It is advisable to use for the basis of the logarithm the number two in the formula for the entropy of elections. In the case of two candidates who have an equal chance of winning, that is the simplest political random experiment, for election entropy we get result one. In information theory this amount of information is called a bit. In our case it would be better to call it otherwise, for example, freed - from the first letters of the English word freedom.

It should be noted that in some countries, where the level of democracy is considered to be high, elections are actually taking place between two candidates with approximately equal chances of winning. It is clear that in this case the entropy of choice will be rather small, for example, comparatively with Ukraine.

In the Soviet Union, elections have always been held on a non-alternative basis. This means that one of the probabilities, for example, $p_1 = 1$ and all others are zero. In this case, the formula for the entropy of elections gives zero result.

If elections are held in two rounds, then the same formula for election entropy should be used for the second round too, and the results, according to the universal entropy property of two independent subsystems of the same system, will be the next sum

$$S = S_1 + S_2,$$

where

$$S_1 = -\sum_{i=1}^{m} p_i \log_2(p_i),$$

$$S_2 = -\sum_{i=1}^{2} P_i \log_2(P_i).$$

From our point of view, the degree of uncertainty of the election results indicates the level of voter freedom in such elections, that is, the level of freedom of the elections themselves. Therefore, since there are no competing variants of the definition for obvious reasons, we propose to call the entropy of elections an index of freedom of elections. In this case, if a voter votes for i–th candidate, then he exercises his freedom of choice in quantitative terms as $-\log_2(p_i)$.

Elections in Ukraine, Russia and EU countries

We apply the formulas we propose to estimate the freedom of choice index in the leading EU countries, as well as in Ukraine and Russia. For simplicity's sake, let's just take the latest elections in Europe. We will have the following result for the parliamentary elections.

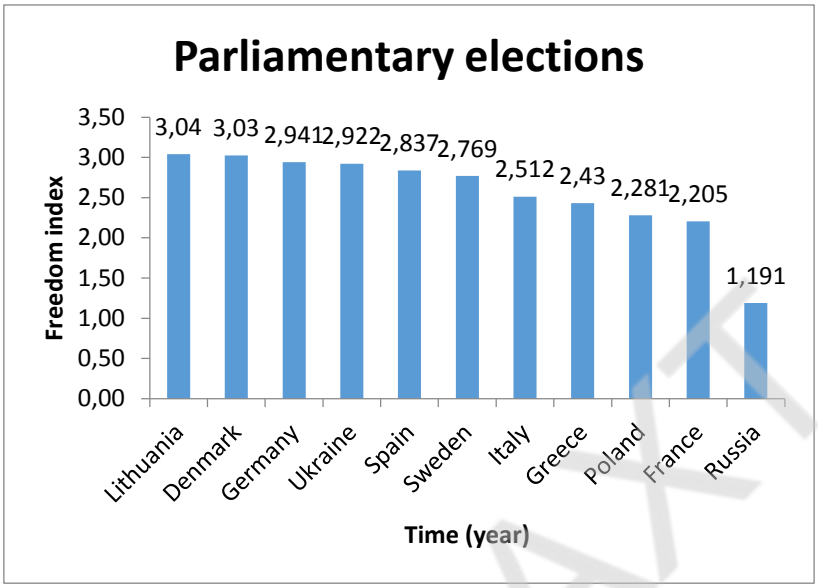

Fig. 1.

The chart above shows that for all the countries considered, which are the leading EU countries, high values of the freedom of election index are characteristic. The difference between the highest and lowest values of this index is relatively small. It is gratifying that only three EU countries have values of the freedom index higher than its value for Ukraine, and the remaining six - lower. Russia, in this list of countries, ranks last by a large margin for the European Union with the lowest value of the freedom of choice index - France. Moreover, the indices of freedom of election for France and Russia differ almost twice in favor of France.

Not all EU countries are elected by direct and general elections. Among the EU countries already considered, there are only four. The relevant chart for the presidential election is as follows.

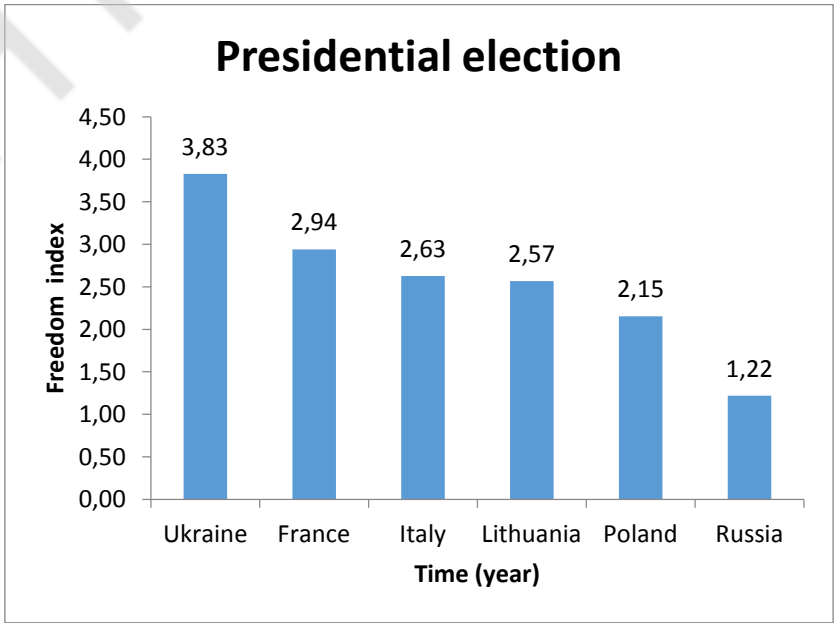

Fig. 2.

Ukraine is already the undisputed leader here, with a large margin for the rest of the countries. Other EU countries are again showing a small variation in the corresponding values of the index of freedom of elections, whose level as a whole is quite high. In the last place in the value of the index of freedom of elections is again Russia. Again, the indices of freedom of election for the EU country with the smallest index of freedom of election - Poland and Russia differ almost twice now in favor of Poland. Note that the data you need to build the charts are easily accessible from the internet, and we did not make any specific links to them.

In order to understand whether the magnitude of the freedom of election index reflects the mentality of the peoples, and whether it can change significantly over time, it is necessary to analyze the behavior of the index over a long period of time in the same country or in several countries with a common past. For this comparison, we chose Ukraine and Russia. They have been part of one empire for hundreds of years, their languages belong to one linguistic group - Slavic, in each of these countries there is still a large percentage of the population, ideologically formed under the same political conditions

Presidential and parliamentary elections in Ukraine

The following chart shows the results of the presidential election in Ukraine over the years of independence.

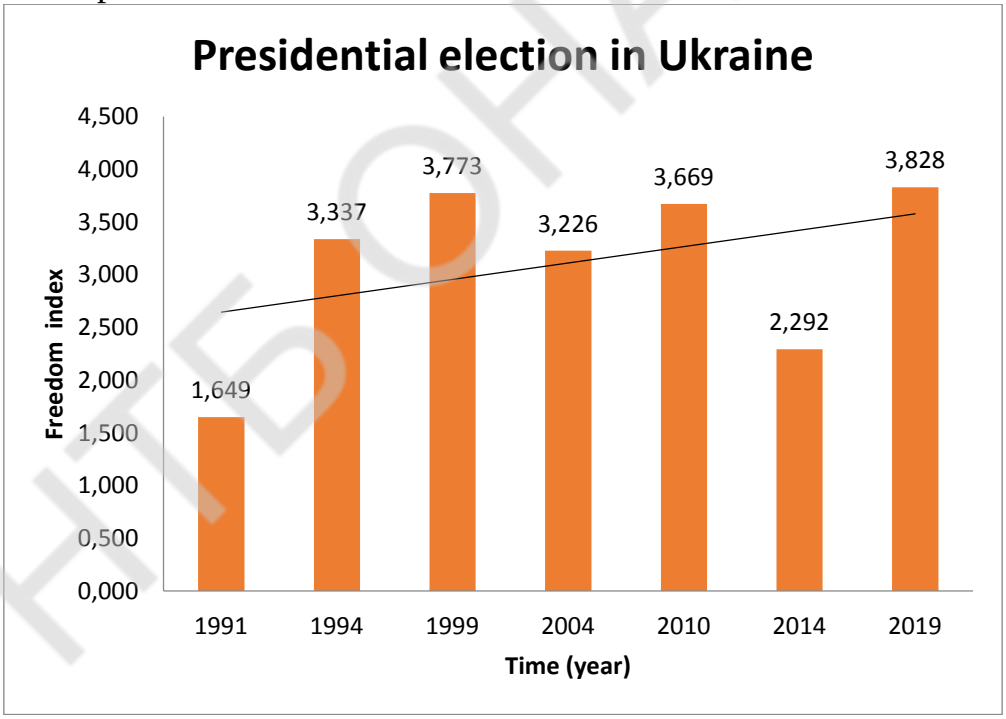

Fig. 3.

The chart shows that the index of freedom of elections in Ukraine is extremely high over the whole period of independence. The lowest level was in the first elections in the recent history of Ukraine. In our view, this was due to the inertia of the thinking of voters, as well as candidates, as a result of the recent Soviet past. This level was relatively low in the 2014 elections. At that time, an imminent war with the Russian Federation was coming to Ukraine. The desire to lead the country at this tragic time for Ukraine was relatively small. Elections in two rounds would be too dangerous for the country. Voters' responsibility for the fate of the state determined exactly this result. One of the candidates surely won the first round.

The highest level of freedom of election was in the last 2019 elections. The elections here took place in two rounds. The number of candidates was unprecedentedly high. The winner of the second round won just over thirty percent of the vote in the first round.

If we follow all the presidential elections in an independent Ukraine, then there is a clear tendency to increase the index of freedom of elections (a straight line that determines the long-term trend).

The following chart shows similar results of the parliamentary elections in Ukraine over the years of independence.

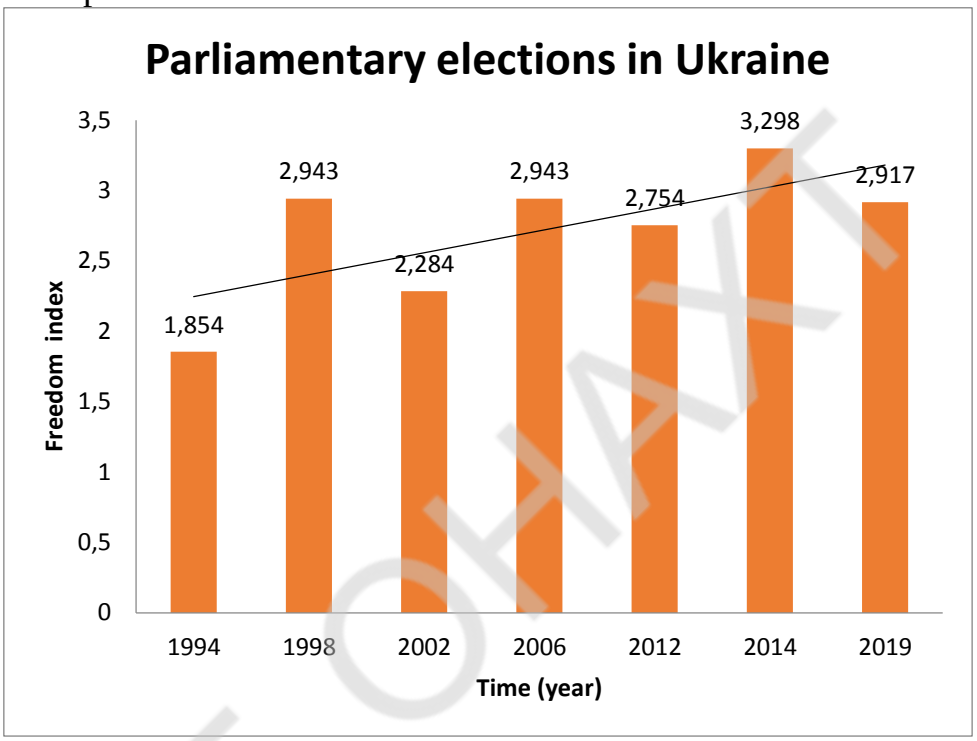

Fig. 4.

The index of freedom in parliamentary elections is also quite high and correlates well with the level of freedom of presidential elections. It also tends to grow. The lowest election freedom was in the first parliamentary elections in 1994, which is consistent with the lowest presidential election rate. However, it was the highest in Ukraine's most difficult year of 2014. A greater number of political parties won a real chance of winning, and the vote was more evenly distributed than in other parliamentary elections. By electing the president in May, the Ukrainian voter brought a huge number of nationally-minded deputies to the parliament on a patriotic wave. There were also parties that did not have such a chance under other conditions. A large number of MPs from the regions occupied by the Russian Federation, traditionally orthogonal to Ukrainian values, did not appear in parliament. Parliament has never worked as effectively as it did between 2014 and 2019.

Presidential and parliamentary elections in the Russian Federation

As we have already said, it is best to compare the Ukrainian elections with the elections in the countries that emerged from the ruins of the Soviet Union. An important factor here is the commonality of starting political and economic conditions. Another important leveling factor is the mentality of the Soviet man, present in all, even the most remote corners of the former Soviet Union at the time of its collapse. If the results of the elections in different countries show significant differences, then those differences would, in the first place, be caused by differences of ethnic origin. The results of the presidential

election in the Russian Federation over the years of its independent existence are as follows.

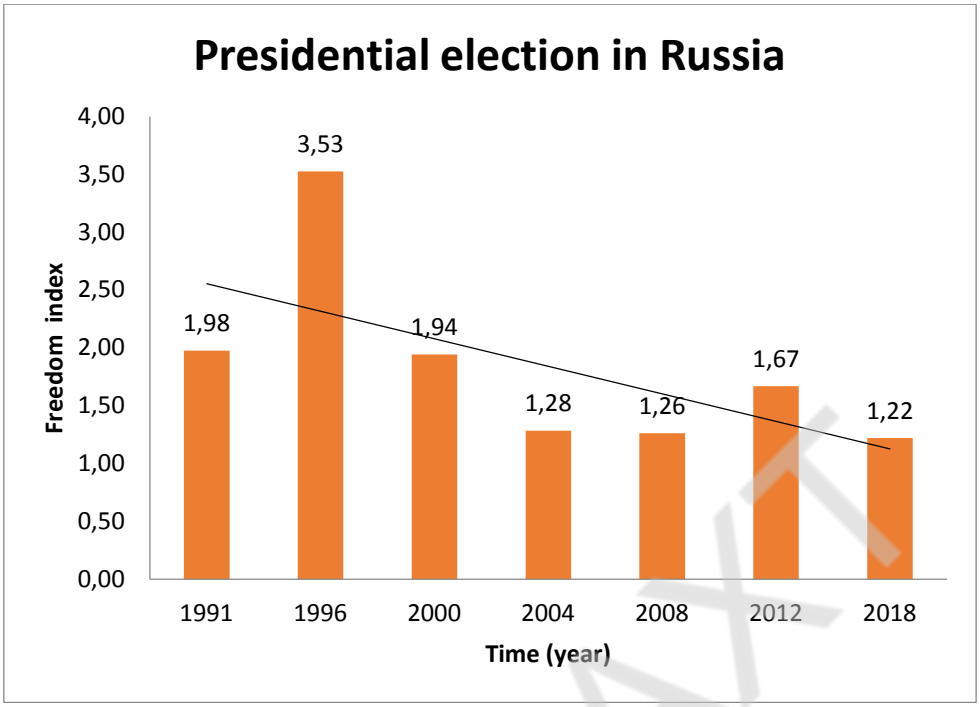

Fig. 5.

The chart shows that the level of freedom of presidential elections in the Russian Federation immediately started from a rather high level in 1991. It peaked in 1996, and for the last nearly twenty years it has shown a clear downward trend. From a mathematical point of view, the immediate reasons for such behavior are the level of freedom of election, both as a decrease in the number of candidates and an increase in the uneven distribution of votes between them. That is, a large number of candidates receive a symbolically small number of votes, but one candidate receives an unprecedented high number of votes.

The results of the parliamentary elections are shown in the following diagram.

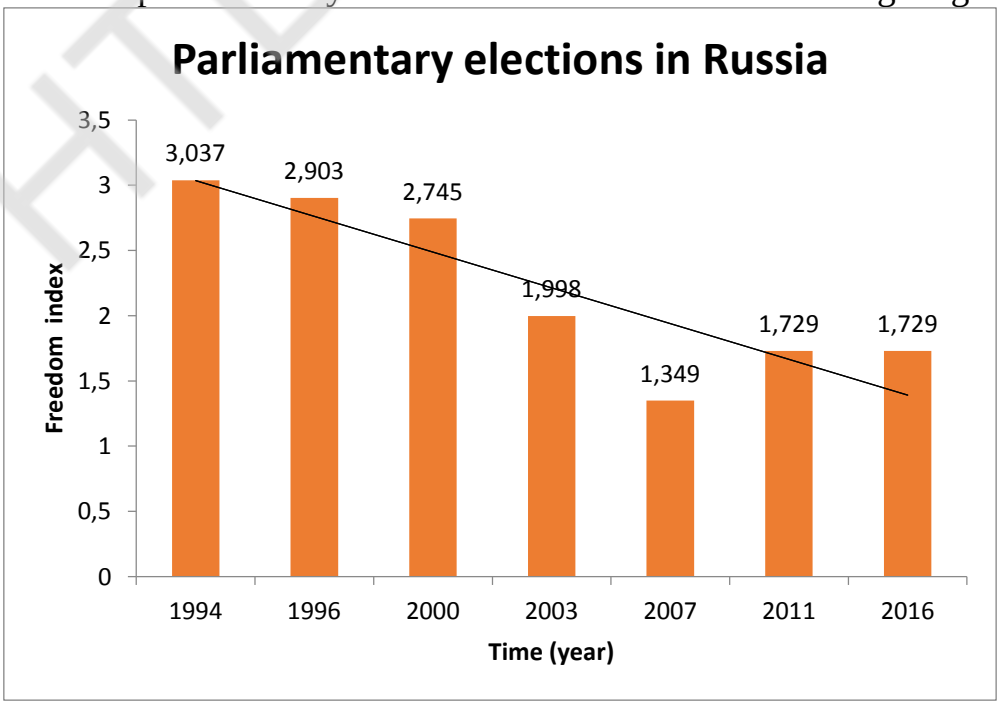

Fig. 6.

This chart also demonstrates the high level of freedom of parliamentary elections in the Russian Federation in 1994, 1996, 2000. However, it also shows a strong tendency to decrease this level for all analyzed years. There is also a strong correlation between the results of the presidential and parliamentary elections. Such a correlation, as in the case of Ukraine, testifies, in our opinion, to the objective nature of the election process for each nation, as the elections may be called. That is, the nature of the election is a reflection of the mentality of one or another nation, its fundamental ethnic values.

Comparing elections in Ukraine and Russia

Only by comparing the election results in different countries gives us the opportunity to determine our own place in today's world political process. The following diagram shows the comparison for the presidential election in Ukraine and the Russian Federation.

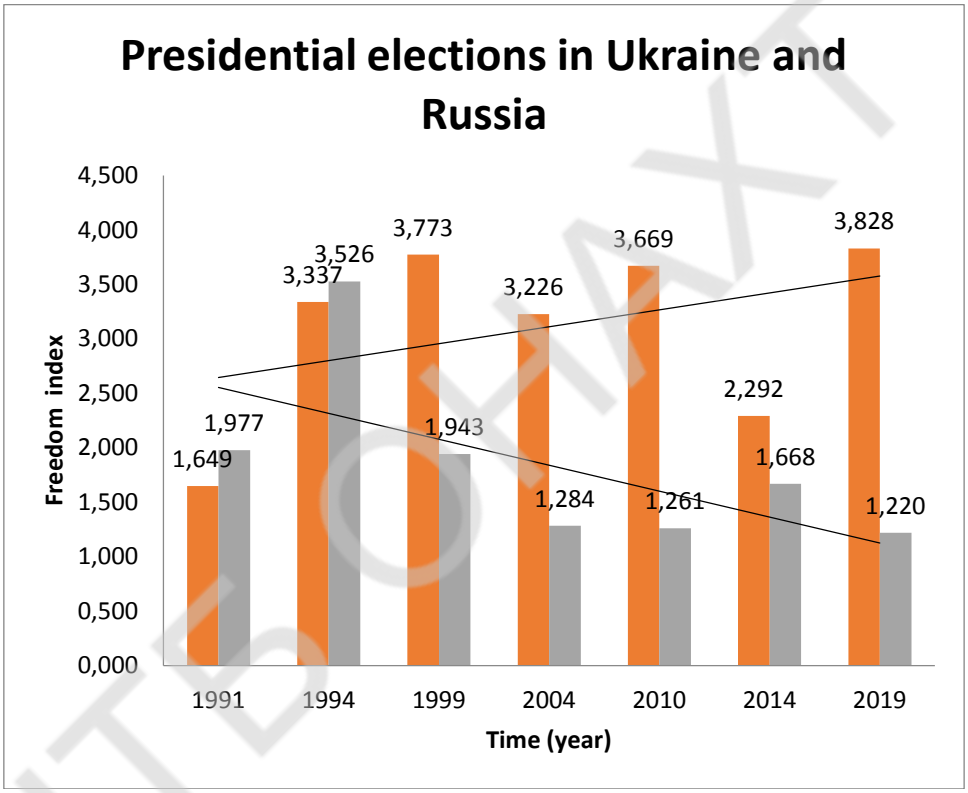

Fig. 7.

The chart shows that the level of freedom of elections in 1991 started in almost the same level in both countries. This may well be explained by the inertia of thinking of Ukrainians and residents of the Russian Federation. Generations of voters in both countries were predominantly formed under the conditions of one political reality - the Soviet Union. But over time, differences began to increase. This was happening as the ballot boxes in Ukraine began to be generated by politically formed voters or even born in an independent Ukrainian state. Accordingly, the number of voters whose outlook was formed in the Soviet Union began to decline substantially for natural reasons. The same evolution began among the voters of the Russian Federation, but in the exact opposite direction. It seems that Soviet education was a compromise for the various ethnic groups that inhabited the Soviet Union. The collapse of the Soviet Union was at the same time the disappearance of this compromise. Then began the evolution of each ethnic group to its own characteristic of its mental worldview. As a result, we received the highest level of freedom of choice in Ukraine's recent presidential elections, and the lowest in the Russian

presidential elections, respectively. However, these results differ in times. The following chart provides a comparative analysis of the presidential elections in both countries.

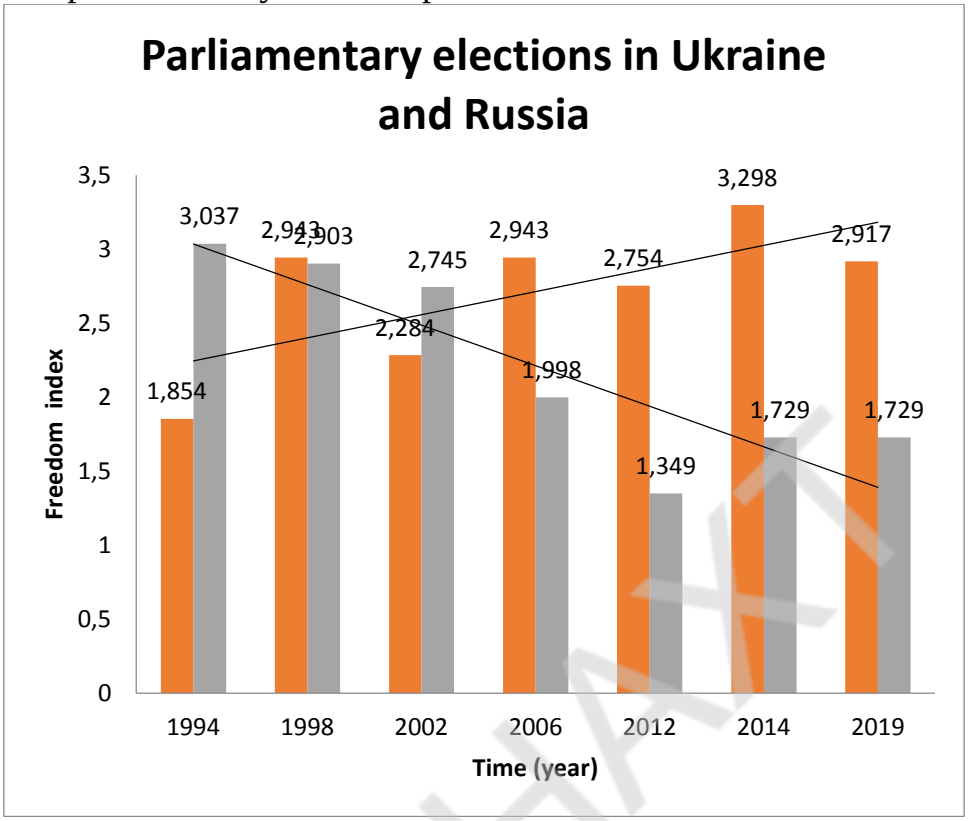

Fig. 8.

The freedom of parliamentary elections in Ukraine and the Russian Federation will also differ significantly in favor of greater freedom of election in Ukraine compared to the Russian Federation. There is a clear tendency for Ukraine to increase freedom of elections, and for the Russian Federation a clear tendency to decrease it. However, there are some differences. The freedom of parliamentary elections in the Russian Federation started with higher values compared to Ukraine. The tendency to significantly reduce the freedom of parliamentary elections in the Russian Federation has become apparent over the last twenty years, when the concentration of power in the hands of the President has increased markedly.

Conclusions:

1. As in the case of the presidential election, the results of all recent parliamentary elections in Ukraine and the Russian Federation differ significantly in favor of greater freedom of election in Ukraine.

2. From the comparative analysis of the presidential and parliamentary elections in Ukraine and the Russian Federation, in our opinion, it follows that the significant difference between the election results in both countries for nearly thirty years testifies to the significant mental difference between the Ukrainians and the residents of the Russian Federation.

3. The index of freedom election in Ukraine is fully consistent with, and sometimes exceeds, the index of freedom election in the leading EU countries. In our opinion, this testifies to the mental closeness of Ukrainians to the peoples of the European Union.

4. The index of freedom election in the Russian Federation is substantially lower than the value of this index for the leading countries of the European Union and

Ukraine. This, in our opinion, testifies to the mental difference of the peoples of the European Union, together with Ukraine, from the peoples of the Russian Federation.

5. All the characteristic features of the bihavior of the index of freedom elections, as seen in the example of two countries with a common history, are of a lasting nature and indicate the existence of deep internal causes of such differences.

6. The mere possibility of noticing the smallest details of both the presidential and parliamentary elections in both countries at the number level indicates, in our opinion, that the formulas proposed by the authors for the election analysis are an effective tool for quantitative research on this political process. We believe that this approach can be applied to quantitative analysis and other aspects of political life in different countries.

7. The some basic ideas of the work have already passed some validation among the scientific community [7,8].

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CREATION OF INFORMATION TECHNOLOGIES BY THE MULTIMEDIA TRAINING COMPLEX FOR TEACHING STUDENTS OF THE 5TH GRADES OF THE BASICS OF ALGORITHMIZATION AND PROGRAMMING

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Abstract*.Technological changes taking place in modern society require students to become familiar with the basic principles of robotics. To do this, children should learn the Scratch programming language taught in computer science lessons in grades 5-6.*

Purpose of the work: description of the process of creation of multimedia training complex by means of information technologies for teaching students of the 5th grades of the basics of algorithmization and programming.

Tasks that were solved: to analyze the interpretations of the concept of "multimedia training complex"; compare the capabilities of software to create different components of a multimedia training complex; to develop and describe the stages of the process of development and creation of a multimedia educational complex; create a multimedia training complex and evaluate its quality; to develop methodological guidelines for teachers on the use of the created multimedia training complex in the educational process and a system of instructions for students to work with the offered educational product.

On the basis of the analysis of psychological and pedagogical works the definition of "multimedia training complex" is specified. As a result of comparing the capabilities of the software, a program has been selected to create a multimedia training complex. The stages of its creation are defined and described.

Emphasis is on continued work on the development and creation of a cover print in the form of a pipe to enhance the organization of work for students in the lesson.

Keywords*: multimedia training complex, Articulate 360, stages of creating a multimedia training complex.*

I. Introduction

In the conditions of the widespread introduction of high technologies in all spheres of life, the problem of an acquaintance of students with the basic provisions of robotics becomes urgent.

In accordance with the New State Standard for Secondary Education, practicing teachers (A. Vasilyuk, Y. Vinnytsky, A. Grigoriev, P. Klimenko, K. Nifantiev, and others) are developing elective courses, one of which is Robotics. In particular, Y. Vinnitsky and A. Grigoriev, considering the peculiarities of the organization of teaching students 8-9 grades of the basics of robotics, emphasize that before starting to program robotic platforms, children should master the language of Scratch programming, which is learned in computer science lessons in Grades 5-6.

The Concept of the New Ukrainian School focuses on "the cross-cutting use of ICT in the educational process, which should move from one-off projects to a systematic process that encompasses all activities" [13, p. 8]. We agree with A. Kolyada's opinion

that "multimedia complexes have the widest opportunities to realize the principle of clarity" [10, p. 121] because they combine text, graphics, video, audio, and other educational materials.

Monitoring the websites of educational fiction publishers has led to the conclusion that there are a number of multimedia training complexes created for elementary and secondary schools. In particular, the multimedia publishing house "Razumniki" specializes in the creation of unified training complexes for different subjects, which are studied in 1-5 or 10 grades, but among them, there is no computer science. The publishing house does not foresee the availability of additional printed materials, which teachers can use in parallel with the training complex. Publishing house "Morning" specializes in creating electronic interactive textbooks on the mozaWeb platform. Almost all of them are designed for primary school.

Taking into account the necessity of the creation of multimedia training complex by means of information technologies for teaching students of 5 grades of the basics of algorithmization and programming, this work is relevant.

The study examines the process of developing and creating a multimedia training complex for teaching students the 5th grade of the basics of algorithmization and programming, which will help prepare them for perception and further mastering the basics of robotics.

II. Analytical review

A characteristic feature of the modern education system is the widespread introduction of electronic didactic teaching aids in the educational process, which scholars call differently.

The analysis of psychological and pedagogical works [1- 5, 7, 10, 11, 12, 14, 16-18, etc.] has led to the conclusion that among the names found in the scientific and technical literature are the following: «electronic didactic resource» (O. Melnyk, O. Mykytyuk, N. Olefirenko, N. Yantz), «electronic educational resource» (O. Melnyk), «educational software tool» (I. Morkvyan), «computer textbook» (L. Gryzun), «multimedia electronic publication» (DSTU 7157: 2010), "Multimedia Training Complex" (I. Bondar). Common in these terms is that electronic didactic teaching tools include presentations, videos, illustrations, diagrams, word clouds; interactive exercises created in various Internet services; electronic didactic complexes which include electronic textbooks, electronic workbooks, etc., which feature is mandatory for the availability of multimedia content. Combining all this, we will look at the process of creating a multimedia training complex. Let's define the essence of the concept of «multimedia training complex». The problem of creation and introduction into the educational process of multimedia educational complexes was investigated by I. Bondar, A. Kolyada, A. Mohonko, N. Pavlenko, and others.

According to DSTU 3017: 2015, the multimedia training complex can be compared to a multimedia electronic publication, in which the text, sound, graphics, and other information is equally and interconnected using the appropriate software [8].

I. Bondar under the multimedia training complex understands the combination of educational texts with different types of content that ensure the independent acquisition of knowledge on a particular subject on the basis of the user's own learning path [3].

A. Mohonko, considering multimedia training complex as a promising way of teaching children, makes clarification. Namely: «An electronic multimedia training complex for children is a set of specific tasks on a specific topic, which includes educational and entertaining elements, is interactive and promotes the acquisition of theoretical material and practical skills» [12].

Based on the above interpretations of the term "multimedia training complex" by this term we will understand a multimedia electronic publication, which will combine educational texts, supporting notes, creative tasks and other educational or explanatory material to facilitate the learning of the theory and practice.

There are a number of software tools available to create multimedia learning complexes. They are divided into online applications and software that need to be installed on your PC.

The most popular software installed on your computer or laptop is Adobe Captivate, Articulate 360, Gitbook, AutoPlay Media Studio, mozaWeb, PubCode, and others. When comparing their capabilities to create a multimedia training complex, we identified the following: text creation and layout; embedding presentations; video recording and processing; import PDF, Word, Epub, HTML2 or PowerPoint files; availability of interactive templates; creating your own project design; availability of additional services (libraries, cloud storage, etc.); creation of animation, interactive testing, scenarios with virtual reality technology; support for program code; export of e-courses in different formats; placement in the WEB space; publication of the created application for application on different mobile devices; placement of 3D objects payment for using the program (see Table 1).

In order to compare online applications, we paid attention to their ability: to place text, audio, and video information; share textbook editing; publish to the developer platform import various PDFs, markup work in a ready-made application, create electronic tutorials in a mobile application, etc. (see Table 2).

Table 1

General features of the software to create a multimedia training complex

Criterion / Program	Creation and design of the text	Embedding presentations	Record and process video	Import files of various formats (Epub, PDF, HTML2, etc.)	Availability of interactive templates	Creating your own project design	Availability of additional services (libraries, cloud storage, etc.)	Creating animations	Creation of interactive testing	Creating with virtual reality technology	Code support	Exports of electronic course in different formats	Placement in the WEB space	Publication of the created application for use on different mobile devices	Placement of 3D objects	Payment for using the program
Adobe Captivate	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
AutoPlay Media Studio	+	-	-	+	-	+	+	+	+	-	+	+	-	-	-	+
ISpring	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	±
Articulate Storyline 360	+	+ *(Add slides to the created presentation)*	+	+	+	+	+	+	+	+	+	+	+	+	+	±

Kotobee	+	-	+	+	+	+	+	+	-	-	+	+	+	+	+	±
PubCoder	+	-	-	-	+	+	+	-	-	-	-	+	+	+	-	+
mozaWeb	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+

Table 2

General features of online applications to create a multimedia training complex

Criterion / Program	Placement of text, video and audio information	Granting joint access to editing	Publishing a finished tutorial on the developer site	Import PDF-files	Adding notes	Ability to create materials in the mobile app
Gitbook *(https://www.gitbook.com/)*	+	+	+	+	-	-
FlippingBook *(https://flippingbook.com/)*	-	-	+	+	+	-
Active Text Book (*https://activetextbook.com/)*	+	-	+	+	+	+
Book creator (*https://bookcreator.com/)*	+	-	+	+	-	-

A comparative analysis of the capabilities of the software has made it possible to conclude that from all the variety of software that is installed on a computer or laptop and services to create multimedia training complexes *Articulate 360*. This application allows you to work with audio and video content, 3D -objects. It also has interactive templates, the ability to add animation effects, export to different formats, adapt to the use of ready edition on different mobile devices, organizes collaboration on creating your own product.

III. Object, subject and research methods

The purpose of this work is to substantiate the process of the creation of multimedia training complexes by means of information technologies for teaching students of the 5th grade of the basics of algorithmization and programming.

The object of research is a multimedia training complex for teaching students of the 5th grade of the basics of algorithmization and programming.

The subject of the research is the development of the stages of the process of creation of multimedia training complex by means of information technologies for teaching the 5th-grade students.

According to the purpose of the study, the following tasks were set:

– to determine the essence of the concept of "multimedia training complex" on the basis of the performed analysis of scientific and pedagogical and technical literature;

– compare software capabilities to create different components of a multimedia training complex;

– to develop and describe the stages of the process of development and creation of a multimedia educational complex;

– create a multimedia training complex and define criteria for evaluating its quality;

– to develop methodological guidelines for teachers to use the created multimedia training complex in the educational process and a system of instructions for students to work with the proposed educational product.

IV. Results of work

During the creation of the multimedia training complex for teaching the students of the 5th grades of the basics of algorithmization and programming the following steps were distinguished and the following steps were performed:

1. Defining the theme and purpose of its creation.

According to the program in computer science for students of 5-9 grades of general educational institutions in studying the topic «Algorithms and programs» children should: clearly understand and explain the concepts of algorithm and program, be aware of their meaning in life; to know different algorithmic structures, to understand their essence, to be able to distinguish these structures and to apply in solving the task; give examples of the performers and the teams they perform; use the environment to describe and execute algorithms and more.

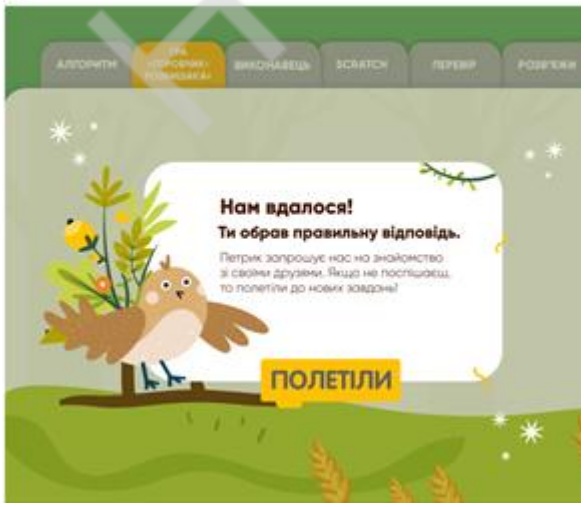
Feature of this multimedia training complex is:

− organizing trips to countries of the world (Ukraine, Israel, Switzerland, Germany, Finland, South Korea), during which students should familiarize themselves with theoretical material, complete logical or practical tasks, take tests and if desired, perform creative tasks;

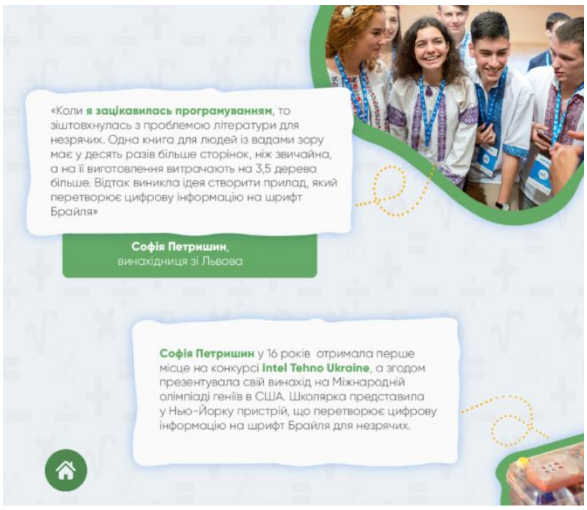
− the introduction of assisting heroes who present tasks for execution, provide clues or outline the theory of the game. For example, "Panda Superhero" – learns with programming students. Animals or birds are symbols of the countries where the study tour is conducted). "Beaver" – a symbol of the international competition in computer science (it means the presence of a creative task);

− the presence of pages with motivational text (Pic. 1) or interesting facts about the development of the IT industry in the country where the lesson was stopped (Pic. 2). Preferably, each supplemented motivational insert animation gif;

− creating animated tips; explanatory text that pops up when you hover your mouse cursor.



Pic. 1. Design of motivational insertion



Pic. 2. Window with interesting facts

2. Define the target audience.

The target audience is 5th-grade students (9-12 years old), who study in various secondary education institutions, either in distance education or in external studies.

3. Determination of the functions that multimedia training complex should perform.

Among the features that should be implemented with the help of this multimedia training complex were the following:

− motivational (facilitating the emergence of students' interest in mastering the basics of algorithmization and programming for further use in the study of other elective courses, in particular, in robotics);

− informative (knowledge formation on the topic "Fundamentals of algorithmization and programming"; ability to apply basic structures of the algorithm in solving practical tasks; developing skills for their use in creating code in Scratch programming environment, etc.);

− supervising (diagnosing students' level of learning with the help of different types of controls (tests, interactive exercises, tasks for practical implementation in the Scratch programming environment);

− reflexive (enabling students to control their knowledge and skills independently).

4. Definition of technical requirements.

The multimedia training complex that is being created should be properly opened, either on a desktop computer or laptop or a smartphone or tablet; no additional installation on the device and no additional applications.

Given these requirements and the results of the analysis of the capabilities of the software for creating multimedia training complexes, we have chosen the program Articulate 360.

5. Identification of topics, selection, elaboration, and development of material required.

Following with the stated purpose of creating a multimedia training course, material from the basics of algorithmization and programming was elaborated, given in textbooks and workbooks for the 5th grade and the necessary educational or explanatory texts were determined. On their basis it was:

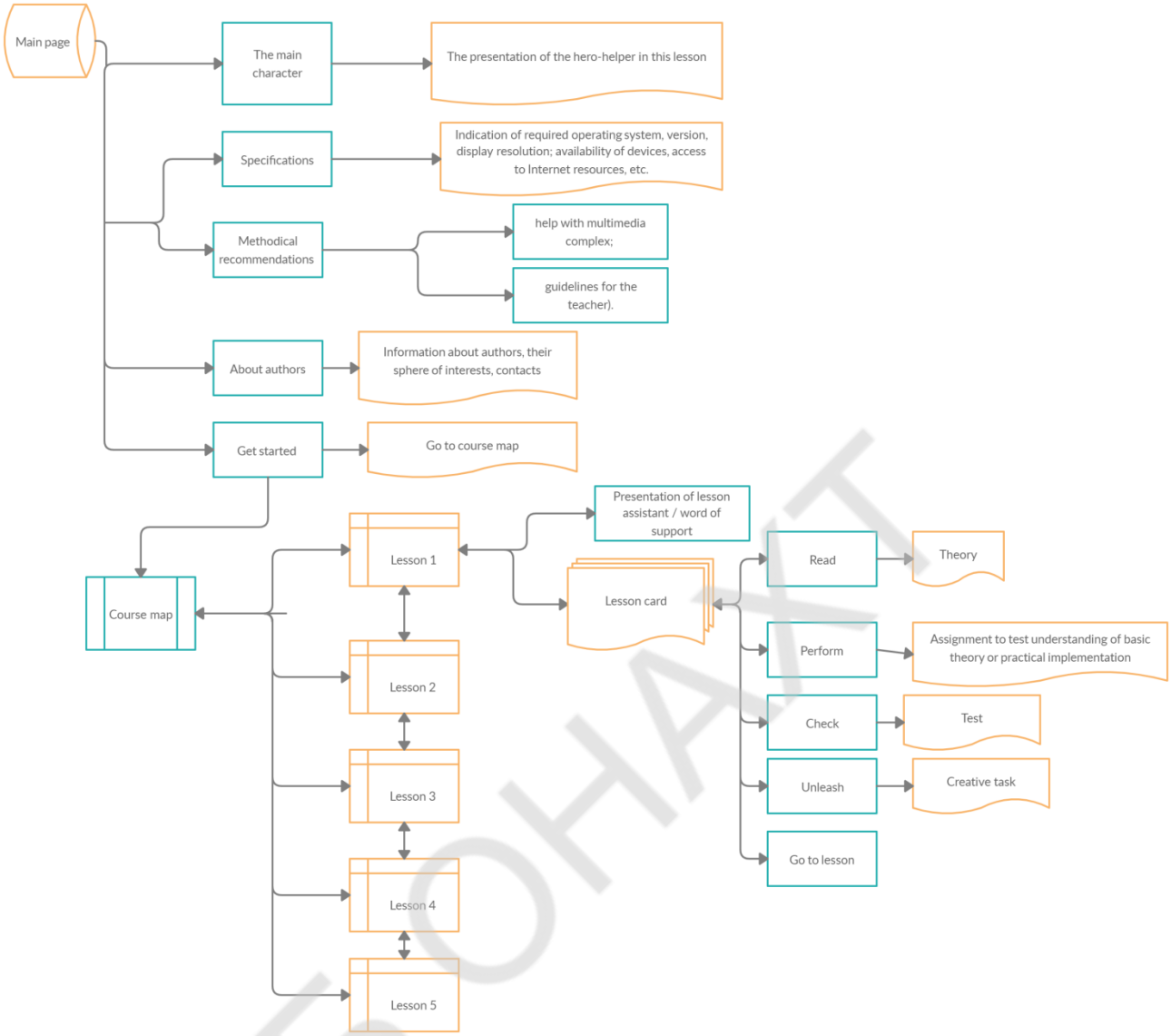
− synopsis lessons have been developed to which reference notes have been created, presented in the form of diagrams, tables, interactive posters, etc;

− formulated creative tasks and tasks for independent practice or performance;

− developed guidelines, tips for implementation and so on.

6. Development of structural scheme of multimedia training complex, determination of its main elements and ways of their presentation.

Following with the defined purpose, objectives and lessons learned, the following structure of the multimedia training complex was developed (see Pic. 3).

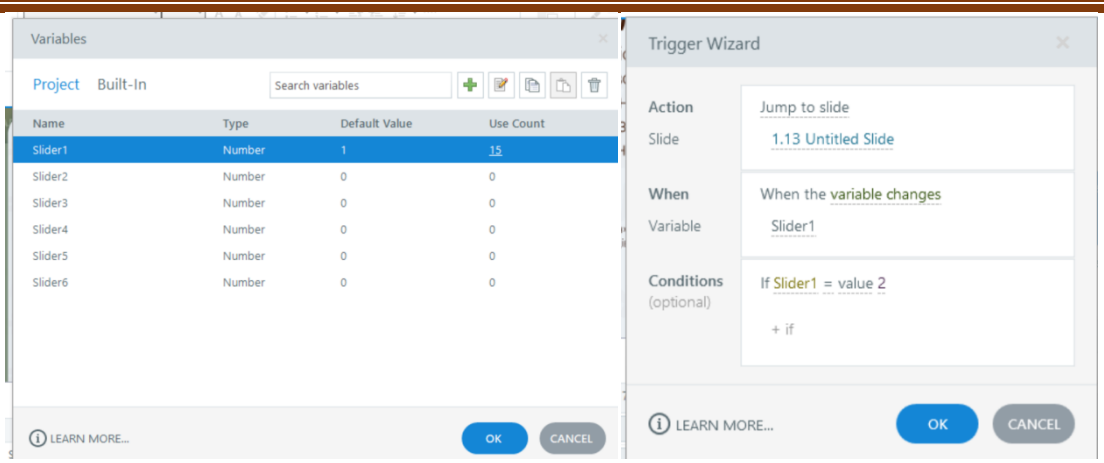


Pic. 3. Structure of the multimedia training complex

7. Develop a system of guidance for students on how to work with a multimedia training complex with the use of multimedia and interactive elements.

The electronic edition provides various multimedia and interactive elements. The buttons were created using the «Insert Picture» – «Trigger Wizard» feature. In the window «Trigger Wizard» we provide the button of functionality. Usually, these were «Jump to slide», «Show layer», «Change the state of» (Select (for button illumination), Hover (for a button with popup tips)). The Hover function is specified in the Timeline - State field.

In addition to the usual buttons, the edition contained a slider that was designed using the Slider function. However, for it to work correctly, two ways were tested: inserting a slider into layers (hidden pages in a slide) and inserting a slider into slides (pages) of a project. Unfortunately, the first variant did not work correctly, so the author developed his method of using the "Variables" function. The author manually set the values of the variables that the slider should perform (Pic. 4).

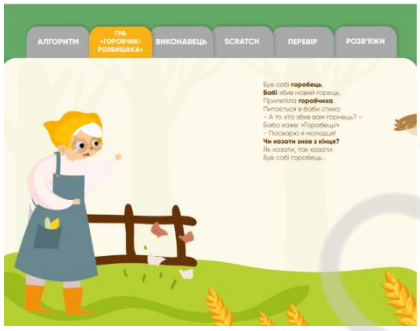


Pic. 4. Application of variables

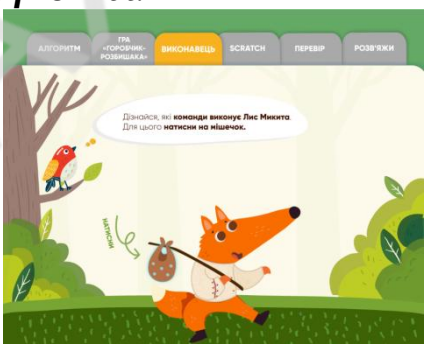
8. Developing and designing the necessary content (creating animated stories or hints, videos and audio tracks).

The animation was created for the dynamic presentation of educational material using programs such as Adobe Photoshop, Articulate 360 (Pic. 5 and 6).

Animation created in Adobe Photoshop is saved in ***.gif*** format.



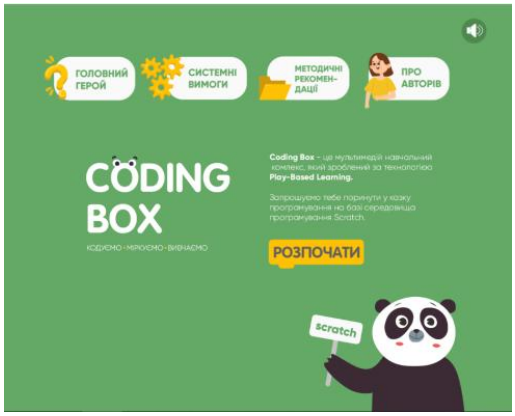
Pic 5. An on-screen copy of a snippet of the animated story



Pic. 6. An example of an animated tooltip *(Click arrows)*

The multimedia educational complex contains audio and video materials.

The audio tracks can be edited or recorded in the Articulate Storilane program itself. It is worth noting that the publication contains not only music (recorded by the author of the edition), but also audio explanations of individual tasks. Added audio tracks were saved in ***.mp3*** format (Pic. 7).

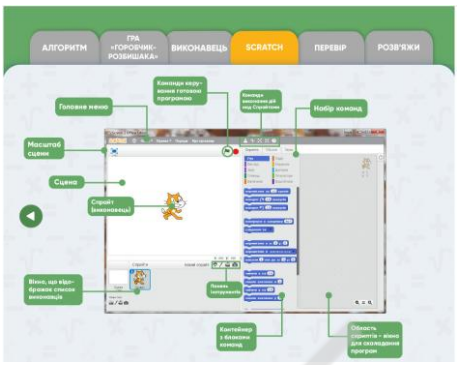


Pic. 7. Placing the audio track on the main page of the project

9. Creating and processing graphic images (interface elements, circuits, actors, etc.).

The multimedia interface has been created in Adobe Illustrator. An example of one of the created windows is shown in pic. 8 and 9.

Pic 8. Example page



Pic. 9. Scratch programming environment diagram

10. Defining the type of tasks for knowledge assessment.

Two types of testing were chosen during the development process. Test tasks were performed using Articulate 360.

Multiple responses. The correct answer consists of more than one option (see Pic. 10).

Matching. This type of interaction represents two types of elements. The student must connect each element of the first row to the element of the second (see Pic. 11).

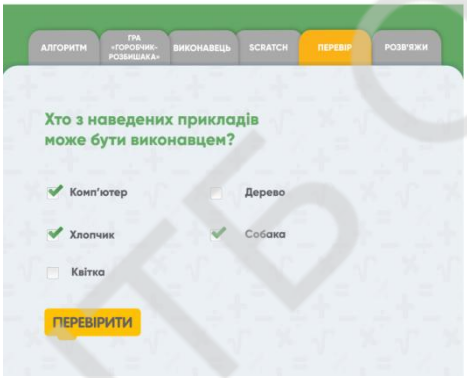


Рис. 10. Multiple responses

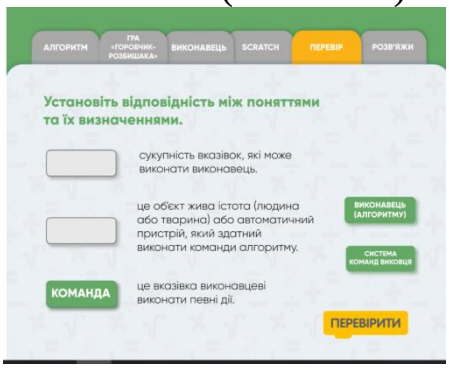
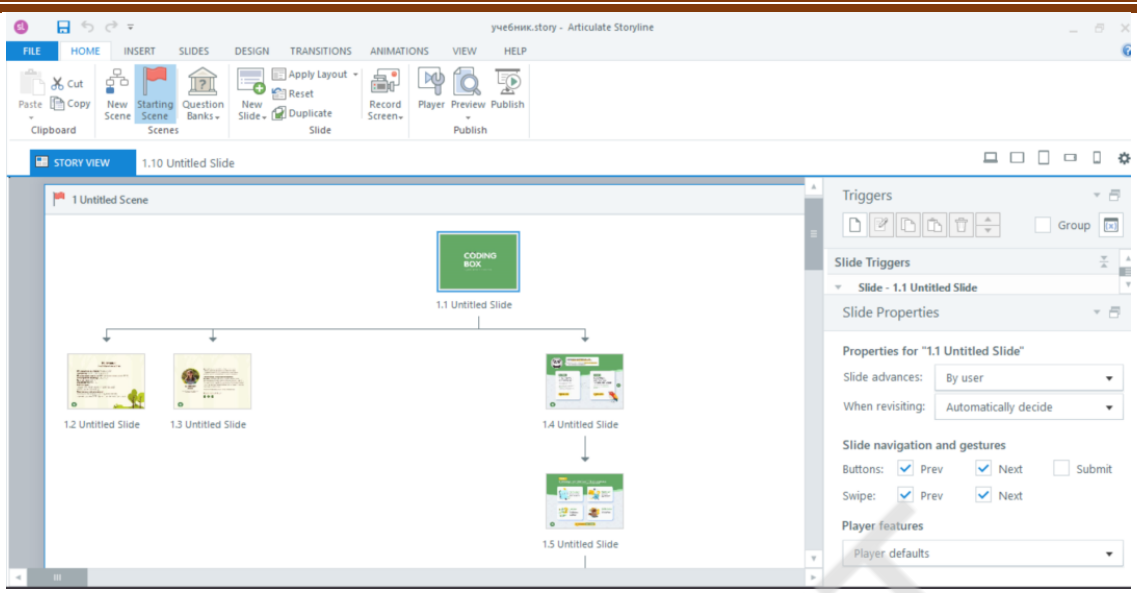


Рис. 11. Matching

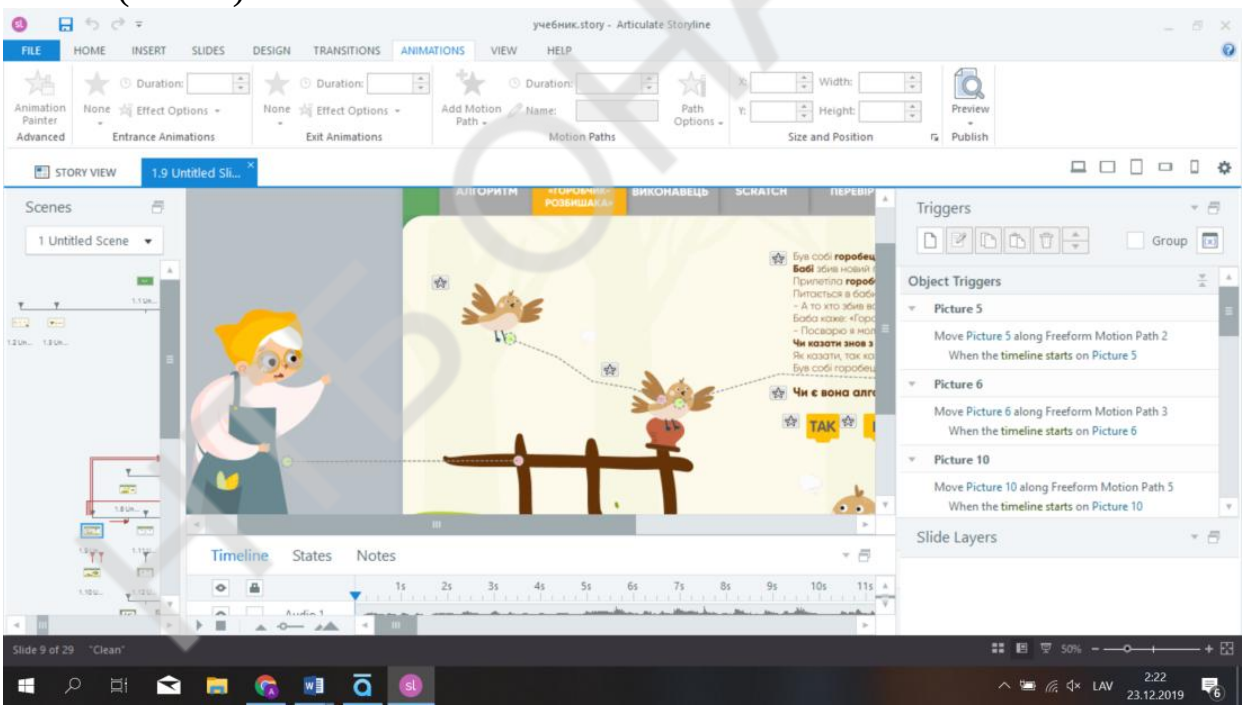
11. Composition of all created elements of the multimedia training complex.

The peculiarity of the layout of all the created elements of the multimedia training complex in the Articulate 360 program is that it has a structural diagram of the project itself, with which you can view the connections between the slides (Pic. 12) and automate the work of the embedded elements.



Pic. 12. Structural diagram of the project in the Articulate 360 program

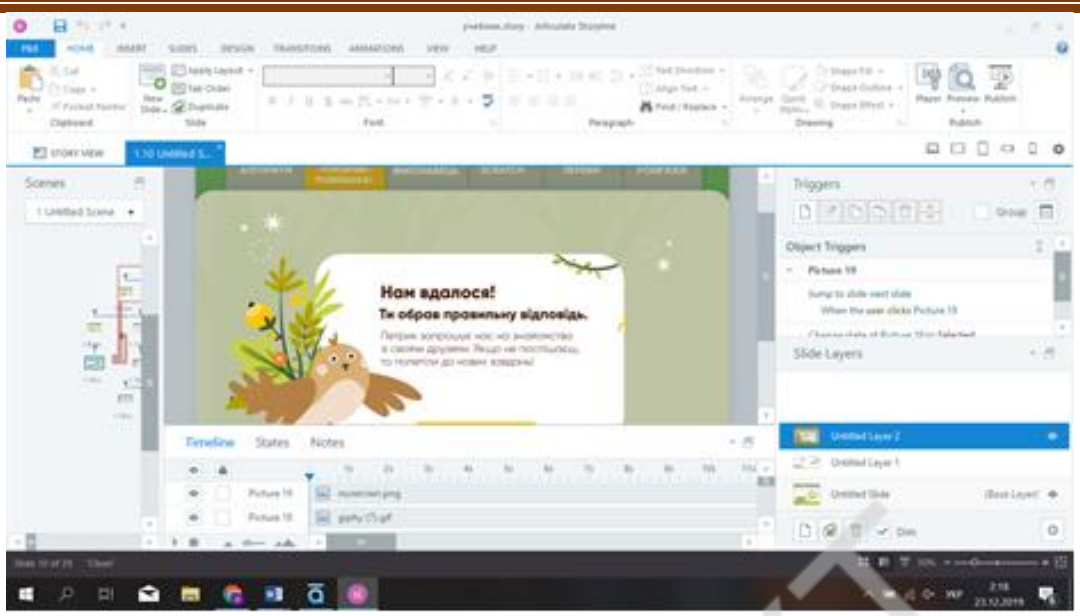
When creating page-to-page transitions as well as animation elements in the middle of the pages, the manual method - Animation - "Add Motion Path" - "Freedom" was used. Each animation must specify the time of appearance and the time of disappearance on the Timeline scale (Pic. 13).



Pic. 13. An example of adding animation to a project slide

Hidden layers on the slide were used to optimize the project. They are usually added to slides where there is a task and it is necessary to show motivational speech bauble when the right answer or the wrong one was chosen.

The layers are set using the New layer function in the slide and layer editing panel (Pic. 14).



Pic. 14. Example of using layers on a slide

12. Testing the correctness of the work of all elements of the complex, if necessary - it's debugging (error correction).

There are three types of testing: α-testing, β-testing, and testing on a computer user's.

Alpha testing (α) involves bug detection by the software developer. It encountered the following errors as a failure to configure buttons that would allow the user to move from one page of the lesson menu to another.

Beta testing (β) is conducted with the participation of invited users. This type of testing was done using the service https://360.articulate.com/. The saved project was able to be protested by five people who did not find any errors in the technical part but provided recommendations regarding the ergonomics of the interface.

After debugging, the final version of the project was saved in different formats.

The testing of the project was carried out on the operating system Windows 10. During testing, the program worked without interruption.

After testing, the finished product was recorded on a disk for which a special cover design with the original data was created (Pic. 15).

Pic. 15. An example of the created back of the cover disc boxes

13. Development of methodological guidelines for teachers to use the created multimedia educational complex in the educational process.

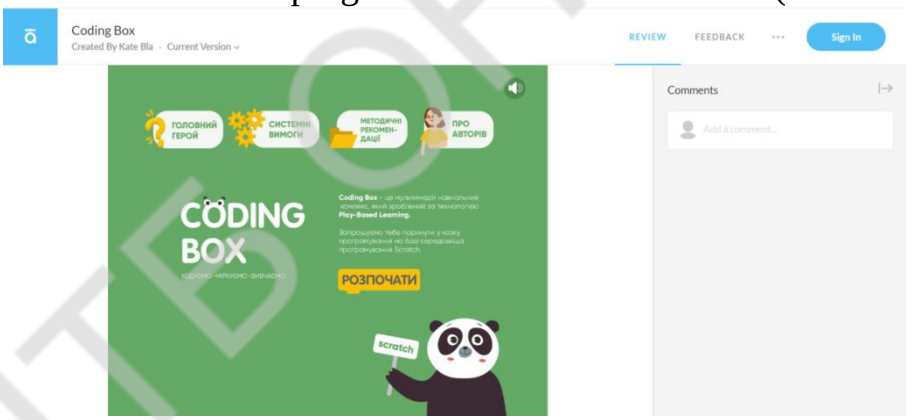
The multimedia suite includes a tutorial that was developed in Adobe InDesign and published as an interactive pdf (Pic. 16).

The edition also includes hyperlinks that are embedded in the middle of the images.

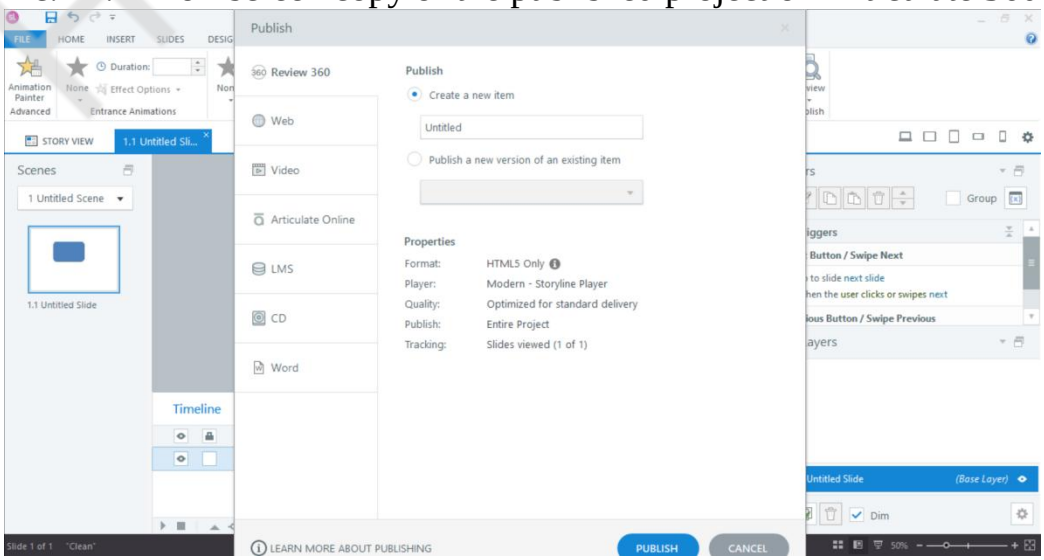
Pic. 16. Help with multimedia complex

14. Saving the created complex on the storage medium.

One of the benefits of using Articulate is storing a finished project in several formats. Namely, as an application that is installed on your computer and a web page that can be accessed on the website of the program itself or in the browser (Pic. 17 and 18).



Pic. 17. An on-screen copy of the published project on Articulate 360



Pic. 18. Save the project in different formats

15. Evaluation of the quality of the created product.

The multimedia training complex was provided for peer review by teachers of computer science and teachers who teach information technology in pedagogical institutions of higher education. As a result, some errors were identified in the formulations and tasks provided, which were revised and corrected and guidelines developed for teachers regarding the use of the created multimedia educational complex in the educational process, and a system of guidance for students to work with the offered educational product was created.

The beta version of the complex was used by the authors during the lessons of computer science in the 5th grade during the pedagogical practice, which allowed us to identify and take into account certain shortcomings in the structure of the complex.

V. Conclusions

Created by the described stages multimedia training complex for teaching students 5 grades of the basics of algorithmization and programming aimed at improving their understanding of the terms "algorithm", "executor", "guidance system performer"; knowledge of types of representation of algorithms; the ability to transform algorithms from verbal to graphic or vice versa, to apply different algorithmic structures when performing practical tasks.

Our study does not exhaust all aspects of the problem raised. In the future, it is planned to develop printed editions in the form of notebooks, which will increase the possibilities of organizing the work of students while learning new complex material.

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AUTONOMOUS SOIL MOISTURE MEASUREMENT SYSTEM WITH WIRELESS DATA TRANSMISSION

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Abstract.The aim of the project is to develop a model of an autonomous device for measuring soil moisture with wireless transmission of parameters and visualization of data on the display.

The main task of the project is: analysis of prototypes of systems for remote transfer of data; research and development of algorithms for remote transfer of data through I2C protocols, and their remote (wireless) transmission to any distance; practical implementation of the project with the production of real working system.

The proposed project involves the development of a stand-alone soil moisture measurement device for real-time data transmission and processing. Data transmission is carried out via GSM channel, which causes its application in almost any area where there is coverage by mobile operators.

This project proposes the development of a stand-alone device for measuring soil moisture with autonomous battery power. The system is designed to collect and analyze soil moisture data at a depth of up to 1 meter.

As a result of our research and development, we have obtained a prototype of the system that operates at the department of the university where the project was carried out. The system provides real-time data transmission

Introduction

The development of modern digital automated systems for monitoring and control of environmental parameters with the possibility of wireless data transmission and their further processing and visualization is of great interest to potential customers as it provides ample opportunities for autonomous operation of the system, complete automation of data collection and processing and is independent of human influence on the quality of the results obtained.

The development of a digital soil moisture measurement system for real-time data transmission and processing is of great interest in a variety of agro-firms and agro-complexes and relates to modern *remote control systems*, which provides additional capabilities for creating a control and forecasting system for complex irrigation systems in Ukraine under conditions of constant warming and increase of arid territories [1-3]. The implementation of this system creates the basis for the development of an automation system for the collection and processing of environmental data. *Remote control systems* based on the introduction of modern information and telecommunications technologies, in particular known as *the Internet of Things (IoT) (Internet of Things)* [4].

This project, which is devoted to the study and development of signal processing processes, uses new data transfer models. This paper proposes solutions that allow the design of an autonomous soil moisture monitoring system with the possibility of wireless data transmission over a GSM channel and their visualization in real time.

The parameters to be measured and transmitted are soil moisture at different depths from 10 to 100 cm.

Models and methods for processing and transmiting data that are proposed in this project are published and tested at the conference [11].

Analytical review of the literature

In the conditions of constant climate change, increase of temperature regimes, changes of climatic zones, the issues of introduction of various irrigation systems become more and more acute[5].

One of the conditions for the effective implementation and operation of such systems is the constant monitoring of soil moisture with the possibility of automated collection and processing of data from large areas without human intervention.

The conducted analysis of the market of Ukraine showed the practical absence of such autonomous soil moisture control systems, and the existing systems are operated manually. Often (as a rule) irrigation of the fields is carried out by the subjective assessment of the responsible person, which leads to incorrect ascertainment of norms and timing of irrigation, which leads to loss of hostility.

To eliminate such shortcomings, it is proposed to automate the process of soil moisture control at a depth of 10 cm to 100 cm with the transmission of data on the radio channel to the control point (server), which makes it possible to analyze the collected data, draw irrigation maps and timing of their implementation. Particularly relevant are similar measures in large areas for cultivation of crops that are sensitive to lack of moisture.

Let us analyze the systems and prototypes that are intended to measure soil moisture and determine the methods and conditions of implementation of the system that will be used to accomplish the task.

Overview of soil moisture measurement systems

The purpose of this project is to create a device that will have sufficient measurement accuracy, the ability to measure soil moisture at different depths up to one meter. As it is often the case that the topsoil is more moist than the bottomsoil, it is necessary to optimally analyze the moisture content, as well as the ability to remotely transmit data to the control point.

Soil hydrometer, garden, DMG-1. DMG-1 soil moisture meter [6]. This hydrometer can be used to determine the soil moisture level of both garden and houseplants (Fig. 1).

Figure 1 - Soil moisture meter, DMG-1

Specifications of soil moisture meter DMG-1 are shown in table table.1

As can be seen from these characteristics, the depth of measurement is not large enough and there is no possibility of data transmission over a distance.

Table 1

Technical characteristics of the device

Length of the measuring probe	196 mm
Humidity measurement range	from 0 to 10 units
Hydrometer material	Plastic
The probe material	copper and zinc alloy
Color	Green
Feeding	do not need
Dimensions	285 mm x 50 mm
Mass	48 grams

TRIME-PICO radar soil moisture meters for mobile soil moisture measurement. TRIME TDR - humidity probes from IMKO [7].

Fig. 2 - TRIME-PICO radar soil moisture meters

The hydrometer soil TRIME-PICO (Fig. 2) can measure both electrical conductivity and humidity, soil temperature, and salt content at different depths directly on site, without the need for labor-intensive laboratory methods. Unlike other measurement technologies, the TRIME-PICO64 and PICO32 moisture meters guarantee accurate measurements even at high temperatures and electrical conductivity. Due to its mechanical strength, the TRIME-PICO64 moisture meter is the optimal solution for mobile applications with the PICO-BT Bluetooth module or the reliable handheld HD2 humidity meter. However, such a device makes it impossible to carry out autonomous measurements at different depths up to 1m. and there is no long distance data transfer capability.

Measurement of soil moisture and other materials using the TRIME-PICO 64 radar moisture meter. A high-tech sensor with an integrated TDR electronic unit measures 3 parameters: water content, temperature, electrical conductivity and salt content with an SDI-12 interface.

Table 2.

Technical characteristics of the device

The range of measured values	0..100%
Supply voltage	7-24B DC
The length of the rod	160 mm
Moisture and dust protection	IP68
Price	From 60000 UAH.

Professional hydrometer with microwave TKM-300 sensor

Professional hygrometer [8] with microwave sensor is first of all convenience and ease of operation if necessary to accurately measure humidity:

- bulk dry mixtures, construction and food
- narrow mushy substances (eg cement, gypsum, dough)
- conductive salts
- soil / soil
- soot, coal

Fig. 3 - hydrometer with microwave TKM-300 sensor

The principle of operation of the device allows to check the production even packed in bags, wrapped in plastic wrap, in cardboard boxes, PET containers. The external type of the sensor of 230 mm long allows to measure humidity inside a material, an embankment, inside viscous solutions.

The TKM-300 is equipped with nine calibrations, zero 0.00% calibration, screen illumination. Powered by standard 9V Crohn's battery (1 pc).

Table 3

Technical characteristics of the device

Display	LCD, backlight
Humidity measurement range	0 ~ 90%
Operating conditions (temperature)	0 ~ 60 C
Operating conditions (relative humidity)	0 ~ 90% RH
Resolution	0,1%
Error	0,5% (1 + n)
Weight	200 г
Dimensions of the device	160 * 70 * 27 mm
Probe	230 mm
Sensor diameter (probe)	6 mm
Price	5900 UAH

Object and research methods

Currently, there are many methods for measuring soil moisture - direct, indirect and remote. Here is a brief overview of how to use one of these for the task at hand.

Direct methods include the extraction of water from a soil sample by evaporation, washing and chemical reaction. Soil moisture is calculated based on the weight of water extracted and dry soil.

Indirect methods include measuring some soil characteristics depending on the water content. They can also measure the characteristics of a particular soil object, usually a porous absorber.

Modern technologies allow us to measure soil moisture at a depth of 0-100cm using satellites (http://ieassa.org/en/). This is possible due to their microwave scanning feature.

Then the obtained data are refined taking into account the amount of rainfall and the type of soil, resulting in the most accurate of the currently existing indicators of soil moisture. It should be noted that this approach is quite expensive and has not yet become widespread.

Indirect methods require pre-calibration to determine the relationship between the moisture content of the material and the measured physical value. Below we look at different methods of indirect measurements of soil moisture in green spaces.

There are various indirect methods of measuring soil moisture [10]: capacitive, resistive, thermistor, optical.

1. Capacitive humidity measurement method.

Capacitive hygrometers, in the simplest case, are capacitors with air as a dielectric in the gap. It is known that dielectric constant in air is directly related to humidity, and changes in dielectric humidity also lead to changes in the capacitance of the air capacitor.

Fig. 4 - Capacitive humidity sensor

2. Resistant humidity measurement method.

Such a sensor is shown in Fig. 5 includes two electrodes, which are deposited on the substrate, and on top of the electrodes is applied a layer of material, which has a fairly low resistance, strongly, however, variable depending on humidity.

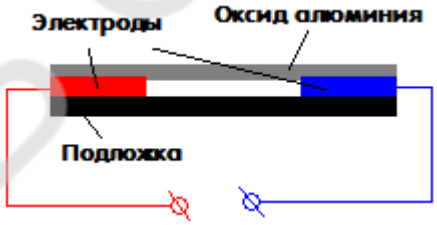

Fig. 5 - Resistant humidity sensor

Suitable material in the device may be aluminum oxide.

3. Thermistor method of measuring humidity.

The thermistor hygrometer consists of a pair of identical thermistors.

One of the thermistors included in the scheme is placed in a sealed chamber with dry air. The other is in the chamber with the openings through which it enters the air with the characteristic humidity that needs to be measured. Thermistors are connected by a pavement circuit, voltage is applied to one of the diagonals of the bridge, and readings from the other diagonal.

When the voltage at the output terminals is zero, the temperatures of both components are equal, so the humidity is the same. If the output is not zero voltage, it indicates the presence of a difference in humidity in the chambers. Thus, the value obtained in the measurements of the voltage determine the humidity

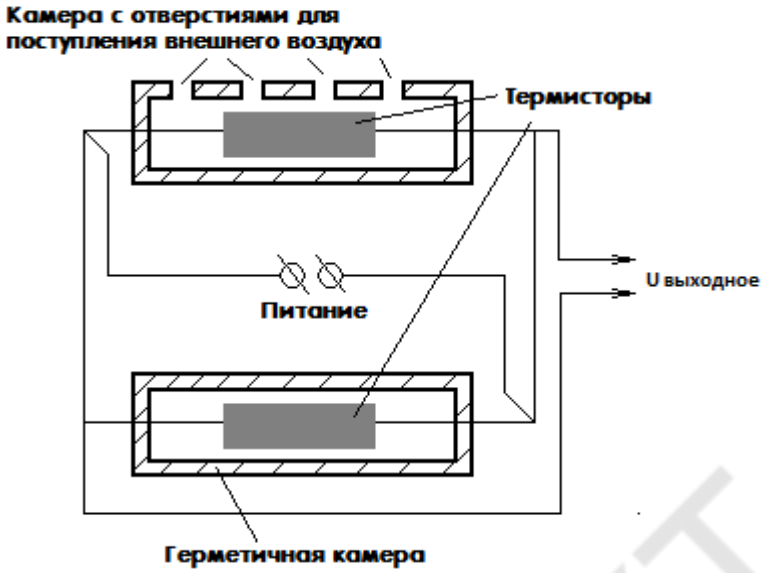

Fig. 6 - Thermistor humidity sensor

As the humidity increases, water begins to evaporate from the thermistor housing, while the temperature of the housing decreases, and the higher the humidity, the more intense the evaporation occurs, and the faster the thermistor cools.

4. Optical method for measuring humidity.

This type of sensors is the most accurate. At the heart of the optical humidity sensor is the phenomenon associated with the concept of "dew point". At the moment of reaching the dew point temperature, the gaseous and liquid phases are in terms of thermodynamic equilibrium.

So, if you take the glass, and set in a gaseous medium, where the temperature at the time of study above the dew point, and then begin the process of cooling of the glass, then at a specific value of temperature on the surface of the glass begins to form water condensate, this water vapor will go into the liquid phase . This temperature will be just the dew point.

Results of work

This project proposes the development of a digital soil moisture measurement system in an automated mode at different depths (from 10 to 100 cm) with the transmission of data via the GSM channel for their further processing, storage and visualization as a time trend on the web server.

The project provides flexible solutions for the system equipment with additional sensors (for example, a sensor for measuring soil temperature, etc.), which allows to expand its capabilities.

The schematic design of this system is shown in Fig. 7 This design will be stationary use, which will be left in a specific place for a long time. It will be powered independently from the solar battery, which will be located in the front panel of the case.

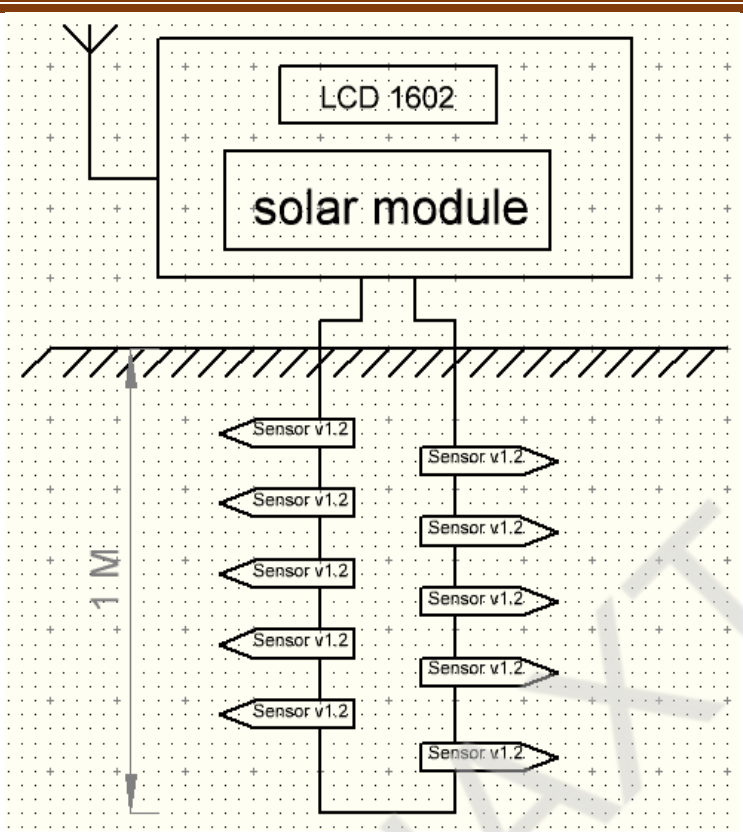

Figure 7 - Schematic representation of the product design

This project is based on the Arduino MEGA2560, all power to this unit comes from a 4.2V lithium-ion battery. The GSM 800L GSM module is used to transmit impressions via radio chenel. For convenience, we used a two-line 16-character LCD display designed to display indicators from 10 sensors, which are located at a depth of 0.1 to 1m. The block diagram of the device is shown in Fig. 8

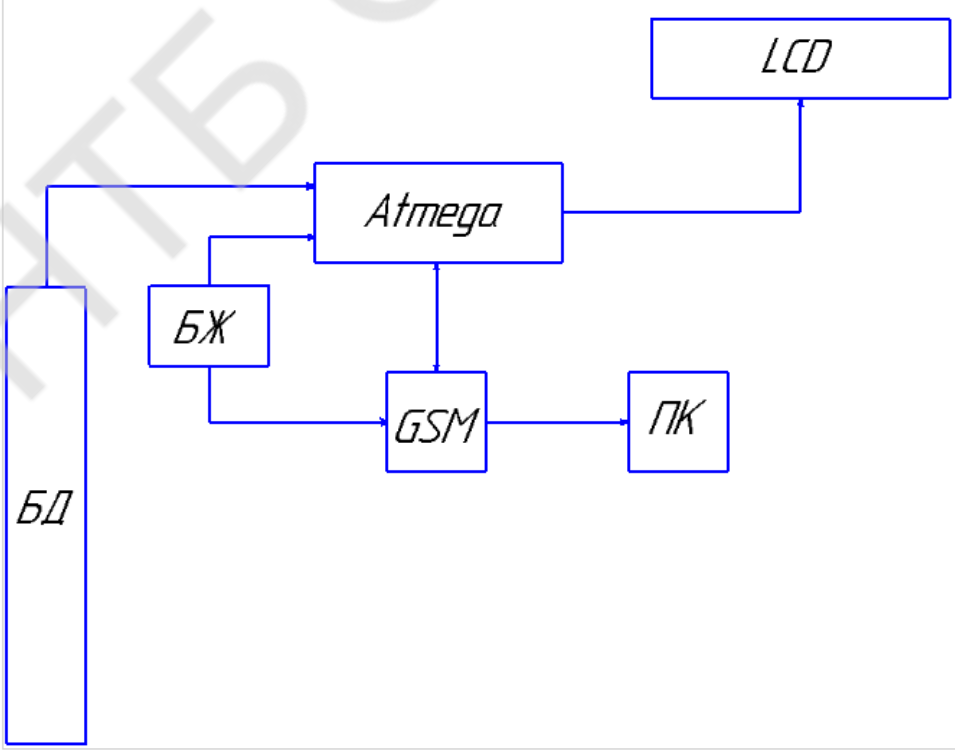

Fig. 8 - Block diagram of the device for humidity measurement and data transmission over GSM channel

The block diagram shows: БЖ – Power Supply; БД – sensor unit; Atmega – Arduino Mega2560; LCD – display 1602; GSM – GSM module SIM 800L; ПК – personal computer (web server).

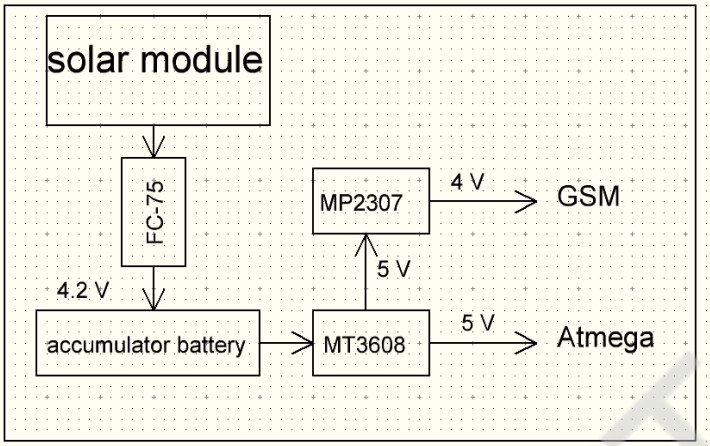

Fig. 8 - Structural diagram of the power supply unit

The block diagram shows: Solar module – solar module; FC-75 - Li-ion battery controller; Accumulator battery – 18650 battery; MT3608 – step-up voltage converter DC-DC 2-24V 2A; MP2307 – DC-DC reducing voltage converter MP2307 5-23V 1-17V.

The principle of operation is based on the measurement of soil capacitance by sensors located in the sensor block at a distance of 10 cm from each other. An analog signal is fed to the ATmega2560 microcontroller, processed and output for in percentage display on the LCD.

The display of indicators is carried out in several stages. First, the readings from the first sensor are displayed, then the second, etc. The time delay between switching is 2 seconds. and can be changed according to the needs of the user. After that, all the readings enter the GSM module block and are sent to the user's server (PC or a specially developed web application).

After one cycle, the device goes into sleep mode in order to save energy. After some time, the process repeats and the data is again transmitted to the user. This approach can significantly save batteries, contributes to the long-term explantation of the device in offline mode.This unit can be equipped with an additional more powerful antenna that connects to the GSM module if necessary. Therefore, the device can be used in virtually any conditions that could interfere with data transmission (bad weather, unstable mobile communications)

Table 4

Technical characteristics of the device

Supply voltage	from 4-5B DC
The range of measured values	0..100%
Type of execution	Stationary
GSM data channel	Kyivstar mobile operator
Moisture and dust protection	IP65
Display	LCD, backlight
Dimensions of the sensor	99x16mm
Error	0,5% (1 + n)
Ability to transmit under difficult reception conditions	yes

The scheme of electrical connections of the device is shown in Fig. 9. All power to this unit comes from a 4.2V lithium battery. The GSM 800L GSM module is used to transmit signal via radio channel. A two-line 16-character LCD display is connected by a four-wire circuit. Humidity sensors have been selected as a self-contained capacitive type sensor, similar to Sensor v1.2, as they are resistant to corrosion and are more accurate than a resistive type sensor.

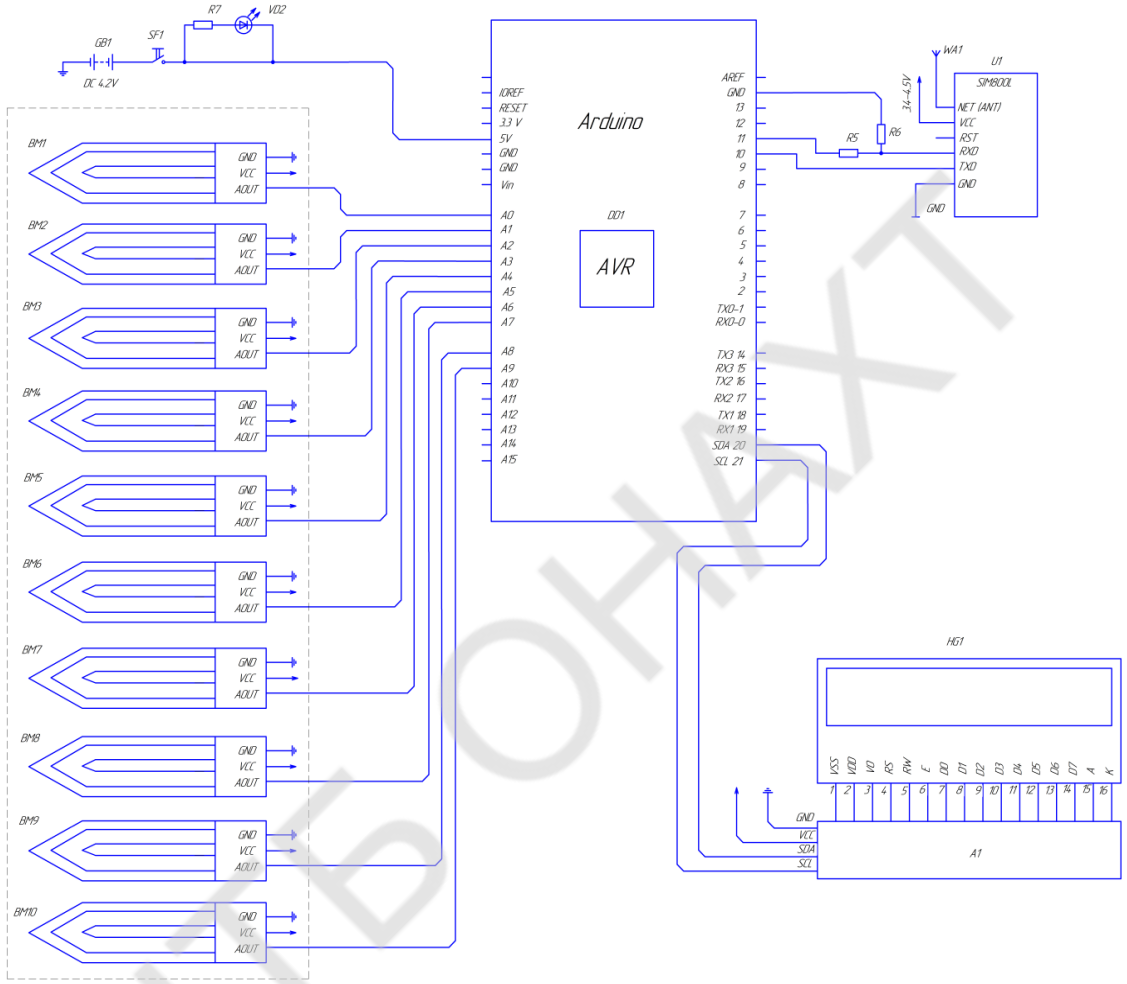

Fig.9 - Schematic diagram of the principle

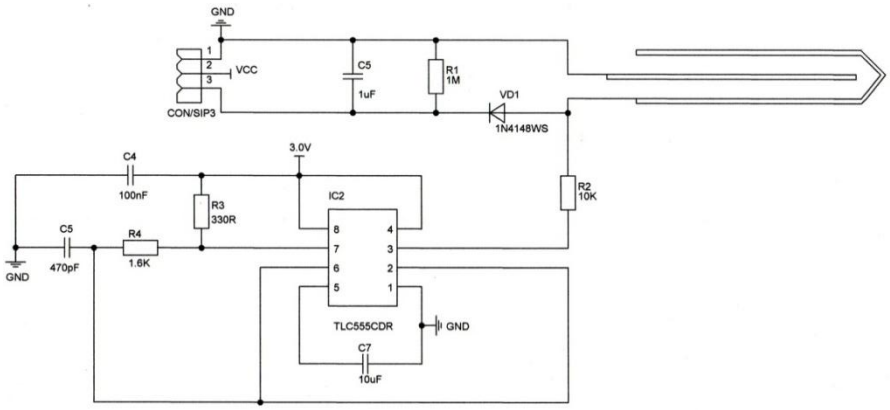

Fig. 10 - Wiring diagram of capacitive humidity sensor Schematic list

In this project, it was decided to replace the Sensor V1.2 soil moisture sensors with a self-made sensor. The principle of operation was based on the measurement of capacitance (capacitive method). The manufacture of sensors was based on LUT technology.

The process of manufacturing sensors.

The first step was the development of a capacitive-type electric sensor circuit.

Microcircuit TLC555	1pc.
Diode 1N 4148	1pc.
Capacitor 1uF	1pc.
Capacitor 100nF	1pc.
Capacitor 470pF	1pc.
Capacitor 10uF	1pc.
Resistor 1M	1pc.
Resistor 10K	1pc.
Resistor 1.6K	1pc.
Resistor 330R	1pc.

In the Sprint-Layout environment, a PCB layout was developed, the diagram of which is shown in Figure 11. The external dimensions of the sensor are 100x31mm, which is slightly larger than the size of the Sensor V1.2

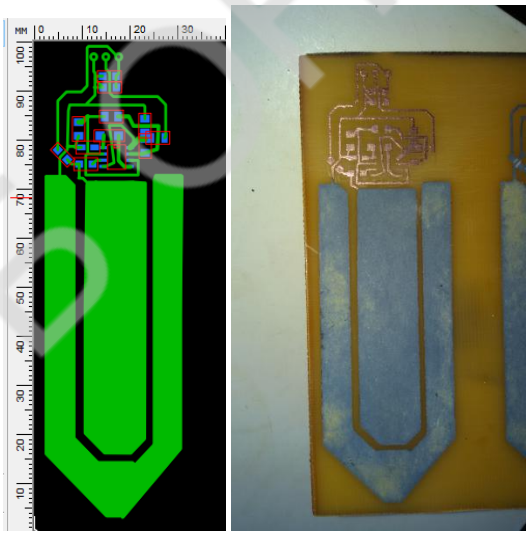

Fig. 11 - Sensor circuit board

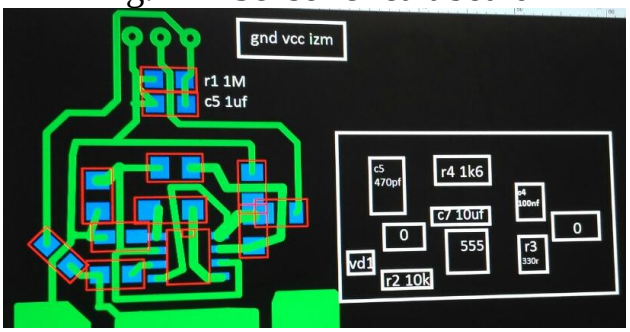

Fig. 12 - Sensor wiring diagram

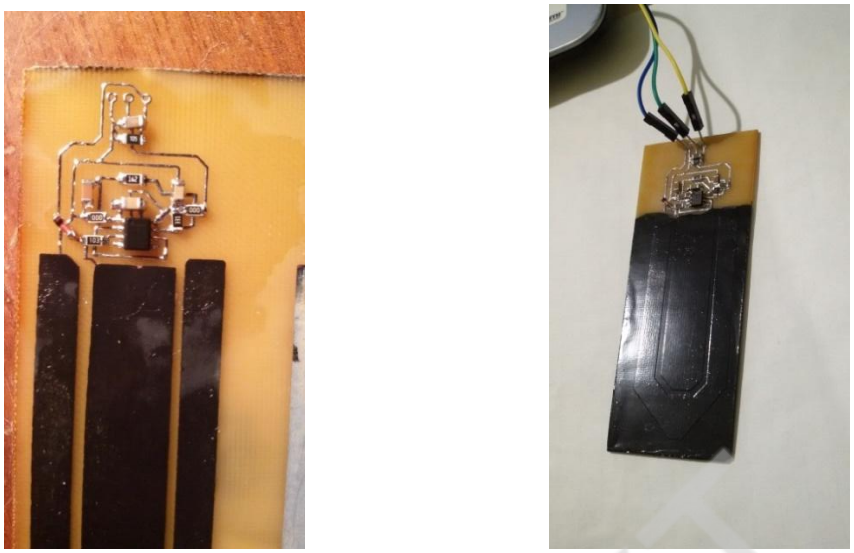

Fig. 13 - Sensor appearance before and after varnishing

The next step is to connect the sensor to the Arduino and calibrate. The analog output of the sensor was connected to the terminal A0 in the Arduino and the power was taken 5V as indicated in the passport to the NE555 chip.

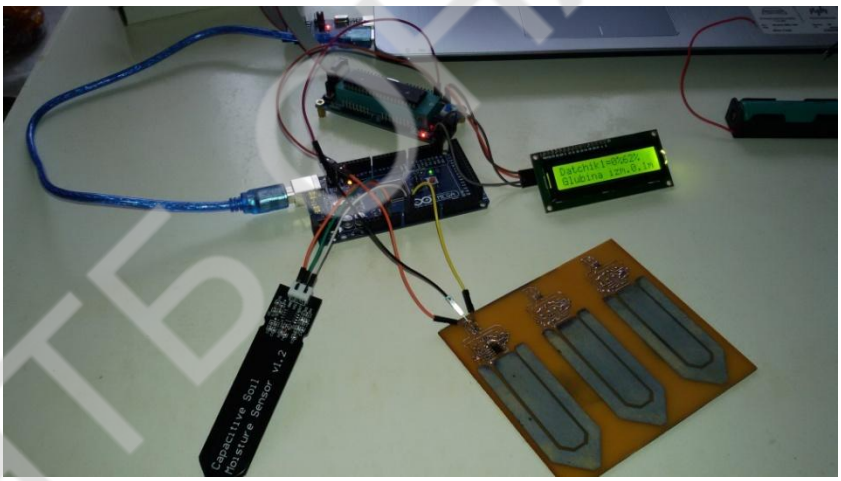

Fig.14 - Testing of working capacity

The sensor calibration was performed using the Sketch file which is shown in Fig. For ease of visualization, an LCD display was connected. At first, experimentally found the largest and smallest readings in digital equivalent. This was done by immersing the sensor in water and then made up a percentage

```
'analogValue =map(analogValue, 263, 707, 100, 0);
```

At maximum immersion in the water the sensor shows the number 263 which equated to 100% humidity, and in a completely dry state the number 707 equated to 0%.

The accuracy of this sensor is no different from that of SensorV1.2. Another main point is the cost of a homemade sensor UAH -24 in relation to SensorV1.2 - 85UAH.

```
#include<Wire.h>
#include<LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
const int analogPin = 0;

void setup() {
     lcd.init();
     lcd.backlight();
  Serial.begin(9600);   // Скорость работы порта
  Serial.println("Датчик 1"); // Выводим текст
  Serial.println();                          // Пустая строка
}

void loop() {
  int analogValue = analogRead(analogPin);  // Задаем переменную analogValue для считывания показаний
  Serial.println(analogValue); // Выводим значения

//analogValue =map(analogValue, 263, 707, 100, 0); // Задаем пропорцию в процентах
  Serial.println(analogValue);   // Выводим значения
  Serial.println("%");

  lcd.setCursor(0,0);
  lcd.print("Datchik1=");
  lcd.print(analogValue);
  lcd.print("%   ");
  lcd.setCursor(0,1);
  lcd.print("Glubina izm.0.1m");

  delay(1000);
  //Serial.println.setTimeout(100);
}
```

Fig. 15 - Sketch file for sensor calibration

In Fig. 16 is an electronic block of a control, receiving and data transmission system housed in a plastic housing.

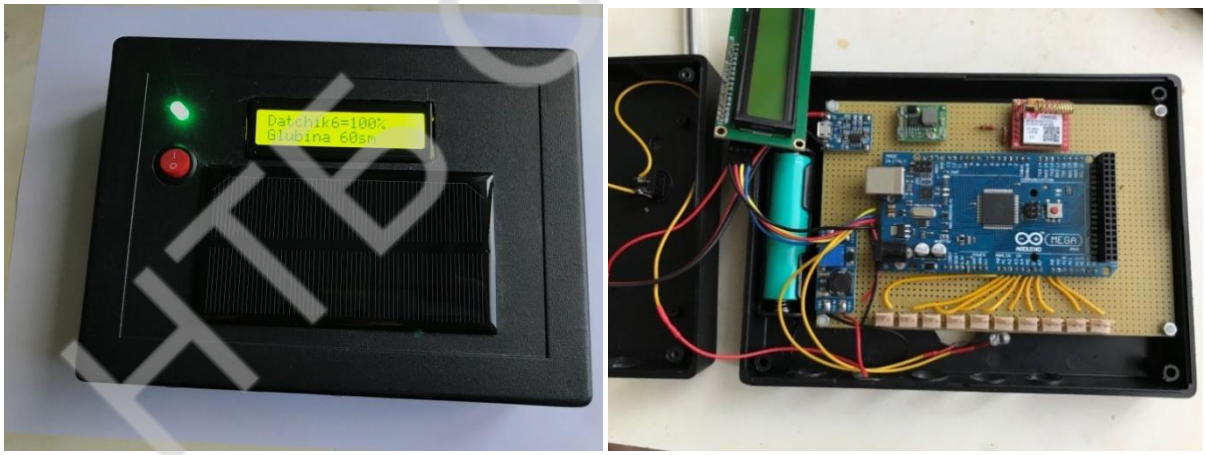

Fig. 16 - Internal and external appearance of the electronic control unit

Figure 17 shows photographs of a functioning stand-alone humidity measuring device consisting of a sensor unit for measuring soil moisture to a depth of up to 1 meter with a measurement interval of 10 cm and an electronic control unit. The entire system is powered by a solar panel.

Fig.17 - Pictures of a working sample of an autonomous soil moisture meter

Conclusions

In this project, a working model of a stand-alone device for measuring soil moisture with data transmission is developed and manufactured. Initially, a market analysis was conducted and a search for similar measurement systems was made. As it turned out, as such, there is no such system that could carry out measurements at a depth of up to 1 m

with the transmission of the data transfer. But such systems were still, but they had a very high price value of about 30 thousand UAH. After that, they got acquainted with the measurement methods and settled on the capacitive method of measuring humidity.

The next step was to develop a block diagram and identify the element base. After that, a schematic diagram of an electrical principle was drawn up. Performed the design and modeling of the hull and collected the current sample. 10 capacitive type sensors were manufactured independently using LUT technology.

The existing sample was calibrated and adjusted for further work. This project cost 1500 UAH.

Models and methods for processing and transmiting data that are proposed in this project are published and tested at the conference [11].

Literature

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ONE SEARCH ENGINE BUILT ON A GIVEN DATABASE WITH JSON

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Introduction

As you know, 'the world is evolving and we are evolving along h it', this development encompasses everything, every area of our life, and we must not lose sight of it.

The development of mankind is a very complex process. There is no doubt that the role of modern technology in today's life is immense. The capabilities of modern technology may be far greater than human beings, but we must remember that it was created by humans to simplify life and save time.

Knowledge of the key aspects of information technology and computer software enables us to collect, modify and disseminate information. While working on this project, one of our goals was to show you our knowledge of the subject.

there are many ways of creating databases, but when we are dealing with small data we don't need to use big database tools like MySQL or Oracle. It's also possible to use local or mini databases, most famous local database program is - **Microsoft Access** - which is only program I know, so that's why I think it's the best. I also tried to use JSON as database, it's very easy to send and receive data from user to server. There is also a thing called search engine, we need 3 parameters for it, one is formed automatically, the rest two user must input it. This paragraph is dedicated for my beloved students so they can learn the wonders world of databases and search engines.

Literature analysis

We use JSON. JSON (JavaScript Object Notation) is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of JavaScript Standard Programming Language ECMA-262 3rd Edition - December 1999. JSON is a fully independent text format but uses conventions that are familiar to programmers of the C-family of languages, including C, C ++, C #, Java, JavaScript, Perl, Python, and many others. These properties make JSON an ideal data-interchange language.

JSON is built on two structures:

A collection of name / value pairs. In various languages, this is realized as an object, record, struct, dictionary, hash table, keyed list, or associative array.

An ordered list of values. In most languages, this is realized as an array, vector, list, or sequence.

These are universal data structures. Virtually all modern programming languages support them in one form or another. It makes sense that a data format that is interchangeable with programming languages would also be based on these structures.

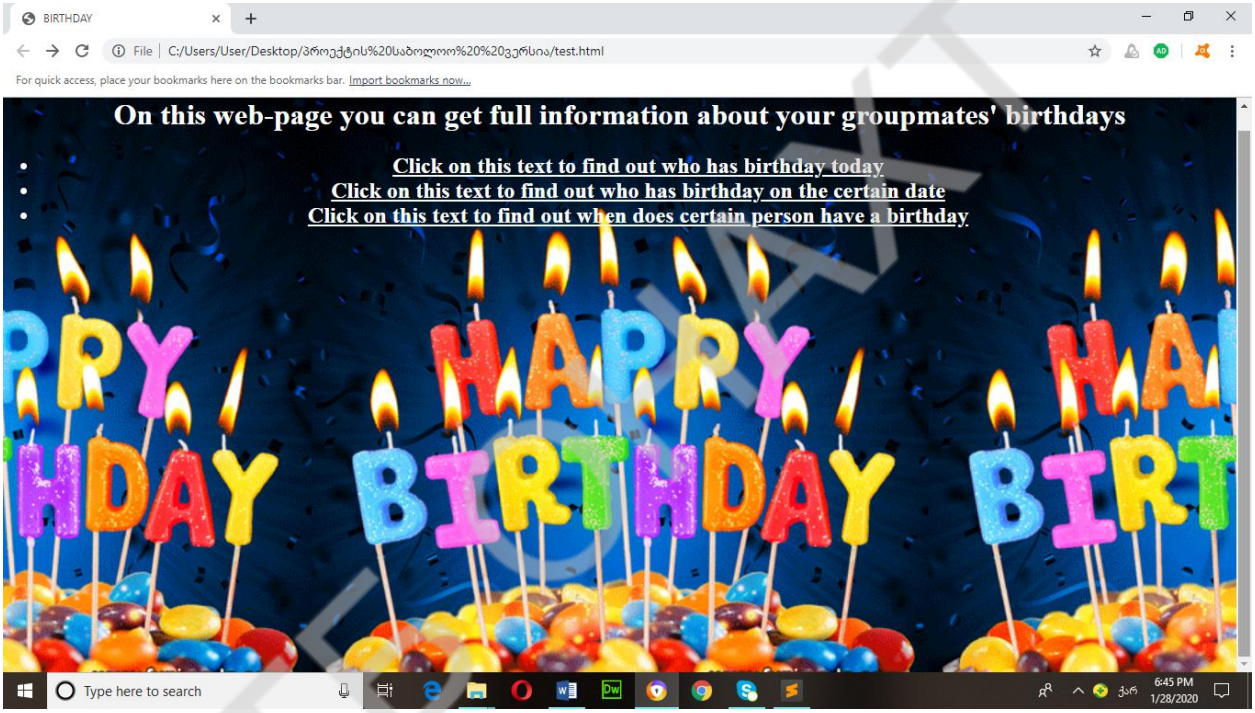
Result

We have created a simple, effective and user-friendly website tailored to the user and provides him with three types of information through simple actions:

1. Who has a birthday today
2.Who has a birthday on a particular day
3. When does a particular person have a birthday?

Obviously, when using the site, the user first focuses on its visual side, so we tried to have a user-friendly, thematic design.

We will see all of this as a link upon logging into the website. The first page looks visually like this



Which is the result of the realization of the following code

Listing 1

```
<!DOCTYPE html>
<html>
 <head>
  <title>BIRTHDAY</title>
   <meta name="viewport">
    <style>
          body, html { height: 100%;
                       margin: 0; }
    </style>
 </head>

  <body>
        <header style="background-image:
```

```
        linear-gradient(rgba(0,0,0,0),rgba(0,0,0,0)),
        url(hb.gif);
        height: 100vh;
        background-size: 50%;
        background-position: center;">

<h1 align=center> <font color="white">On this web-page you can get full information about your groupmates' birthdays </font></h1>

<h2>
        <font color="white">
<ul align=center>
  <li >
    <a href=1.html> <font color="white">Click on this text to find out who has birthday today</a>
  </li>
  <li>
    <a href=2.html> <font color="white">Click on this text to find out who has birthday on the certain date</a>
  </li>
  <li>
    <a href=3.html> <font color="white">Click on this text to find out when does certain person have a birthday</a>
  </li>
</ul>
    </font>
</h2>

 </body>
</html>
```

When we click on the first link, we will move to a new page, to check if anyone has a birthday today.

Listing 2

```
<!DOCTYPE html>
<html>
<head>
<title>BIRTHDAY</title>
<style>  body, html  {height: 100%;
                    margin: 5;}
div {margin-left: 20px; }
</style>
</head>
<body>
```

```
        <header style="background-image:
        linear-gradient(rgba(0,0,0,0.1),rgba(0,0,0,0.1)),
        url(cake1.jpg);
        height: 100vh;
        background-size: cover;
        background-position: center;
        background-attachment: fixed;">
        <br><br>
  <h2 align=center> On this web-page we can find out who has birthday today</h2>
   <p id="demo"></p>
<div><script src="one.js" ></script></div>
</body>
</html>
```

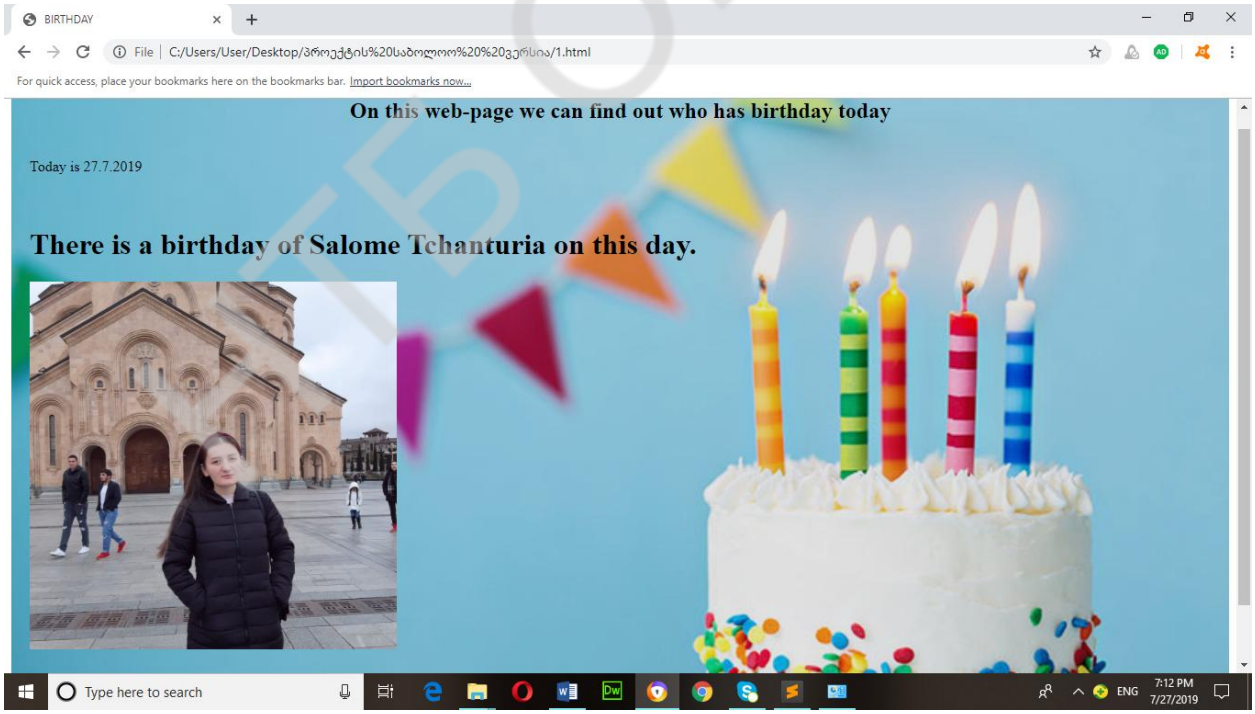
As you can see in this code is indicated file address js. The database is stored in this file and uses JSON for this.

Listing 3

```
 var d = new Date();
  var a = d.getDate();
  var b = d.getMonth()+1;
  var c = d.getFullYear();
  var e = d.getFullYear();
  document.write("<br align=center>", "Today is  ", a, ".", b, ".", c, "<br>");
var text = '{"chveni_jgufi":[' +
        '{"firstName":"Besarion",
"lastName":"Anjafaridze","day":28,"month":12,"year":"1998","img":"besa.jpg"},' +
        '{"firstName":"Ana",
"lastName":"Ediberidze","day":"12","month":9,"year":"1997","img":"ana.jpg"},' +
        '{"firstName":"Salome",
"lastName":"Tchanturia","day":"27","month":7,"year":"1998","img":"salo.jpg"},' +
        '{"firstName":"Eka",
"lastName":"Onezashvili","day":"20","month":1,"year":"1998","img":"eka.jpg"},' +
        '{"firstName":"Ucha",
"lastName":"Todria","day":"18","month":7,"year":"1997","img":"ucha.jpg"},' +
        '{"firstName":"Lia",
"lastName":"Ormotsadze","day":"25","month":9,"year":"1998","img":"lika.jpg"},' +
        '{"firstName":"Nino",
"lastName":"Bagalishvili","day":"17","month":3,"year":"1998","img":"nini.jpg"},' +
        '{"firstName":"Valeri",
"lastName":"Kalandadze","day":20,"month":12,"year":"1989","img":"valeri.jpg"}]}';
obj = JSON.parse(text);
for (i = 0; i < obj.chveni_jgufi.length; i++) {
```

```
        if (obj.chveni_jgufi[i].day == a && obj.chveni_jgufi[i].month == b) {
                e = c - obj.chveni_jgufi[i].year;
                if (e % 5 == 0) {
                        document.write("<h1>There is a jubilee of ", obj.chveni_jgufi[i].firstName, " ", obj.chveni_jgufi[i].lastName, " on this day. He(She) became ", e, " year</h1>");
                        document.write("<img src=", obj.chveni_jgufi[i].img, " width = 400 height = 400 marginLeft = 500>");
                } else {
                        document.write("<h1>There is a birthday of ", obj.chveni_jgufi[i].firstName, " ", obj.chveni_jgufi[i].lastName, " on this day.</h1>")
                        document.write("<img src=", obj.chveni_jgufi[i].img, " width = 400 height = 400 marginLeft = 500>");
                }
        };
obj.chveni_jgufi[i].firstName + " " + obj.chveni_jgufi[i].lastName + " Date of birthday: " + obj.chveni_jgufi[i].day + " " + obj.chveni_jgufi[i].month + " " + obj.chveni_jgufi[i].year +" year.";
document.write("<br>");
}
```

The result looks visually like this



When moving to the second and third links, unlike the first, we search for information through forms ourselves. According, if we are interested in whose birthday is in a specific number. We will go to the second link and we will see a window appear, where we have the number first and then the month. It's code is

Listing 4

```
<html>
<head>
<title>BIRTHDAY</title>
<meta name="viewport">
<style>
        body, html {
                height: 100%;
                margin: 5; }
        div {
  margin-left: 20px;
    }
</style>
</head>
<body>
        <header style="background-image:
        linear-gradient(rgba(0,0,0,0.1), rgba(0,0,0,0.1)),
        url(cake1.jpg);
        height: 100vh;
        background-size: cover;
        background-position: center;
        background-attachment: fixed;">
    <h2 align=center>On this web-page you can find out who has birthday on the certain date</h2>
    <p id="demo"></p>

<div><script src="two.js" ></script></div>
</body>
</html>
```

In this code is indecated file address js. In which the database is stored and uses JSON for this

Listing 5

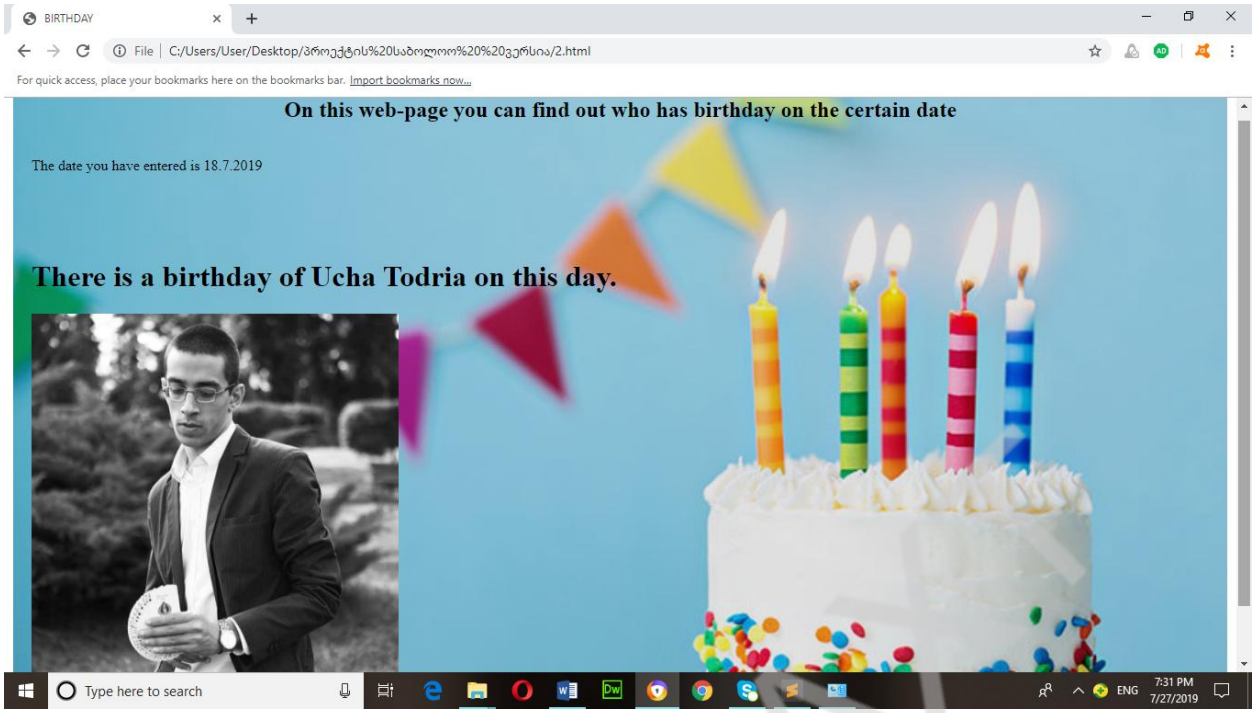
```
var d = new Date();
  var a = d.getDate();
  var b = d.getMonth()+1;
  var c = d.getFullYear();
  var e = d.getFullYear();
a = prompt("Insert the birthday number");
b = prompt("Insert number of the birth month");
document.write("<br>", "The date you have entered is ", a, ".", b, ".", c, "<br>");
var text = '{"chveni_jgufi":[' +
```

```
'{"firstName":"Besarion","lastName":"Anjafaridze","day":28,"month":12,"year":"1998","img
":"besa.jpg"},' +
'{"firstName":"Ana",
    "lastName":"Ediberidze","day":"12","month":9,"year":"1997","img":"ana.jpg"},' +

 '{"firstName":"Salome","lastName":"Tchanturia","day":"27","month":7,"year":"1998","img"
 :"salo.jpg"},' +
'{"firstName":"Eka",
"lastName":"Onezashvili","day":"20","month":1,"year":"1998","img":"eka.jpg"},'          +
'{"firstName":"Ucha",
"lastName":"Todria","day":"18","month":7,"year":"1997","img":"ucha.jpg"},'              +
'{"firstName":"Lia",
"lastName":"Ormotsadze","day":"25","month":9,"year":"1998","img":"lika.jpg"},'          +
'{"firstName":"nino",
"lastName":"Bagalishvili","day":"17","month":3,"year":"1998","img":"nini.jpg"},'+
'{"firstName":"Valeri","lastName":"Kalandadze","day":5,"month":12,"year":"1989","img":"v
aleri.jpg"}]}';
    obj = JSON.parse(text);
    for (i = 0; i < obj.chveni_jgufi.length; i++) {
      if (obj.chveni_jgufi[i].day == a && obj.chveni_jgufi[i].month == b) {
        e = c - obj.chveni_jgufi[i].year;
        if (e % 5 == 0) {
          document.write("<h1>There is a jubilee of ", obj.chveni_jgufi[i].firstName, " ",
    obj.chveni_jgufi[i].lastName, ". He(She) became  ", e, " year</h1>");
          document.write("<img src=", obj.chveni_jgufi[i].img, " width = 400 height = 400
    marginLeft = 500>");
        } else {
          document.write("<h1>There is a birthday of ", obj.chveni_jgufi[i].firstName, " ",
    obj.chveni_jgufi[i].lastName, " on this day.</h1>")
          document.write("<img src=", obj.chveni_jgufi[i].img, " width = 400 height = 400
    marginLeft = 500>");
        }
      };


    obj.chveni_jgufi[i].firstName + " " + obj.chveni_jgufi[i].lastName + " Date of birth: " +
    obj.chveni_jgufi[i].day + "  " + obj.chveni_jgufi[i].month + " " + obj.chveni_jgufi[i].year
    +" year.";
    document.write("<br>");
    }
```

The result looks visually like this



The same is true in the third, the only difference here is that when we move to the link in the disabled window, we will enter the person's name and surname (in the first-name, in the second-surname). Because we know when he has a birthday. All this is done, through html code, it is also mentioned here address of the is file. See below html and js codes

Listing 6

```
<html>
<head>
<title>BIRTHDAY</title>
<meta name="viewport">
<style>
        body, html {
                height: 100%;
                margin: 5;
        }
        div {
  margin-left: 20px;
    }
</style>
</head>
<body>
        <header style="background-image:
        linear-gradient(rgba(0,0,0,0.1),rgba(0,0,0,0.1)),
        url(cake1.jpg);
```

```
        height: 100vh;
        background-size: cover;
        background-position: center;
        background-attachment: fixed;">

    <h2 align=center>On this web-page you can find out when does certain person have a birthday</h2>
    <p id="demo"></p>
<div><script src="three.js"></script></div>

</body>
</html>
```

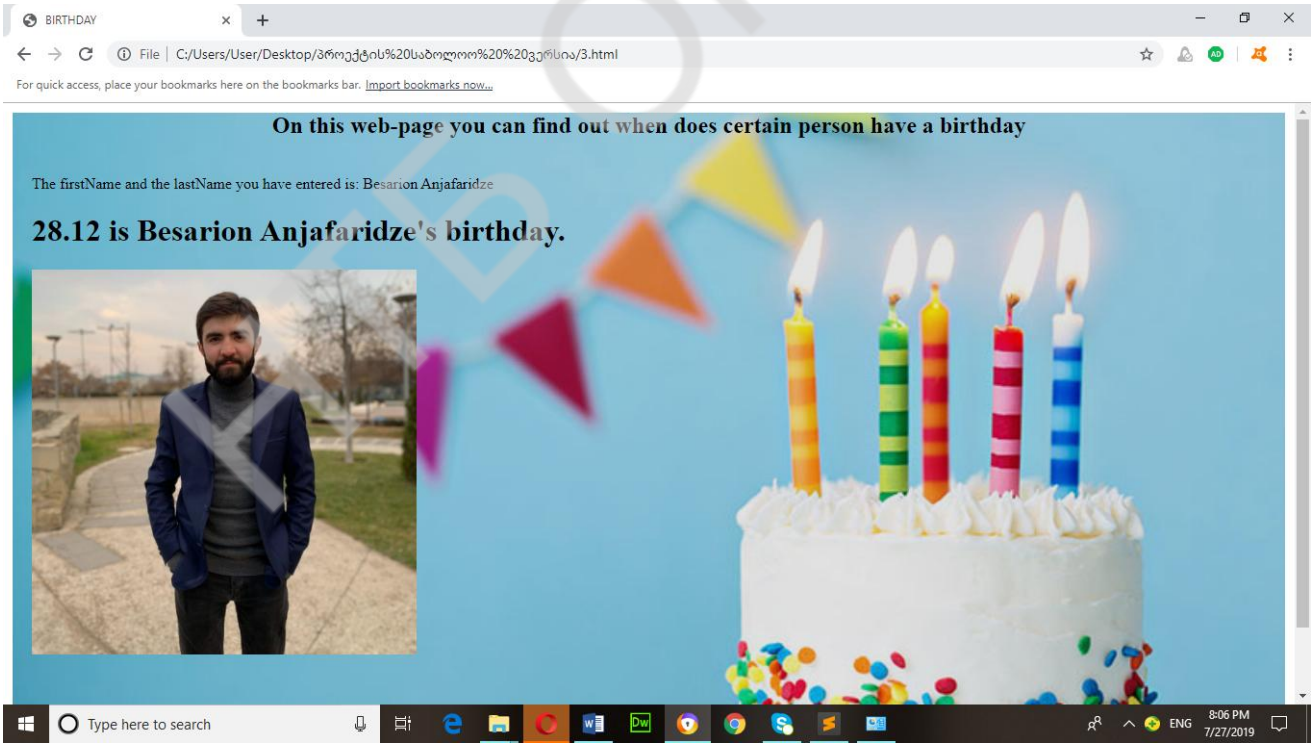
Listing 7

```
 var d = new Date();
  var a = d.getDate();
  var b = d.getMonth()+1;
  var c = d.getFullYear();
  var e = d.getFullYear();
f = prompt("Enter the firstName");
g = prompt("Enter the lastName");
document.write("<br>","The firstName and the lastName you have entered is: ",f," ",g, "<br>");
var text = '{"chveni_jgufi":['+
  '{"firstName":"Besarion",
"lastName":"Anjafaridze","day":28,"month":12,"year":"1998","img":"besa.jpg"},' +
  '{"firstName":"Ana",
"lastName":"Ediberidze","day":"12","month":9,"year":"1997","img":"ana.jpg"},' +
  '{"firstName":"Salome",
"lastName":"Tchanturia","day":"27","month":7,"year":"1998","img":"salo.jpg"},' +
  '{"firstName":"Eka",
"lastName":"Onezashvili","day":"20","month":1,"year":"1998","img":"eka.jpg"},' +
  '{"firstName":"Ucha",
"lastName":"Todria","day":"18","month":7,"year":"1997","img":"ucha.jpg"},' +
  '{"firstName":"Lia",
"lastName":"Ormotsadze","day":"25","month":9,"year":"1998","img":"lika.jpg"},' +
  '{"firstName":"nino",
"lastName":"Bagalishvili","day":"17","month":3,"year":"1998","img":"nini.jpg"},' +
  '{"firstName":"Valeri",
"lastName":"Kalandadze","day":5,"month":12,"year":"1989","img":"valeri.jpg"}]}';
obj = JSON.parse(text);
for(i=0;i<obj.chveni_jgufi.length;i++)
{
```

```
        if(obj.chveni_jgufi[i].firstName==f && obj.chveni_jgufi[i].lastName==g)
            {e=c-obj.chveni_jgufi[i].year;
              if(e%5==0)
{document.write("<h1>",obj.chveni_jgufi[i].day,".",obj.chveni_jgufi[i].month," is ",obj.chveni_jgufi[i].firstName," ",obj.chveni_jgufi[i].lastName,"'s jubilee birthday. He (She) was ", e, " years old</h1>");
                    document.write("<img src=",obj.chveni_jgufi[i].img, " width = 400 height = 400 marginLeft = 500>");}
                  else
{document.write("<h1>",obj.chveni_jgufi[i].day,".",obj.chveni_jgufi[i].month," is ",obj.chveni_jgufi[i].firstName," ",obj.chveni_jgufi[i].lastName,"'s birthday.</h1>")
                    document.write("<img src=",obj.chveni_jgufi[i].img, " width = 400 height = 400 marginLeft = 500>");}};

obj.chveni_jgufi[i].firstName + " " + obj.chveni_jgufi[i].lastName + " Date of birth: " + obj.chveni_jgufi[i].day + "  " + obj.chveni_jgufi[i].month + " " + obj.chveni_jgufi[i].year +" years.";
document.write("<br>");
}
```

The result looks visually like this



Conclusion

As you know, the third revolution is related to the computer era, automation and the creation and development of robotics. The goal of this revolution is a symbiosis of computer technology, artificial intelligence, and automation. Eminent writers of the

twentieth century have described an era where the main function of man is to manage robots and artificial intelligence. All this is promised by Industry 4.0 today.

Take, for example, any factory / production that fits into the 4.0 model:

** All operations of this factory are automated;

** Introduced auto-monitoring system;

** Machines / installations are fully computer driven;

** Computers can learn, analyze situations, and make optimal, independent decisions for the enterprise.

Therefore, any business is in charge of keeping an eye on innovations in its field, timely implementing these innovations, developing a new model of competitiveness, and adapting timely to these changes.

Modern technology makes it easy, fast, efficient, secure, tailor-made, inexpensive, and so on. If you used to spend a lot of time, energy, money, and now in just a few seconds you can send information anywhere ... And electronic signatures can be said to be one of the great achievements of modernity when you can handle anything without leaving the room, with a range of security measures with protection.

THE USE OF SUPERVISED LEARNING IN ROBOTICS

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Abstract. *In this paper, there are considered definitions of the direct and inverse kinematics. The solution of inverse kinematics problem is shown in detail on the example of the kinematic scheme of the manipulator. Also, it is discovered the concept of degrees of freedom and coordinate system.*

The example of path-planning shows the process of moving the robot along a curved path, determining the angle and distance that robot needs to go to the next point of the path.

Machine learning is also considered to be a unit of artificial intelligence. Classification and regression are found to be the main tasks of supervised learning. There were analyzed cases in which regression or classification are applied and were given examples of application of machine learning in the modern world and robotics.

This science paper contains 15 pages and 4 figures.

Keywords*: Inverse Kinematics Problem, Manipulator, Path-Planning, Machine Learning, Classification, Regression.*

I. Introduction

Nowadays the need of using robots is growing more and more in various spheres of human life. The use of machine learning in robotics extends their application, facilitates human labor, and is highly efficient through the handling with the large amounts of data,

which is difficult enough for humans and sometimes even is impossible. All this contributes to further prospects in this direction.

That is why the science paper related to machine learning and robotics is now relevant and will gain further interest from both professionals and users. The purpose of my work is to study the kinematics of robots, to solve the inverse kinematics problem, to get acquainted with machine learning and the problems that are solved with the help of supervised learning and the practical application of machine learning.

This science paper considers the kinematics of the manipulator and the basic concepts used in its work and machine learning, solving some problems of supervised learning, the use of machine learning in robotics.

II. Analytical literature survey

In [1] there were examined the formulation and solution of direct and inverse kinematics problems, revealed the importance of solving the inverse kinematics problem, explained the presence of ambiguity in its resolution.

Thus, in [2] there were discussed such basic concepts as the coordinate system, the degrees of freedom. Also this article showed the process of path-planning of the robot.

Using [5] there were found out the possibilities of using robots with machine learning, their limitations in comparison with the human being and given the examples of using of supervised learning in the modern world.

With the help of [6], theoretical information on supervised learning, differences between regression and classification were introduced.

The studying [7] examines the work of Google's laboratory on the application of machine learning to robotics, the prospects for their further development and the problems encountered by specialists.

III. The object, subject and research methods

The research object is a mobile robot.

The research subject is the application of inverse problem solution of kinematics in robotics with using machine learning.

This paper uses a method of theoretical research as analysis and synthesis, since we first consider the individual parts of the subject of study, its properties, and then combine these parts to a single whole.

IV. Results

IV.I Definition of direct and inverse kinematics problems

In general robotics considers the solution of direct and inverse kinematics problems depending on the information about the motion of a point. Let us find out the differences between them by the example of the kinematic scheme of the two-link manipulator (fig. 1).

The direct task of kinematics is to find the position of the manipulator (X, Y, Z) according to its kinematic scheme and given orientation $(A_1, A_2, \dots, A_n)$ its links (n – the number of degrees of freedom of the manipulator, A – angles of rotation). The solution of the direct kinematics problem determines the position of manipulator at given angles of its joints [1].

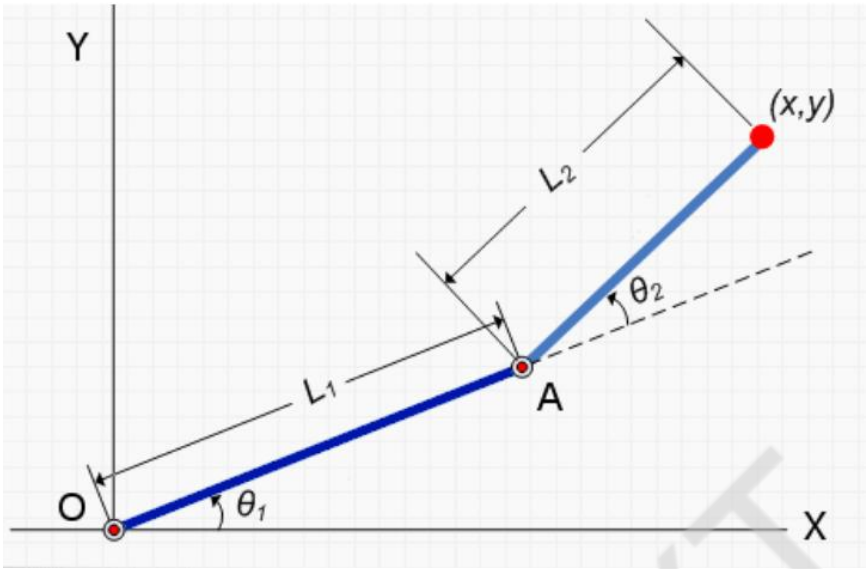

Fig. 1 - Kinematic scheme of the two-link manipulator

The inverse of kinematics, in contrast, allows us to determine angles $(A_1, A_2, \dots, A_n)$ by a given position (X, Y, Z) manipulator and kinematics scheme. By solving the inverse kinematics problem, one finds out how to move the manipulator in order to get it in the right position.

It should be noted that in solving the direct kinematics problem the solution can be only one, because there is a single position of manipulator(X, Y, Z) with the angles $(A_1, A_2, \dots, A_n)$. However, solving the inverse problem of kinematics may be in several solutions: the achieving a given position (X, Y, Z) can occur with different combinations of angles $(A_1, A_2, \dots, A_n)$ (fig. 2).

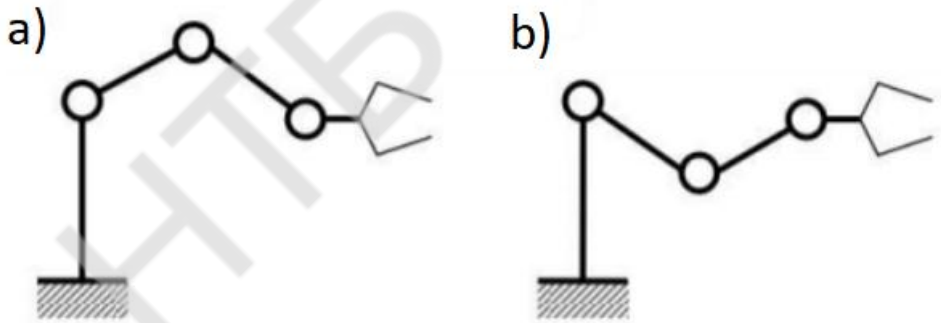

Fig. 2 - Kinematic scheme of the two-link manipulator
a) links above; b) links below

For our research topic is more important the solving of inverse kinematics problem.

IV.II Solution of inverse kinematics problem

The task is to find the angles θ_1 та θ_2 that would allow the manipulator with the link L_1 and link L_2 to move the manipulator to a given point (x, y) (fig. 3).

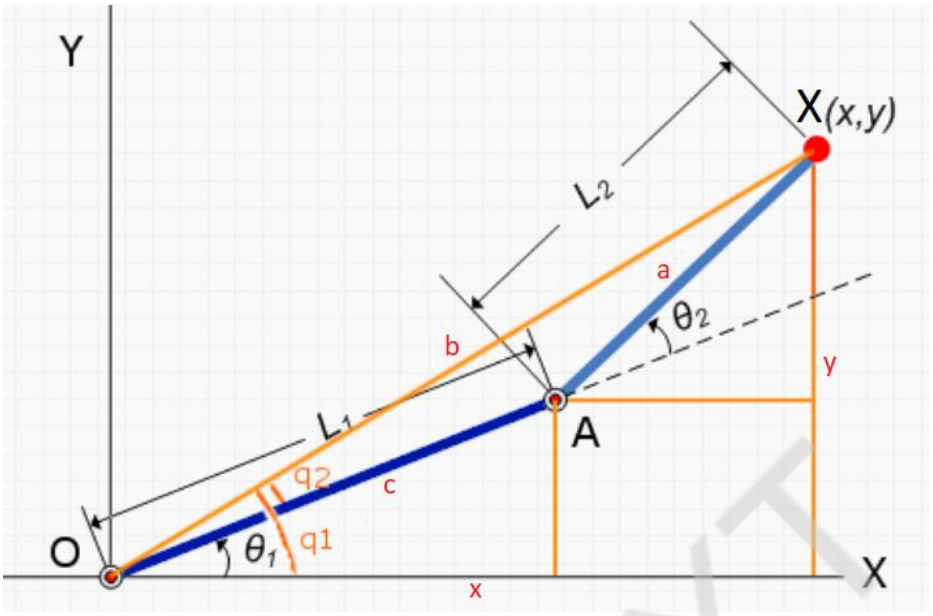

Fig. 3 - Kinematic scheme of the manipulator

Draw a straight line b, which connects the origin *(p. O)* and the point at which the manipulator takes a given position *(p. X)*.

q_1 – the angle between the abscissa and b.

According to Pythagorean theorem:

$$b^2 = x^2 + y^2.$$

From here

$$\cos(q_1) = \frac{x}{b},\ \ x = b * cos(q_1);$$

$$q_1 = arrcos\left(\frac{x}{b}\right);$$

$$\sin(q_1) = \frac{y}{b},\ \ y = b * sin(q_1);$$

$$tg(q_1) = \frac{y}{x},\ \ q_1 = arctg\left(\frac{y}{x}\right).$$

Let us denote:

q_2 – the angle between the b and L_1;

θ_1 – angle, which is necessary to return the working body of the manipulator to achieve a given position.

Then $\theta_1 = q_1 - q_2$.

Find q_2 using the cosine theorem:

$$L_2^2 = b^2 + L_1^2 + 2 * b * L_1 * \cos(q_2);$$

$$2 * b * L_1 * \cos(q_2) = b^2 + L_1^2 + L_2^2;$$

$$\cos(q_2) = \frac{b^2 + L_1^2 + L_2^2}{2 * b * L_1};$$

$$q_2 = \arccos\left(\frac{b^2 + L_1^2 + L_2^2}{2 * b * L_1}\right).$$

Now find θ_2. Consider the triangle OAX (fig. 3):

$$\theta_2 = \pi - \angle OAX;$$

Find $\angle OAX$ using the cosine theorem:

$$b^2 = L_1^2 + L_2^2 - 2 * L_1 * L_2 * cos\angle OAX;$$
$$2 * L_1 * L_2 * cos\angle OAX = L_1^2 + L_2^2 - b^2;$$
$$\angle OAX = arccos\left(\frac{L_1^2 + L_2^2 - b^2}{2 * L_1 * L_2}\right);$$

Then the required angles θ_1 i θ_2 can be defined as follows:

$$\theta_2 = \pi - arccos\left(\frac{L_1^2 + L_2^2 - b^2}{2 * L_1 * L_2}\right);$$
$$\theta_1 = arrcos\left(\frac{x}{b}\right) - \arccos\left(\frac{b^2 + L_1^2 + L_2^2}{2 * b * L_1}\right).$$

It should be noted that the solution of the inverse kinematics problem requires minimizing the distance at which the manipulator's working body needs to change position.

IV.III Degrees of freedom (DoF)

The number of degrees of freedom determines the minimum number of independent variables required to fully describe the motion of a particular mechanical system [2].

A distinction is made between the translational and rotational degrees of freedom. The translational degree implies movement in a straight line, while the rotational degree of freedom implies the presence of some mechanical system of axes of rotation.

By the number of degrees of freedom mechanical systems are divided into holonomic and nonholonomic [3]. A holonomic mechanical system is a mechanical system which has 6 physical degrees of freedom, and nonholonomic - when a system has less than 6 physical degrees of freedom.

IV.IV Coordinate system

A coordinate system is required for mathematical describing the motion of a robot.

A distinction is made between the following coordinate systems [2]:

- W (World) – world's coordinate system. It is characterized by constancy and motionless.
- R (Robot) – robot's coordinate system. It is characterized by changes in space, but it remains motionless to the robot.

IV.V Path-planning

In the case where the robot knows the location of the target point and its relation to the world's coordinate system, it becomes possible to move the robot along some sequence of points that are determined in advance [2]. Various curvilinear trajectories are planned to provide the further optimization of the path with minimization the time spent on movement and energy consumption.

The movement of robot consists of straight segments separately from turns in place. As the robot tries to minimize the total distance of the path, it always rotates the way the direction vector of its motion points to the next point and goes straight to it. It continues until the robot reaches its target point.

The current position of the robot can be described by vector X:

$$X = (x, y, \theta).$$

where x, y – location of the point of the center of work according to the world's coordinate system; θ is the angle of rotation between the coordinate systems W and R.

The location of the next waypoint to which the robot follows can be described this way:$A = (W_x,\ W_y)$. The fig. 4 shows robot's moving to the next target point.

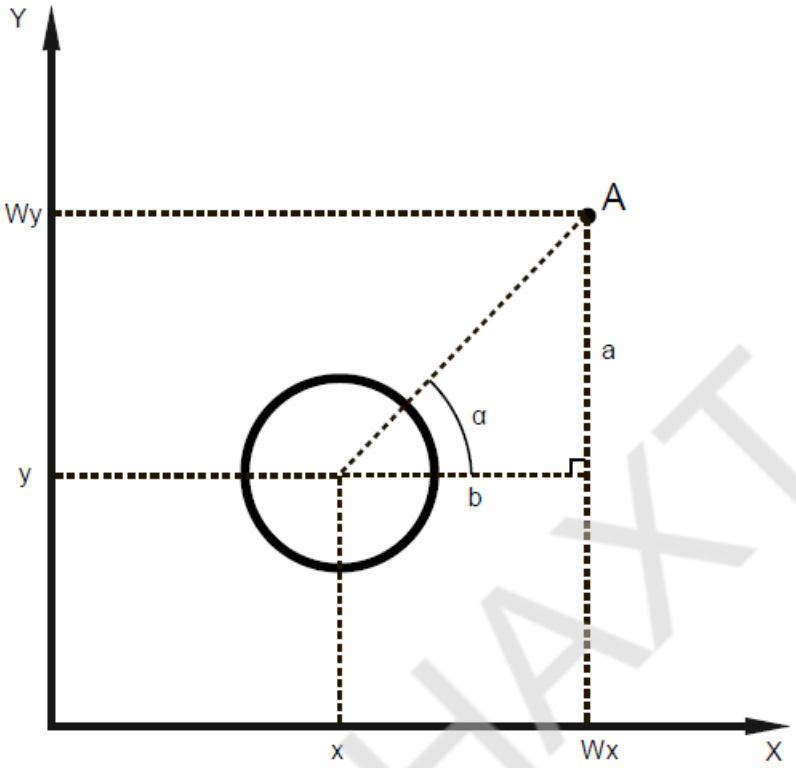

Fig. 4 – Path-planning

Firstly, robot returns to the next waypoint. To do this, we have to find the angle α, at which the robot must return.

Find the offset relative to abscissa and ordinate that will occur because of robot's moving from the current point to the following:

$$W_x - x = b;$$
$$W_y - y = a.$$

Then $tg\alpha = \frac{a}{b} = \frac{W_y - y}{W_x - x}, \alpha = arctg\frac{W_y - y}{W_x - x}$.

Since the robot has already returned to some angle, the angle to which the robot must be returned can be noted as follows:

$$\beta = a - \theta.$$

Now we need to find the distance that the robot needs to overcome by moving at a given angle to the next point.

Let us denote: d – the distance at which the robot has to move in a straight line. It can be found by using Pythagoras' theorem:

$$d = \sqrt{a^2 + b^2} = \sqrt{(W_y - y)^2 + (W_x - x)^2}.$$

IV.VI Supervised learning

Machine learning is a unit of artificial intelligence that studies methods of constructing algorithms capable of learning [4]. Thus, the idea of machine learning is the fact that the machine has learned itself to solve some problems, but cannot solve it with the already known algorithm.

It should be noted that while the machine is capable of predicting, memorizing and selecting the best option, it still cannot create a new one [5].

Classical teaching is the one of machine learning's types which can be divided into supervised learning and unsupervised learning. In supervised learning machine is trained on examples set input already contains the necessary input and output values. The algorithm should establish how the input values are obtained by means of analysis, identification of various regularities. In this way machine learns from observations and is capable to make predictions. These predictions are adjusted by the operator. The process continues until the algorithm reaches the required accuracy [6].

Among the problems that are solved with the help of supervised learning there are problems of classification and regression. In solving the classification problem, the machine has to conclude to which category the new object belongs, and in regression - determine the location for the object on a numerical line relative to the previous analysis of the relationship between the variables.

IV.VII The use of supervised learning

Classification is widely used for spam filters, language detection, handwriting and number recognition, suspicious transaction detection, definition object's type in a photo, spam/ham distribution. The most popular algorithms are Naive Bayes classifier (previously used for spam filters), Decision tree, Support-vector machine [5].

Thus, regression is used to predict the value of securities, beat and sell analysis, and when there is a time dependence. A distinction is made between linear and nonlinear regression, depending on what curve the regression draws: if a straight line is a linear regression, if a curve is a nonlinear regression.

Now a variety of companies are developing methods by which machines can learn new things. It makes the use of machine learning an important step in development of robotics. For example, in a new Google lab, specialists were developing a manipulator that sorts the trash in the recycle bin [7]. Thus, as the manipulator is equipped with a camera it analyzes objects using classification and learns to sort objects by different categories. It should be noted that this technology has proven itself well in a laboratory, but sometimes there are difficulties in a distribution center, because the robot can face unknown objects or tasks that require movement, which the robot has not done before. That's why it makes mistakes.

Specialists have also been teaching mobile robot to orientate in unknown areas. Such robots can be useful in warehouse work [7]. Here, regression can be used to construct the path which allows the robot to reach the destination point.

That is, depending on the sphere of using there can be created robots with their further learning. These robots will receive the information from various sensors (photo sensor, camera, motion sensor) and facilitate human labor.

V. Conclusion

In this science paper there were introduced the kinematics of the robot, the solution of the inverse kinematics problem on the example of a manipulator, the concept of the degree of freedom and the coordinate system. It has been found that mechanical systems can be divided on holonomic and nonholonomic according to the number of degrees of freedom.

Also there were considered the process of path-planning, constructing a curvilinear trajectory, describing the current location of the robot and finding the necessary angle and distance for robot's moving to the next waypoint.

In the course of the work, it was found out that machine learning is a topical subject in the modern world and is a unit of artificial intelligence. Classification and regression were reviewed as the main tasks of supervised learning. There were discussed the possibilities of using in various spheres of human life and given examples of applications in robotics.

The application of machine learning is a topical issue for the modern world and has a great potential for further development. The use of machine learning in robotics can simplify human performance, do it faster and more efficiently. Some companies have already involved in machine learning, such as Google Labs developing a manipulator that can be used for sorting trash based on classification. The main problem now is to transfer this technology to the real world because the robot may encounter objects and tasks that are unknown to it.

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THE ALGORITHM OF INFORMATION SECURITY RISK ASSESSMENT BASED ON FUZZY-MULTIPLE APPROACH

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Abstract*.The* ***subject*** *of the study is the process of assessing the level of information security risk that is being implemented with the help of the fuzzy logic apparatus. The* ***purpose*** *of this work is to develop a methodology for assessing the degree of information security risk, which would avoid the uncertainty factor, that occurs when some parts of*

*information about the analyzed automated information system are absent. The methodology is based on the use of fuzzy logic and fuzzy sets. Which implies the introduction of the term sets for each of the system characteristics and the linguistic assessment of the indicators. The **tasks** to be solved are to analyze existing information security risk assessment methodologies for identifying their strengths and weaknesses. On the basis of the conducted analysis, a new method for assessing the risk of automated information systems information security is proposed. The following **results** were obtained: the advantages and disadvantages of qualitative and quantitative methodologies for assessing the risk degree of automated systems information security were identified; the main stages of the proposed methodology were described. **Conclusion**: The methodology presented in the article provides an opportunity to translate the obtained results of risk assessment from a mathematical language into a linguistic form that is more comprehensible to the decision-maker. This increases the effectiveness of the management of automated information systems protection mechanisms.*

Keywords: *information security, risk assessment, information security risk assessment methodology, fuzzy sets.*

Introduction

The revolutionary development of information technology over the last decade has led to an increase in the number of threat types and their transformation. The modern world has confidently entered the era of high technology. Automated information systems (AIS) are now gaining popularity in solving the problems of providing information base for various services that deal with technical, economic and other issues. In the process of operation, they can be vulnerable to various threats, which are also modified and have become hybrid. Currently, they combine influences on information security (IS), cyber security (CySec) and security of information (SI). The main target of hybrid attacks is the country's economic sector. With the increase in the amount of data processed, the value of information for business is increasing. In this regard, the task of information security (InfoSec) is becoming increasingly relevant.

There is a need for hybrid technologies to counteract risks that play a significant role in business processes. That is why during the design and development of reliable AIS, it is necessary to provide a set of measures aimed at ensuring their protection against intentional or accidental influences, which can lead to disruption of the system. Such failures in AIS work entail serious losses in the form of assets or material resources, deterioration of the image of the owner or developer of AIS.

Information security threats to automated information systems that directly affect the system include internal and external threats to staff and its customers. Both the former and the latter in their targeting and nature of influence on the activity of certain subjects and objects can be economic, physical and intellectual [1], [2].

Information security is part of managing the information system as a whole. One of the most important components of the InfoSec management system is risk assessment, which is designed to determine the effectiveness of the security mechanisms based on specific metrics. The challenge remains to refine existing methods of assessing IS risk in view of the emergence of new types of threats. Therefore, the purpose of the work is to increase the level of information security of automated information systems by introducing

an automated methodology for assessing information security risks based on the use of fuzzy sets.

Analytical review of literature

Research priority areas in the field of information security are:

— development of security threats models to information and telecommunication systems (ITS) and ways of their implementation;

— determining the criteria of systems vulnerability and resilience to destructive effects;

— development of monitoring methods and means for revealing the facts of unauthorized information influences;

— development of methodology and methodological apparatus for assessing damage from information security threats;

— improvement of existing methodologies for risk assessment and its further management [3].

To ensure information security it is equally important to develop methods and tools for information security of information and telecommunication systems, including automated security management systems, methods and means of key distribution and protection of information and information resources from unauthorized access and destructive information impact, anti-virus technologies, methods and means of control of protection conditions against unauthorized access of modern and perspective technical means and solution of the problem of guaranteed destruction of residual information on magnetic media, research and development of methods of designing secure systems using unreliable (from the point of information security view) elements, including the problem of their testing.

Urgent tasks stem from the rapid development of information and telecommunication systems, which today are transformed into distributed systems of multiple objects, entities, with various information flows and connections. The consequence of the complication of information systems is the growing number of factors affecting information security, the emergence of new processes, states and variants of behavior in systems and beyond. Therefore, when creating reliable, flexible systems of protection modeling is of special relevance. One of the main goals of information security modeling is to build a model that takes into account the largest number of influential factors and allows to calculate the probability of vulnerability and threat realization, to calculate the time of realization of the threat and possible losses, to determine the effectiveness of implementation of security measures and the level of protection. Modeling and deriving the above metrics will allow you to make decisions about your InfoSec system, that is, manage information security risks.

The basis of AIS information security management is risk analysis. In fact, the risk is an integral assessment of how effectively existing defenses are able to withstand information attacks.

There are usually two main groups of methods for calculating security risks. The first group allows you to set the level of risk by assessing the degree of compliance with a specific set of information security requirements. The second group of information security risk assessment techniques is based on determining the likelihood of attacks and their levels of damage. The value of the damage is determined by the owner of the

information resource, and the probability of an attack is calculated by a team of experts who conduct the audit procedure.

In today's scientific community, there is a large number of researchers whose work focuses on assessing information security risk for systems. For example, in [4] the existing InfoSec risk analysis is classified, the sequences of risk analysis processes are described, a comparison of software tools for risk management of InfoSec is presented. Another example of research in this subject area is the work [5], [6], which describes methods of risk assessment and management.

Article [7] proposes mathematical formulation of risk using the basic concepts of InfoSec of such risk management methodologies as Mehari, Ebios, CRAMM and SP 800-30 (NIST).

The basics for risk assessment, in particular in the context of the risk assessment of access control systems that make authorization decisions, are set out in [8].

In [9], approaches and software solutions for information risk assessment and control are considered as a fundamental organizational stage in the construction of information security systems for computerized systems.

In [10], an advanced methodology for estimating information risk in an automated system was proposed and analyzed. The necessary normative legal documents of information security are covered. The work of a prototype of an expert system is considered, which allows to estimate the level of information risk for a certain automated system and to determine the necessity of application of additional information security measures [11].

The work [12] analyzes the process of work of the most common models of information security risk assessment in information and telecommunication systems. The basic approaches to the assessment of information security risks are revealed.

An analysis of information security threats and a detailed description of intentional sources, classification and causes of their occurrence are given in [13].

Object, subject matter and methods of research

According to the purpose of the work, the object of the work is the process of assessment information security risk level for automated information systems. The subject is algorithmic support for information security risk level assessment of automated information systems.

After analyzing the existing scientific literature from the specified subject area, two main groups of methodology for assessing information security risks are possible to determine: quantitative and qualitative.

Quantitative methods use measurable, objective data to determine the value of assets, likelihood of loss and associated risks. The goal is to calculate the numerical values for each of the components collected during the risk assessment and analysis of costs and benefits.

Qualitative methods use a relative risk or asset value based on rating or categorization, such as low, medium, high, not important, important, very important, on a scale from 1 to 10. A qualitative model evaluates the actions and probabilities of identified risks at a rapid rate and in a cost-effective way. Risk sets are written and analyzed in a qualitative risk assessment, and can serve as a basis for a targeted quantitative assessment.

Quantitative and qualitative information security risk assessment methods have both advantages and disadvantages

Accordingly, the combination of quantitative and qualitative methods represents a mixed set of advantages and disadvantages of the above mentioned methods.

Table 1 – Advantages and disadvantages of qualitative and quantitative risk assessment methods of InfoSec

+/–	Quantitative	Qualitative
Advantages	- risks are the financial consequences priority; - assets are the financial values priority; - obtaining simplified risk management results and investment returns into providing security; - results can be expressed in specific management terminology (for example, monetary value and probability is expressed as a certain percentage); - Accuracy tends to increase over time as the business constantly records data.	- Provides clarity and understanding of risk classification; - the opportunity to reach consensus; - there is no need to determine the financial value of assets; - it is easier to involve people who are not experts in the field of computer security.
Disadvantages	- Importance influence attributed to risks on the basis of judgmental opinions of participants; - the process for achieving reliable results and consensus takes a lot of time; - calculation might be complex and time-consuming; - the results are presented only in monetary terms and they are difficult to interpret for "non-techies"; - the process requires special knowledge, so it is difficult to train staff.	- insufficient distinction between among significant risks; - it is difficult to justify investments in control of implementation, because there are no grounds for the analysis of costs and benefits; - The results depend on the quality of the created risk management team

Security risks of information systems are very closely related to uncertainty. Two cases of uncertainty can be determined: identification of the current and future state of the systems.

When solving tasks related to security risk assessment, the question about the qualitative interpretation of certain levels of parameters often arises. The linguistic assessment of the security level is clearer and best describes the state of IT infrastructure security, which in turn encourages the manager to take one or another decision.

In order to fulfill the linguistic assessment, two things are required:

First, you need to define a linguistic scale for evaluation. Most often pentascale is used (five-level classifier) "Very low (VL) – Low (L) – Average (A) – High (H) – Very high (VH)."

Secondly, it is necessary to collect all available information to define linguistic assessment: quantitative data collected in a group of similar objects of observation.

For example, for a qualitative assessment of the level of information security, it is necessary to collect statistical information on similar information systems for a relatively short period of monitoring. This is necessary to maintain the condition of statistical homogeneity. At the same time, it is necessary to take into account the laws that are inherent to the objects of information security.

It should be noted that there are no general universal rules for accurate and rapid assessment of AIS information security. A set of problems may also arise with the collection of initial data for linguistic analysis.

There is a question connected to the additional data analysis, which is related to different time segments of observations. There may be a question about replacing the

missing data in one-time period with the data from another similar one, and the parameters of this law will be given according to special rules in order to satisfy the necessary authenticity of the identification of the monitoring law.

The presence of quasistatistics makes it possible to make qualitative conclusions about the behavior of a particular parameter of the investigated IS, makes it possible to conduct a linguistic analysis of input data.

Basic steps of the linguistic classification:

1. The studies of the source data set and its verification as a quasi-statistic are conducted. There is evidence that some data distribution law is hidden in these data, for example, the "gray" Pospelov scale.

2. Next, define the main nodes. In the absence of expert evaluation, nodal points can be determined by the simple rule: node point – left end of media interval, nodal point – right end of media interval, middle point – corresponds to the maximum histogram or median histogram.

3. The interval between the two nodal points standing next is divided into three zones, the middle one is the zone of expert uncertainty in the classification. Thus, the primary linguistic interpretation of the histogram is complete.

After the classificatory definition it is possible to make a correction of pestascale. To do this, you can modify nodal classification points, bringing them closer together and narrowing the uncertainty zone. You can also replace the nodal point with an absolute confidence interval and try to expand it on both sides of the nodal point. All clarifications must be made on the basis of an agreed expert evaluation.

Work results

The main result of this work is the proposed methodology for the risk assessment of AIS InfoSec, which is based on a fuzzy-multiple approach:

Stage 1. In the first stage, term sets are introduced to describe the basic sets of the IS state and the subset of states, described in the natural language:

The complete set of information security status assessment E of IS is broken down into five subsets of the form:

E_1 – subset of states "extremely unsuccessful state of IS InfoSec";

E_2 – subset of states "unsuccessful state of IS InfoSec";

E_3 – subset of states of "average quality of the IS InfoSec state";

E_4 – subset of states "relatively safe state of IS InfoSec";

E_5 – subset of states "the maximum safe state of the IS InfoSec".

The corresponding set E of a full risk set of IS InfoSec threats G is divided into 5 subsets:

G_1 – subset of "marginal threat risk of InfoSec";

G_2 – subset of "high threat risk to InfoSec";

G_3 – subset of "average threat risk to InfoSec";

G_4 – subset of "low threat risk to InfoSec";

G_5 – subset of " insignificant risk threat to InfoSec".

Assume that G takes the value from zero to one by definition.

For an arbitrary separate indicator of the InfoSec assessment X_i, the complete set of its values of B_i is divided into five subsets:

B_{i1} – subset "very low level of indicator X_i";

B_{i2} – subset of "low level of indicator X_i";
B_{i3} – subset of "average level of indicator X_i";
B_{i4} – subset of "high level of indicator X_i";
B_{i5} – subset of "very high level of indicator X_i".

An additional condition for matching the sets *B*, *E* and *G* of the following form is performed: if all the indicators in the analysis have, according to the classification, the level of the subset B_{ij}, then the state of the InfoSec is qualified as E_j, and the degree of InfoSec threat risk is qualified as G_j. Fulfilment of this condition affects the correct quantitative classification of the levels of indicators and the correct determination of the level of significance of the indicator in the evaluation system.

Stage 2. Construct a set of indicators $X = \{X_i\}$ in the number $N = 4$, which, according to expert-analyst, on the one hand, affect the assessment InfoSec threat risk, and, on the other hand, evaluate the different sides of IS InfoSec.

Stage 3. Summarize to each indicator the level of its significance for the analysis of ri. To estimate this level, you need to position all the values in descending order of magnitude so that the rule is complied with:

$$r_1 \geq r_2 \geq ... \geq r_n \quad (1)$$

If the system of indicators is put in descending order of their significance, then the significance of the *i*-th index should be determined by the Fishburn's rule [15]:

$$r_i = \frac{1}{N} \quad (2)$$

The Fishburn's Rule reflects the fact that nothing is known about the level of significance of the indicators (1). Then the estimate (2) corresponds to the maximum entropy of the existing information uncertainty about the object of the study

If all the indicators are of equal significance, then

$$r_i = \frac{2(N-i+1)}{(N-1)N} \quad (3)$$

Stage 4. Construct a classification of the current value g of the risk factor G as a criterion for dividing this set into a subset (Table 2):

Table 2 – Value of indicator *g*

Interval *G*	Set names
$0.8 < g < 1$	G_1 – subset of "marginal threat risk to InfoSec";
$0.6 < g < 0.8$	G_2 – subset of "high threat risk to InfoSec";
$0.4 < g < 0.6$	G_3 – subset of "average threat risk to InfoSec";
$0.2 < g < 0.4$	G_4 – subset of "low threat risk to InfoSec";
$0 < g < 0.2$	G_5 – subset of " insignificant risk threat to InfoSec".

Stage 5. Construct a classification of the current values x of the X indicators as a criterion for breaking up the complete set of their values into a subset of type B (Table 3).

Table 3 – Value subset partition

Indicator name	Criteria of subset partition				
	B_{i1}	B_{i2}	B_{i3}	B_{i4}	B_{i5}
X_1	$x_1<b_{11}$	$b_{11}<x_l<b_{12}$	$b_{12}<x_l<b_{13}$	$b_{13}<x_l<b_{14}$	$b_{14}<x_l$
…	…	…	…	…	…
X_i	$x_i<b_{i1}$	$b_{i1}<x_i<b_{i2}$	$b_{i2}<x_i<b_{i3}$	$b_{i3}<x_i<b_{i4}$	$b_{i4}<x_i$
…	…	…	…	…	…
X_N	$x_N<b_{N1}$	$b_{N1}<x_N<b_{N2}$	$b_{N2}<x_N<b_{N3}$	$b_{N3}<x_N<b_{N4}$	$b_{N4}<x_N$

Stage 6. Evaluate the current level of indicators and reduce the results:

Таблиця 4 – Indicator's level evaluation

Indicator name	Current value
Very high (VH)	$X_1>1$
High (H)	$0.1< X_2 <1$
Medium (M)	$0.01< X_3 <0.1$
Low (L)	$0.001< X_4 <0.01$
Very low (VL)	<0.001

Stage 7. Classify the current values of x according to the criterion of Table 3. The result of the classification is Table 5. $\lambda_{ij}=1$, if $b_{i(j-1)} < x_i < b_{ij}$, and $\lambda_{ij}=0$, when the value does not fall into the selected range of classification.

Table 5 – Classification result

Indicator name	The result of classification by subsets				
	B_{i1}	B_{i2}	B_{i3}	B_{i4}	B_{i5}
X_1	λ_{11}	λ_{12}	λ_{13}	λ_{14}	λ_{15}
…	…	…	…	…	…
X_i	λ_{i1}	λ_{i2}	λ_{i3}	λ_{i4}	λ_{i5}
…	…	…	…	…	…
X_N	λ_{N1}	λ_{N2}	λ_{N3}	λ_{N4}	λ_{N5}

Stage 8. Carry out arithmetical steps to assess the degree of bankruptcy risk of *g*:

$$G = \sum_{j=1}^{5} g_j \sum_{i=1}^{N} r_i \lambda_{ij} \quad (4)$$

$$g_j = 0.9 - 0.2(j-1) \quad (5)$$

r_i is defined by formulas (2) and (3).

The contents of formulas (4-5) is as follows: first, we evaluate the significance of a particular subset B in the assessment of state E and in the assessment of the threats risk level G. These index numbers are further involved in the external summation to determine the average value of *g*, where g_j is the average estimate of *g* from the corresponding range of table 2 of the method stage.

Step 9. We classify the obtained value of the degree of risk of InfoSec on the basis of table 2. Thus, the conclusion about the threat risk level of AIS InfoSec takes on a linguistic form.

Conclusions

The relevance of the issues for information security risk assessment of automated information systems is considered in the paper. Existing methods of risk assessment of AIS InfoSec are considered.

After analyzing the literature, the techniques were classified into two principles - those that provide a qualitative risk assessment; those that provide a quantitative risk assessment. The advantages of each type of methods and their disadvantages are revealed. In the course of the analysis, it was found that the most effective assessment is given by mixed types of methodologies that combine the characteristics of both types of assessment.

During the course of the work, a risk assessment technique was developed based on a fuzzy multiple approach that avoids the uncertainty factor during the process of assessing the system security degree and obtains the risk level in a linguistic form. The proposed methodology assesses the risk of a mixed type – combining qualitative and quantitative characteristics.

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INTELLIGENT AGENT OF ACCESS MANAGEMENT AND CONTROL SYSTEM

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Abstract*.This article is devoted to the research and development of an agent for a distributed system of access management and control. It consists of different modules, which allows for addition of new features and improves its security and redundancy capabilities. This system allows for a precise control of movement of authorized and unauthorized personnel.*

Keywords: *distributed systems, multiagent systems, ACS systems, security*

Introduction

In the conditions of fierce competition in the market of new technologies, observance of conditions of secrecy and counteraction of technological information leakage, information security, unauthorized access to equipment and territory for some enterprises, the question of organization and control of access to technological zones and premises becomes critical.

This paper addresses the problem of adapting the access control and management system as a way of managing an object in the context of the changing state of the environment and the object itself (technological zone, etc.).

Adaptation of the access control and management system is based on changing the scenarios of its behavior according to external factors, such as time of day, the presence in the technical area of authorized personnel with higher priority, the presence of authorization in general, etc. In the case of a distributed access control and management system, the possible scenarios for its behavior are much more complicated.

Modern access control and management systems do not have adaptive algorithms for organizing regulations of their operation.

This paper describes the creation of an agent for a distributed system of access control and management to technological zones and premises (hereinafter ACS). Its role is to ensure regulations and scenarios for authorized and unauthorized access and movement of persons within the control area.

In order to ensure a high level of protection of the object against unauthorized interference in a changing situation, the following should be considered:

1. Possibility to change access regulations during the day.
2. Possibility to change access regulations in case of emergencies (fire, accident, terrorist attack, natural disaster, etc.).
3. Possibility to change the regulations for access to the equipment, its activation and / or change of the operating mode according to the access level.
4. Ability to monitor the movements of persons (and their legitimacy) in the control area.

Access control systems

The existing literature about modern access management and control systems describes the following principles of ACS operation [4, 7]:

- countering industrial espionage;
- anti-theft action;
- against sabotage;
- against intentional damage to material assets;
- time tracking;
- controlling the arrival and departure of employees on time;
- protection of confidentiality of information;
- regulation of the flow of visitors;
- control of entry and exit of transport and freight.

In addition, ACS is a barrier to the "curious" people [4].

When implementing specific access control systems, different methods and devices are used to identify and verify a person.

As the most commonly used ACS can be called such [4]:

- regular carousels and walls;
- turnstiles for passage in the corridors;
- lock cabins;
- automatic gates;
- rotating turnstiles;
- revolving doors;
- roadblocks;
- barriers;
- parking systems;
- sliding round doors;
- three-bar turnstiles;
- full-height turnstiles;
- sliding turnstiles.

A very important issue is the possibility of integrating ACS with any security system using an open protocol [4].

The main objectives of the checkpoint regulations are [4, 7]:

- protecting the legitimate interests of the plant, maintaining internal management;
- protection of business property, its rational and efficient use;
- increase in corporate profits;
- internal and external stability of the organization;
- protection of trade secrets and intellectual property rights.

Checkpoint regulations as part of the security system allows owner to solve the following tasks [4, 7]:

- Ensuring licensed transition of employees and visitors, import / export of material products and assets, butchering of enterprise;
- Preventing uncontrolled penetration of unauthorized persons and vehicles into protected areas and private buildings (premises);
- Timely identification of threats to the interests of the plant, as well as potentially dangerous conditions that could cause material and moral harm to the venture;
- Creating reliable guarantees for maintaining the organizational stability of the external and internal relationships of the enterprise, developing a rapid response mechanism for threats and negative trends;
- Suppression of outbreaks in the legitimate interests of the enterprise, the use of legal, economic, organizational, socio-psychological, technical and other means to identify and reduce sources of threat to the security of the enterprise.

Checkpoint regulations can be defined as a system of providing regulatory, organizational and material guarantees for identifying, preventing and combating infringement of the legal rights of an enterprise, its property, intellectual property, production discipline, technological leadership, scientific achievements and protected information, and as a combination of organizational and legal restrictions and rules, establishing the procedure for passing through the checkpoint employees of the facility, visitors, transport of import / export of material assets [4].

Multi agent systems

An agent is a computer system located in a particular environment, and can operate autonomously in that environment to meet its design goals.

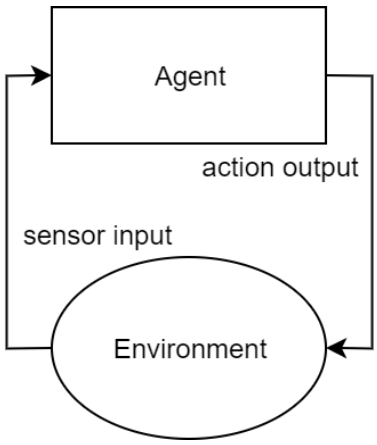

Figure 1. An agent in its environment. The agent takes sensory input from the environment, and produces as output actions that affect it. The interaction is usually an ongoing, non-terminating one.

Figure 1 gives an abstract view of an agent. In this diagram, we can see the action output generated by the agent in order to affect its environment. In most areas of reasonable complexity, an agent will not have complete control over its environment. It will have at best partial control, in that it can influence it. From the agent's point of view, this means that the same action performed twice in apparently identical circumstances might appear to have completely different effects, and in particular, it may not have the desired effect. Therefore, agents should be prepared in environments other than the most natural for the possibility of failure. We can formally summarize the situation by saying that environments are in general assumed to be nondeterministic. Usually, an agent will have a variety of actions available to it. This set of possible actions represents its ability to change its environment. Note that not all actions can be performed in all situations. For example, an action 'lift table' is only applicable in situations where the weight of the table is sufficiently small that the agent can lift it. Similarly, the action 'purchase a Ferrari' will fail if insufficient money are available to do so.Operations therefore have preconditions that define the possible situations in which they can be applied. The key problem facing an agent is that of deciding which of its actions it should perform in order to best satisfy its design objectives. Agent architectures are really software architectures for decision-making systems that are embedded in an environment [1, 2, 5, 6].

Control system can be viewed as an agent. A simple example of such a system is a thermostat. Thermostats have a sensor for detecting room temperature. This sensor is embedded directly in the environment (i.e. the room), and it produces as output one of two signals: one that indicates that the temperature is too low, another, which indicates that the temperature is OK. The actions available to the thermostat are 'heating on' or 'heating off'. The action 'heating on' will generally have the effect of raising the room temperature, but this cannot be a guaranteed effect - if the door to the room is open, for example, switching on the heater may have no effect. The (very simple) decision making component of the

thermostat implements (usually in electro-mechanical hardware) the following rules [1, 3, 6]:

- too cold - heating on,
- temperature OK - heating off.

More complex environment control systems, of course, have considerably richer decision structures. Examples include autonomous space probes, fly-by-wire aircraft, nuclear reactor control systems, and so on [1, 5].

Main conditions of agents' intelligence [1]:

- Reactivity. Intelligent agents are able to perceive their environment, and respond in a timely fashion to changes that occur in it in order to satisfy their design objectives.
- Proactiveness. Intelligent agents are able to exhibit goal-directed behaviour by taking the initiative in order to satisfy their design objectives.
- Social ability. Intelligent agents are capable of interacting with other agents (and possibly humans) in order to satisfy their design objectives.

Research result

Within the performed work, the concept and the software-hardware complex of the distributed access control and management system were developed.

The developed system consists of three basic parts:

- ACS management Interface;
- Lock Agent;
- Agent for activity monitoring and decision-making.

The software system of the information system has the structure shown in Figure 2.

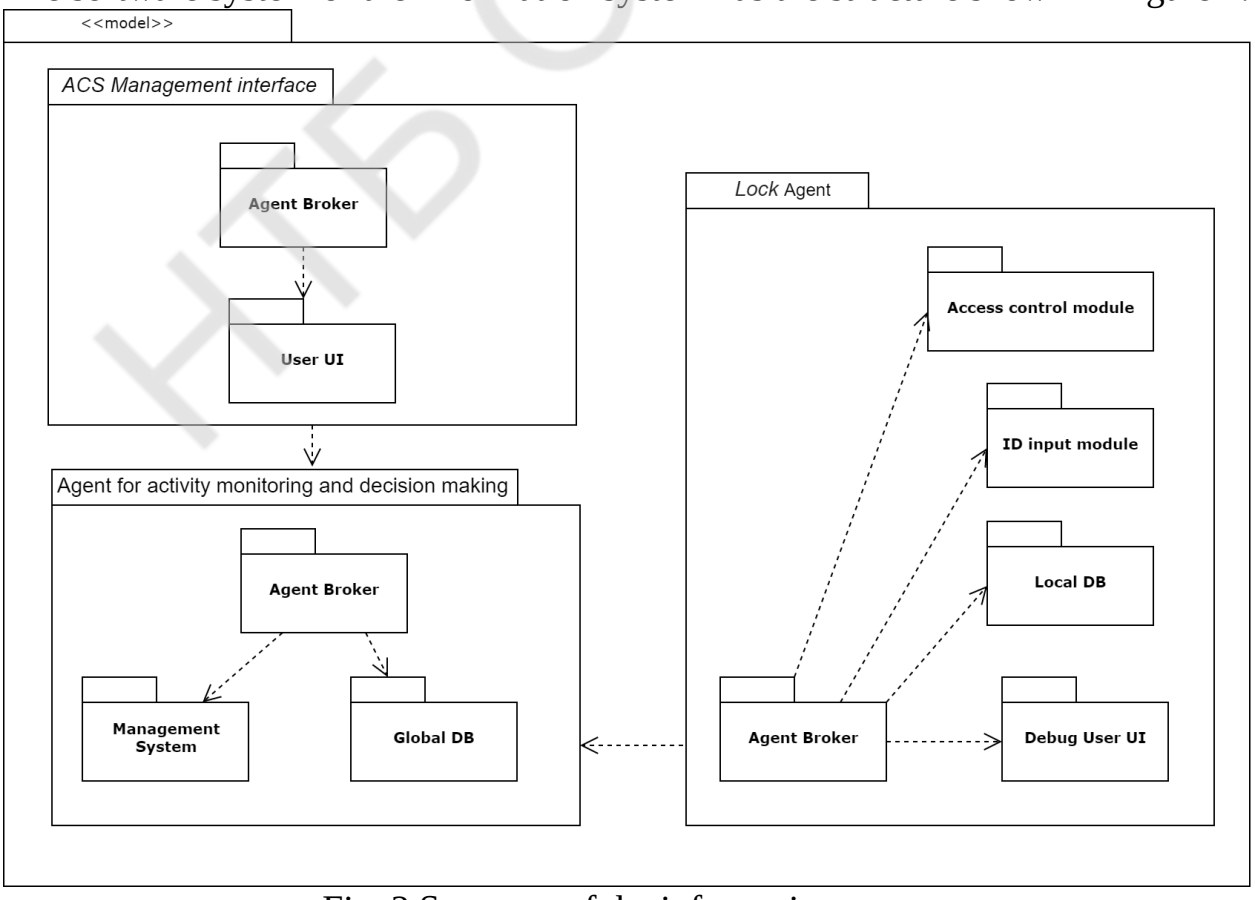

Fig. 2 Structure of the information system

The ACS management interface and the activity monitoring and decision-making agent are software implementations. The lock agent is a hardware and software complex.

The hardware implementation of a lock agent is based on an ARM32-compliant microcomputer, reader modules and access modules (lock actuator, turnstile, power supply, etc.).

The lock agent software is developed in Java programming language, using Hibernate, Netty and GSON libraries and runs on Java Runtime Environment 8 under Armbian Linux operating system.

The admin interface software is designed using the Java programming language, including the Vaadin Framework, using Netty and GSON libraries, and runs on Java Runtime Environment 8.

The activity monitoring and decision-making agent software is developed in Java programming language, including Spring framework, using Netty library and runs on Java Runtime Environment 8.

Each lock agent has a built-in local H2 database in which it stores access rules. The activity monitoring and decision-making agent operates a global database (it is unique to one defined distributed system) MySQL. The management interface manages a copy of the global database. Any changes to the rules coming from the management interface are made to the global database. The activity monitoring and decision-making agent, upon receipt of the new regulation, shall make appropriate adjustments to the system. All changes to the regulation are synchronized with the lock agents, according to the following parameters:

- each lock agent receives only those parts of the regulation that relate to his control area;
- each lock agent receives a minimum amount of personal information.
- data exchange is performed by standardized JSON serialization commands

The software part performs the following main tasks:

- Activation of the system and updating of local databases of lock agents.
- Formation of access regulations by the system administrator according to different situations (fire, accident, terrorist attack, natural disaster, etc.).
- Monitoring of the technical state (status) and controllability of lock agents by the monitoring and decision-making agent.
- Reading information using the readout module.
- Identification of the person by the lock agent using build-in database and determination of permissions of authorized and unauthorized persons.
- Logging events to the system log.
- Monitoring the activity and displacement of individuals.
- Generation of notifications and alarms.
- Prepare and report on relevant services (managers, security and safety services).

The ACS management interface is shown in Figure 3, 4 and 5. It provides the system administrator with the following tools:

- Allows access to the operator's personal cabinet (personal data, identification keys, access keys, etc.).
- Formulation of a list of situations and regulations of access and activity of authorized and unauthorized persons and scenarios of reactions to all possible events.

- Maintenance of a global database of authorized persons.
- Visualization of activities and movements within the control area.
- Monitoring of the status of technical equipment of the ACS.
- Generate reports for different services.

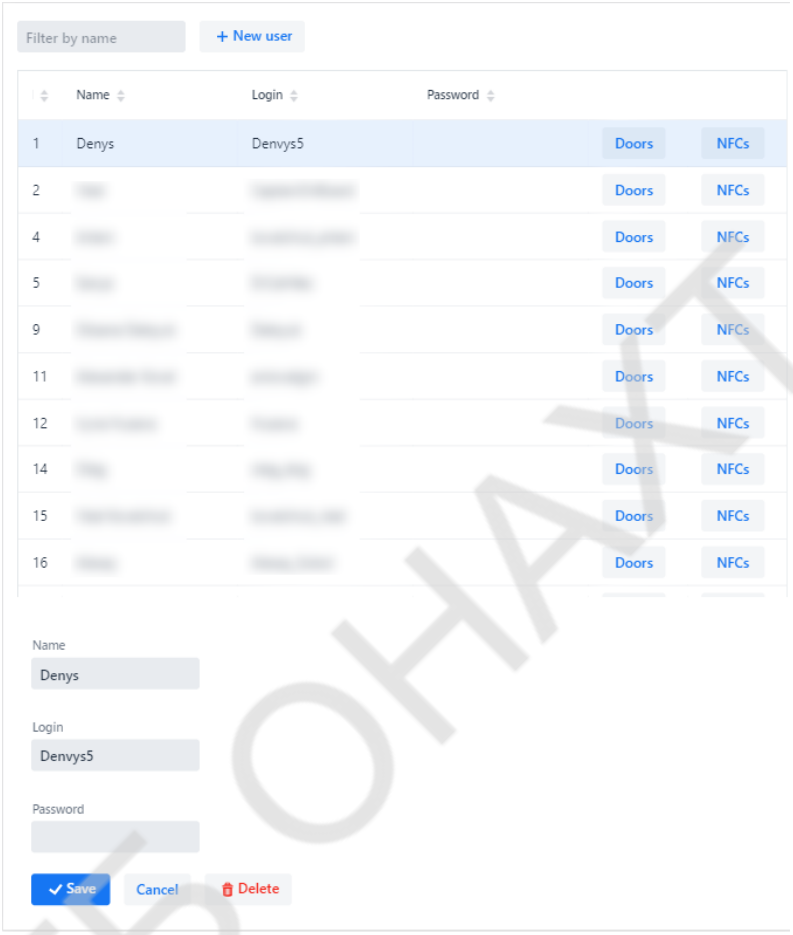

Fig. 3 User List Interface

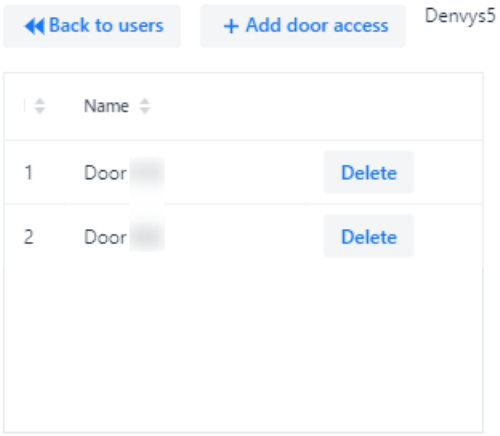

Fig. 4 List of user-accessible premises interface

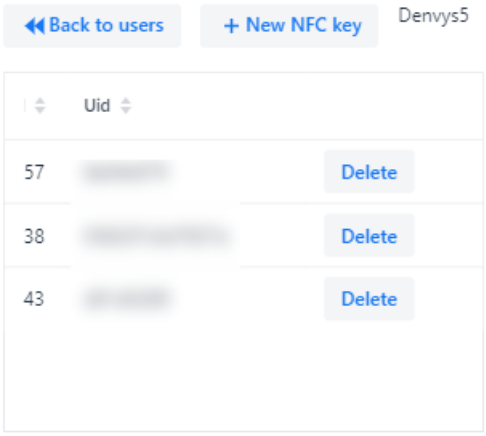

Fig. 5 User authentication keys interface

The lock agent constantly communicates with the monitoring and decision-making agent. Its main task is to enforce the access regulations to the premises on which it is assigned. The lock agent provides the possibility of authorization of persons according to the following identification data:

- credit card
- fingerprint
- personal smartcard
- face scan
- etc.

Conclusion

The result of conducted research is the creation of a multi-agent distributed ACS. It allows you to set rules for access of authorized and unauthorized persons to premises or territories controlled by the system.

This agent allows the multi-agent system to track the movement of people through controlled premises and respond accordingly to the movement of authorized personnel.

This development has the greatest potential in facilities with a high level of security and a large hierarchy of access to premises or territories. After consultations, the military service and large business companies became interested in this development.

The introduction of such a control system will allow enterprises with a high level of internal security to increase the savings of internal resources (by controlling the number of people in different zones and premises of buildings), to improve the details of reporting (about the movement of authorized personnel inside objects controlled by the system) and to reduce the volume of overhead maintenance costs for access control and control systems.

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EMPLOYEES NOTIFICATION SYSTEMS IN THE EVENT OF EMERGENCY SITUATIONS THROUGH PUBLIC WIRELESS ACCESS POINTS

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Abstract. *In the event of an emergency, there are still actions that people must take to save themselves. Currently everyone has a mobile phone. Almost all establishments have an open Wi-Fi network. Therefore, the purpose of the work is to design and develop a system that, when connected to the network, informed about the threats that have arisen and the actions that citizens must take to avoid damage. The alert system works around the clock. It complements the existing fire alarm and security systems.*

In the work a critical analysis of existing and prospective emergency alert systems was carried out, which showed that there is currently a revision of the requirements for the civil protection notification system towards the transition to new structures of such systems organization, taking into account the current state of technical means of communication, protection against unauthorized access and the spread of malware, identified the possibility of improving them.

The mathematical model of choosing the optimal coverage of the territory with the signal WI-FI alert has been improved, which takes into account losses during repeated passage of the signal through obstacles, which allows to predict the frequency reuse on different floors of the building.

The study was made on 19 pages of printed text, contains 3 drawings and a list of references, which consist of 22 sources. The study was done in English.

Key words: *Alerts, Public Wireless APs, Unauthorized Data Access, Alert Nodes, Emergencies.*

Introduction

One of the main ways of protecting the population from emergencies is timely notification of the danger in the situation that has arisen as a result of its development, as well as informing about the procedure and rules of behavior in the context of the emergency.

Today there is a revision of the requirements regarding modern alert systems (AS), which were created for the purpose of civil protection tasks by means of automated systems of centralized notification, communication networks, radio broadcasting. There is a transition to new structures of organization of such systems, taking into account the

current state of technical means of communication, protection against unauthorized access and distribution of malicious software.

However, the current AS structure does not take into account the possibility of using a large number of FREE WI-FI points for notification, and is not intended for hearing impaired people.

Loudspeaker in such places, of course, attracts attention and may provide the necessary information for further action, but at the same time the presence on the screen of a smartphone, tablet, laptop clear scheme, evacuation plan and instructions for actions of the population especially with hearing impairments, which will minimize the time to make decisions about emergency response or mitigation measures.

Thus, it is promising to create ASs that will increase the number of people covered by emergency alert systems. Therefore, the problem posed in the work is certainly urgent

In the event of emergencies, the danger must be notified first. What is there for calls, howls, sirens, whatever. But it is still necessary to report on the actions that love must take to escape. Currently everyone has a mobile phone. Almost all establishments have an open Wi-Fi network. Therefore, the purpose of the work is to design and develop a system that, when connected to the network, informed about the threats that have arisen and the actions that citizens must take to avoid damage.

Review of literature and analysis of the current status of the civil protection notification of employees

Significant contribution to the development of AS in the emergence of emergencies was made by Ukrainian and foreign scientists V.G. Oliver, A.P. Smolyakov, BF Lomov, V.F. Wendy, VP Zinchenko, I.I. Litvak, I.E. Soloveychik, A.M. Smolyarov and others. But at the same time, the use of free WI-FI hotspot for alerting employees in case of emergency situations is not considered enough in the scientific and technical literature today.

This determines the urgency of the problem that needs to be addressed when creating and maintaining it on an ongoing basis, as well as replacing and operating old ones, and implementing and maintaining new alert systems.

The alert system works around the clock. It complements the existing fire alarm and security systems. Each such system operates in real time.

A real-time system is an automated system with time constraints, and it must respond to events within a specified time frame.

Based on the existing systems, we can understand that they are aimed at the target audience, so the goal was to make a more specialized system.

One of the tasks of civil protection (CP) is to inform employees about the threat or emergencies of anthropogenic and natural nature, to constantly inform employees about the current situation.

The main danger of emergencies is their suddenness and spontaneity, which provoke negative consequences. For businesses with potentially dangerous manufacturing processes, there are urgent questions about the need to prevent the panic caused by the suddenness of a disaster, to prepare themselves and others for the inevitable, and possibly very dangerous, reversal of natural disasters or man-made disasters.

Today, the urgency of protecting employees and territories from emergencies, timely alerting and informing employees about emergencies, is driven by the enormous

magnitude of the consequences of accidents, catastrophes and natural disasters. In order to prevent and eliminate these consequences, it is necessary to concentrate the efforts of the whole state, to organize the interaction of different government bodies, forces and means - that is, to form and implement state policy in this field.

Thus, in the current geopolitical, economic, environmental and military-strategic conditions, the problems of protecting employees and territories from emergencies are very urgent.

General principles of state policy in the field of civil protection of Employees and territories from the National Assembly are regulated by the following basic laws and resolutions of the Cabinet of Ministers of Ukraine:

- the Law of Ukraine “On Protection of Employees and Territories from Emergencies of Technogenic and Natural Character” of June 8, 2000;
- the Law of Ukraine “On Civil Defense of Ukraine” of February 3, 1993;
- Resolution of the Cabinet of Ministers of Ukraine No. 192 of February 15, 1999. "On approval of the Regulation on organization of alert and communication in emergency situations";
- Resolution of the Cabinet of Ministers of Ukraine No. 1198 dated January 3, 1998. "On a unified state system of prevention and response to emergencies of anthropogenic and natural character" and others.

According to Article 8 of the Law of Ukraine "On Protection of Population and Territories from Emergencies of Technogenic and Natural Character", timely notification and constant informing of Employees about the threat of emergencies of technogenic and natural character shall be provided.

This determines the urgency of the problem that needs to be addressed when creating and maintaining it on an ongoing basis, as well as replacing and operating old ones, and implementing and maintaining new alert systems.

The notification organization shall be organized in accordance with the requirements of the provision "On the organization of alert and communication in emergencies", approved by the Cabinet of Ministers of Ukraine Resolution No. 192 of 15.02.1999. Accordingly, the AS for civil protection is organized taking into account the structure of government, the nature and level of emergencies, the availability and location of forces that may be involved in the elimination of the consequences of emergencies. For the present period, the CP AS consists of national, regional and specialized centralized notification systems; local and object systems.

Modern AS and information support is created to fulfill the tasks of the CP on the basis of automated systems of centralized notification, communication network, broadcasting. Also, when building alert systems, it is necessary to take into account the security of access points against the penetration of malicious software everywhere, prevention of DDos attacks, etc.

Today in Ukraine there is a need to replace the existing ASs (equipment that has already worked out the installed resource, was discontinued, exhausted spare parts for repair, etc.) with automated ones, which allow to fulfill the requirements of the AS in modern conditions, which also proves the relevance of the issues under study.

Despite the fact that a number of problems in the construction of alert systems are already solved in the world, in Ukraine the introduction of modern AS, early detection of emergency is restrained by a number of economic and other components, lack of

methodological, practical and educational literature on the organization of alerts, as well as in connection with untimely adoption of the relevant legislative acts.

It is known that the existing alert system in Ukraine is created mainly on the basis of equipment P-160, P-164. The equipment has already fulfilled the installed resource, much of it, especially end devices, has been discontinued. The schematic design of the existing P-160, P-164 equipment does not allow upgrading to provide additional functions, including service. Replacing legacy analog telephone exchanges with modern digital automatic telephone exchanges eliminates the possibility of existing equipment. Equipment P-160, P-164 has the ability to transmit commands only on rigid lines, eliminating the possibility of changing their routing.

Therefore, the equipment in use does not allow the following basic functions:

- to carry out remotely reliable diagnosis of the state of the terminal devices, as well as reliable control of the sirens;
- carry out the selective inclusion of individual end devices or the desired group;
- to give the operator information on the presence or absence of power supply 380V, 50Hz for electric sirens;
- Document input and output information;
- visualize the terrain map with installed terminal devices;
- to transmit information to the population when the power supply is switched off 380V, 50Hz from the terminal devices;
- transfer information to officials via mobile phones.

All these shortcomings of the equipment of the existing AS do not allow not only to promptly eliminate the malfunction, but also to maintain it in working order. In addition, employees may not be alerted to employees in any particular case, nor can employees be promptly alerted. The deterioration of the power supply of 380V, 50Hz (protection against switching and lightning surges, especially in rural networks) has led to a significant increase in the number of failures of the final equipment and its inability to repair. All this is mainly due to the fact that the terminal equipment is designed for a standard surge protection 380V, 50Hz, which currently does not meet these requirements.

On the basis of the above, there was an urgent need to replace existing equipment with equipment with a modern element base, which ensures that the requirements of the alert system are fulfilled in the current conditions.

The structure of the AS technical support should be a combination of telecommunication facilities, individual automated workplaces (AWs), end-user devices, end-to-end alerting devices (EEAD), which are integrated into a distributed network by connecting them through different communication channels. On the basis of separate personal electronic computers (PCs), functionally oriented AWs of the operative duty consoles should be created. According to their purpose, AWs must be system, application, software and hardware that implements the functions of subsystems. Software and hardware provide interfaces for interacting with relevant users, thus creating functionally oriented AWs.

End-to-end alert management devices are technical means that should ensure that various types of existing employee alerting systems are used effectively. The ultimate means of alerting employees include: street speakers; sirens; wired radio stations; radio broadcasting stations; television broadcasting stations; dashboards, which include

advertising dashboards, dashboards located in places where employees gather (areas, subways, public transport stops, etc.).

The effectiveness of alerting agents should be understood as the choice of technical solutions with the maximum efficiency. For example, for loudspeakers and sirens, the determination of the efficiency is based on the use of electrical power to obtain the required sound level (dB).

Based on the above analysis of the state of the art and prospective AS employees in the event of emergencies, it can be argued that, the development of such systems should be conducted in the direction of attracting modern communications, security (ensuring access points against penetration through them of malicious software, prevent DDos attacks), processing, data storage. But at the same time, it is promising to create ancillary systems that will increase the number of people covered by emergency alert systems.

Object of the subject matter of research

The object of research is the processes of exchange, transfer, authorization and protection against unauthorized access of data at the sites of alerting employees in case of emergencies.

The subject of the study is a system of high-tech devices in the administrative building

The purpose of the work is to improve the system of alerting employees in case of emergencies by organizing alerts through the points of FREE WI-FI wireless access to the Internet.

To achieve this goal, the following main tasks have been set and solved.

1. The structure of the alert node (AN) is synthesized.

2. Improved mathematical model of the employee notification system through the nodes of wireless Internet access.

3. The software of AP with data protection system and protection against unauthorized access has been developed.

4. The employee alert network has been designed.

5. Testing of AP in real conditions of operation was carried out.

Scientific novelty:

- Improved mathematical model of the choice of optimal coverage of the territory by the signal WI-FI alert, which takes into account losses during repeated passage of the signal through obstacles, which allows to predict the frequency reuse on different floors of the building;

- Improved system of alerting employees in case of emergencies by creating alert nodes through the points of FREE WI-FI wireless access to the Internet, which allows to minimize the time to make decisions on measures to reduce or eliminate the consequences of the emergency.

Let's build a mathematical model of the employee notification system through the nodes of wireless access to the Internet

The peculiarity of the mathematical model of AS employees at the emergency room using WI-FI access points is to optimize the choice of equipment types, placement of used WI-FI access points, the choice of their spatial orientation, taking into account uncertain weather conditions and time of day. Due to the nonlinearity of the problem, the large

dimension and the complex nature of the constraints, we can switch to an approximate model.

Let there be an area in which to place some set of alert devices. As variables we choose: points of dislocation of devices, type of device for each point of dislocation; the orientation of the alert devices (the position of the axis of the radiation pattern) at each point of dislocation. The devices can be placed on existing structures and on special masts. In the latter case, additional costs for the installation of masts are required.

We formulate requirements for the alert network - it should be ensured throughout the territory of the distribution of the alert signal with a power of not less than the specified. This condition must be fulfilled with all possible values of the natural factors characteristic of the locality, which affect the magnitude of the transmitted signal (time of day, humidity, precipitation, air temperature, fog). As a criterion for optimization (minimization) we accept the cost of a synthesized notification system.

Function construction. The values of the signal strength at the distance from the type I source at the angle A between the axis of the access points and the axis of the receiver are shown in table 1. The values of the angles are taken with some steps.

Table 1

Outputs for access points of different types

A	$R(I, A)$
0	$R(I,0)$
l	$R(I,l)$
$2l$	$R(I,2l)$
…	…
3600	$R(I,3600) = R(I,0)$

Let the numbers and the following inequalities hold:

$$nl < E < (n+1)l$$

$$2mL_0 < \sqrt{(\mathrm{x}-\mathrm{v})^2 + (\mathrm{y}-\mathrm{w})^2} < 2m + lL_0$$

The numbers m and n can be clearly defined

$$n = \left[\frac{E}{l}\right] m = \left[\log_2 \frac{\sqrt{(\mathrm{x}-\mathrm{v})^2 + (\mathrm{y}-\mathrm{w})^2}}{L_0}\right]$$

then the function P can be calculated approximately (the template for calculating the function P is shown in Fig. 1, based on the laws of linear approximation as follows

$$P(I,L,\mathrm{x},\mathrm{y},\mathrm{v},\mathrm{w}) \approx (2 - \frac{\sqrt{(\mathrm{x}-\mathrm{v})^2 + (y-w)^2}}{2^{\mathrm{m}} L_0})((n+1-\frac{E}{l})R(I,nl)(\frac{E}{l}-n)R(I,(n+1)l) - mr) +$$

$$+ (\frac{\sqrt{(\mathrm{x}-\mathrm{v})^2 + (y-w)^2}}{2^{\mathrm{m}} L_0} - 1)((n+1-\frac{E}{l})R(I,nl) + (\frac{E}{l}-n)R(I,(n+1)l) - (m+1)r).$$

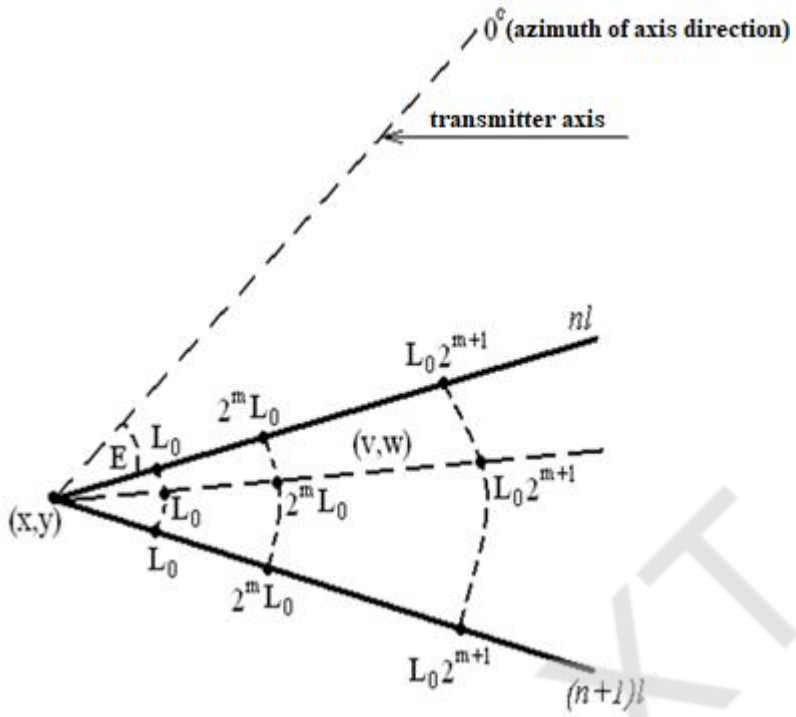

Fig.1 Template for calculating function $P(I, L, \mathrm{x}, \mathrm{y}, \mathrm{v}, \mathrm{w})$

Mathematical model of distributed AS of minimum value, providing signal strength not lower than given in given territory, has the form

$$\begin{gathered}(\sum_{i=1}^{N} C_{I_i} + \sum_{i(x_i, y_i) \in S / S_0} r_i) \to \min_x \\ \max_{1<i<N} P(I_i, L_i, \mathrm{x}_i, \mathrm{y}_i, \mathrm{v}_i, \mathrm{w}_i) \geq P_{\min} \\ (\mathrm{v}, \mathrm{w}) \in S\end{gathered} \quad (1)$$

Where $\mathrm{x} = (N, \mathrm{x}_1, \ldots, \mathrm{x}_N, \mathrm{y}_1, \ldots, \mathrm{y}_N, I_1, \ldots, I_N, L_1, \ldots, L_N)$

The mathematical model (1) does not account for a number of external factors affecting the magnitude of the signal power. From the theory of radio communication it is known that sound pressure depends on such factors as: time of day, humidity of air, precipitation, air temperature, fog.

According to the formulation of the original problem, the AS must provide the minimum permissible signal power in the given territory at all possible values of the external factors listed above. In this case, the mathematical model (1) takes the following form:

$$\begin{gathered}(\sum_{i=1}^{N} C_{I_i} + \sum_{i(x_i, y_i) \in S / S_0} r_i) \to \min_x \\ \min_{(\mathrm{v}, \mathrm{w}) \in S} \max_{1<i<N} \min_{\substack{K_1 \in A_1, \\ \ldots\ldots \\ K_7 \in A_7}} P(I_i, L_i, \mathrm{x}_i, \mathrm{y}_i, \mathrm{v}_i, \mathrm{w}_i, K_1, \ldots, K_7) \geq P_{\min}\end{gathered} \quad (2)$$

Where $\mathrm{x} = (N, \mathrm{x}_1, \ldots, \mathrm{x}_N, \mathrm{y}_1, \ldots, \mathrm{y}_N, I_1, \ldots, I_N, L_1, \ldots, L_N)$.

It is difficult to solve this problem explicitly because of its nonlinearity, considerable dimensions and the complex nature of the constraints. Therefore, an approximation model was constructed. Without fully describing the rules for constructing an approximate model, we formulate the basic ideas of its formation.

The set of points in the coverage area is replaced by the finite number of points in the grid structure. It is assumed that providing a given level of signal power at a given set of points entails fulfilling this condition on the entire set. Only the set points are considered as the locations of the access points. The set of possible angles of access points is approximated by a uniform finite grid with increments.

The dependence of the signal power on external factors is approximated by multiplicative coefficients for the signal power function. At the same time, their least favorable values are considered.

The mathematical model for selecting the optimal coverage of the area with the WI-FI alert signal is fully consistent with the above model (2). However, the specificity of the research task allows the WI-FI alert in comparison with model (2.2) to make two important simplifications.

We are only considering one access point type (R=1). Conditions for checking the achievement of the required signal power at a point (v,w) are simpler than calculating a function P in model (2.2). Namely, only the point in a sector with a given angular size ($d_{\max}$) and a given radius ($R_{\max}$) is checked (Fig. 2.2).

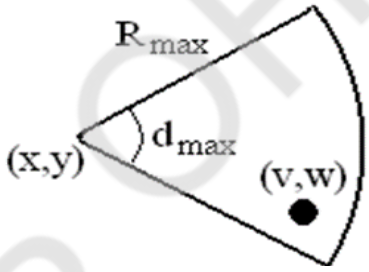

Fig. 2.2 Signal zone

This model takes into account losses during repeated passage of the signal through the floor, which allows to predict such characteristics as frequency reuse on different floors of a building. Remote power loss ratios include implicitly correcting for signal loss through walls or obstructions, as well as other loss mechanisms that may occur within one floor of a building:

$$L = 20\log f + N\log d + P_f(n) - 28(l)$$

where d is the distance (coverage radius), m; f - frequency, MHz; N - signal power loss factor depending on distance; n - number of obstacles; $P_f(n)$ - parameter of signal power loss when passing through obstacles.

Characteristic parameters based on the results of various measurements are given in the reference data, in this case we use values for office space, namely N=30, frequency f = 2,4 GHZ, power loss parameter $P_f(n) = 14$ [2].

The calculations are for non-overlapping channels 1 (2412MHz), 6 (2437MHz), 11 (2462MHz) and 8m coverage radius:

$$L_{ch1} = 20\log(2412) + 30\log(8) + 14 - 28 = 80{,}74 дБ;$$

$$L_{ch6} = 20\log(2437) + 30\log(8) + 14 - 28 = 80{,}83 дБ;$$

$$L_{ch11} = 20\log(2462) + 30\log(8) + 14 - 28 = 80{,}92\partial E$$

Development results

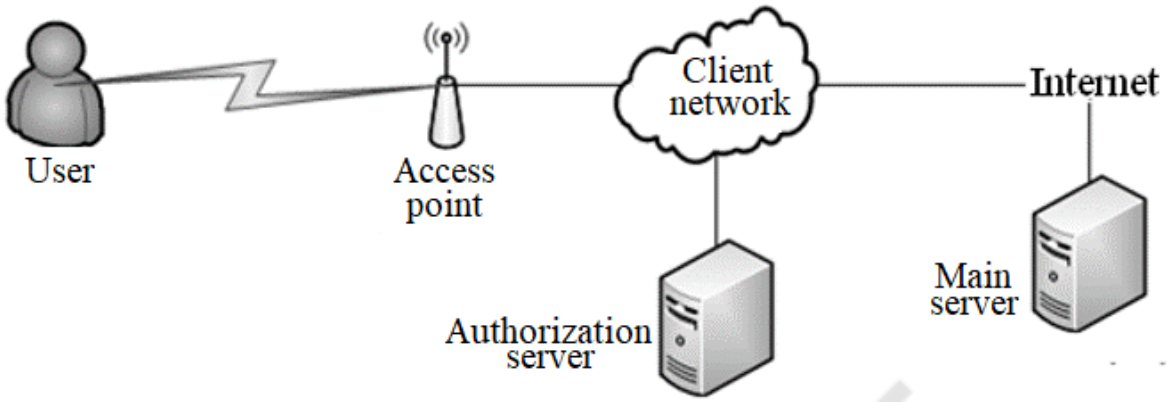

Fig. 1. Alert node scheme

The WI-FI network will be organized in a three-storey building. The network must be expanded on the second floor of the building. There is a grocery store, five convenience stores, three catering facilities, a bathroom and a toilet on this floor.

The need for a WI-FI network is that the marketing policy of the center provides for visitors and employees of the center and shops the opportunity to access the Internet. There are times when you need to access the Internet not only from your computer or laptop, but also from portable devices that allow you to optimize your workflow at the expense of modern network infrastructures - video conferencing, IP-telephony, e-mail, server management and network devices.

The high level of security of WI-FI indicates its advantages when used in public places where information security is one of the main criteria of the network. WI-FI uses sophisticated encryption methods.

Determine the number of access points for the selected room. There are two ways to determine the number of access points when designing a wireless data network for your premises. The first method considers the covering of the premises by zones in the form of a square (Fig. 2.1), and the second method - in the form of a hexagon (Fig.2.2).

Since the selected room has a small space and simple layout, we choose the first way to determine the number of access points for ease of calculation. The calculation is made by the formula

$$, \ S = (\frac{a}{\sqrt{2}(r-t)})(\frac{b}{\sqrt{2}(r-t)}) \qquad (1)$$

Where a is the length of the room; b - width of the room; r - coverage radius of one access point; t - Crossing of zones is required.

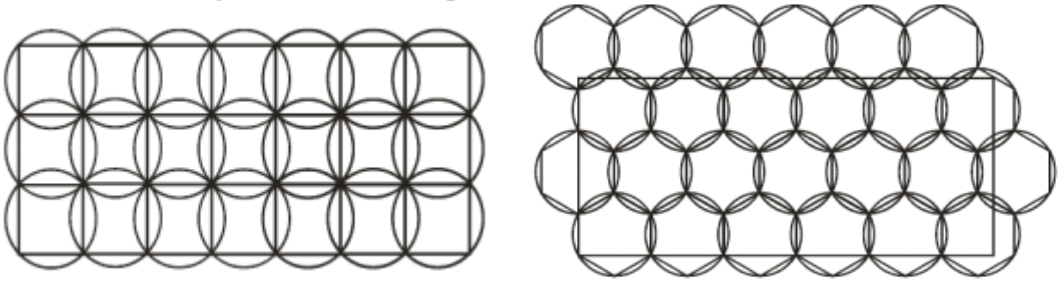

Fig. 2.1. Covering zones in the form of squares 2.2. Hexagonal zone coverings

For this room we calculate the number of points

$$S = (\frac{25}{\sqrt{2}(8-2)})(\frac{10}{\sqrt{2}(8-2)}) = 3.47$$

This value is rounded to the greater side, therefore, 4 access points are needed to cover the room.

Based on the above calculations, the arrangement of the internal access points, as well as the external access point and directional antenna. When connecting the equipment, namely the internal access points, we will use the topology of the type "star", to connect them using a UDP cable, the so-called "twisted pair". The TP-Link TL-ANT24PT3 cable assembly is used to connect the antenna to the external access point. Figure 3 shows a diagram of the connection of the equipment for clarity.

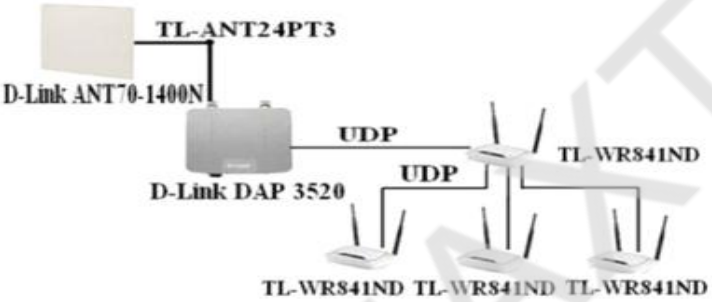

Fig. 3 Wiring Diagram

Developed software based on the FreeRadius server solution and the chillispot installed on the router is used to ensure that the alert node operates properly.

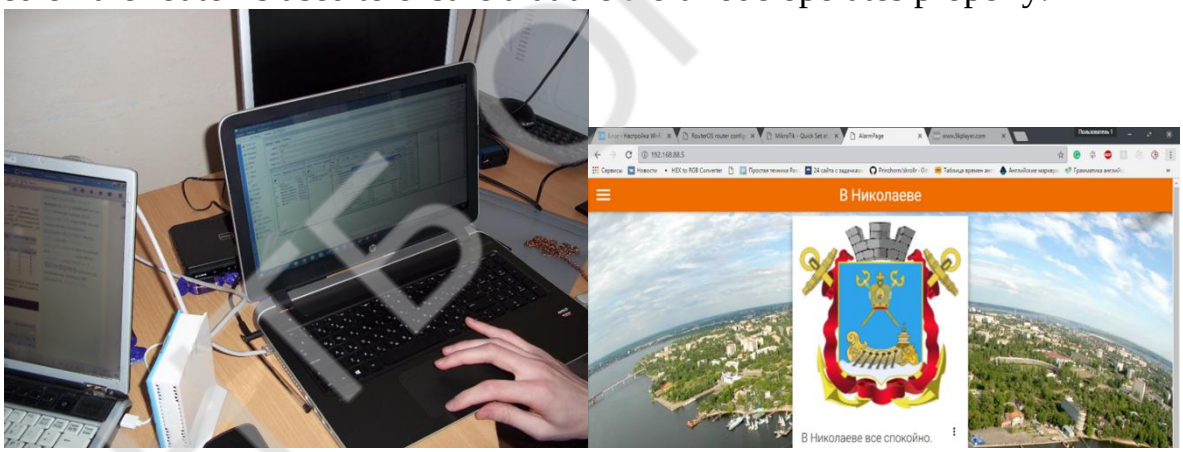

Figure 4 Development results

To protect against unauthorized access to the alert node and save the database of connected subscribers The RADIUS Protocol (aHra. Remote Authentication in Dial-In User Service) is the most common AAA (authentication, authorization and accounting) protocol now developed to transmit information between application programs. (NAS, Network Access Server) and billing system. This protocol owes its popularity to its openness, unlike TACACS + (Cisco) and Kerberos (Merit).

Conclusions

In the work a critical analysis of existing and prospective emergency alert systems was carried out. and the spread of malware, identified the possibility of improving them.

It is suggested to use the FREE WI-FI hotspots as an employee alert center in case of emergencies.

The mathematical model of choosing the optimal coverage of the territory with the signal WI-FI alert, which takes into account losses during repeated passage of the signal through obstacles, allows to predict the frequency reuse on different floors of the building.

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MONITORING AND CONTROLLING AGENT OF MICROGRID CLUSTER

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Annotation

Abstract.*The article is devoted to the research of multiagent systems and methods of their usage in monitoring and controlling Microgrid clusters. Such systems must be able to adapt to changes in energy demand from the user side and respond to changes in environmental parameters, taking into account environmental constraints and the dynamics of energy costs. It allows to easily integrate different energy sources of distributed generation, especially renewable resources. This article is reviewing in detail Multiagent systems and their possible implementation in Microgrid clusters and describes as an example created agent for small energetic system.*

Key words*: distributed systems, multi-agent systems, microgrid systems, remote control*

I. Introduction

With the rapid development of modern technologies, it becomes more and more important to create a reliable network of permanent stable energy supply. Not only important the efficiently divided load distribution on the network, but also the possibility of integration various sources of distributed generation into such systems, especially renewable ones, characterized by the variability of the generation parameters. The system must be able to adapt to changes in energy demand from the user side and respond to

changes in environmental parameters, taking into account environmental constraints and the dynamics of energy prices.

One of the most promising solutions is a way to organize energy communications using Microgrid. Microgrid systems are localized group of sources of energy resources and loads that can work both autonomously and can be part of a larger system. The idea behind such an organization is to make local systems (city, village, etc.) more autonomous and resilient and able to communicate efficiently with other systems. The simplest Microgrid system can consist of distributed generators, renewable energy resources, energy-efficient clusters with flexible load.

The existence of such a system is impossible without the right approach in its management. There are two ways to manage such systems: a more conventional centralized way where all systems are subordinate to one main element (center); or in a decentralized way where each system controls its function or system and is able to regulate its work, adapt to external changes, and share requests and information with other systems.

The centralized approach of managing such systems loses its effectiveness due to the constant complication of systems - constant dynamic modes of operation and the need for constant adaptation to rapid changes of parameters of nonlinear solvable problems of the system.

The decentralized system is based on the idea of dividing it into independent systems, which are able not only to perform all the necessary functions to regulate the internal state, but also to adjust their work relative to the external situation and the operation of other systems. This method of control makes the system flexible to external changes and allows you to effectively adapt the system to the current situation without stopping it.

II. Multiagent systems

Microgrid systems can be a promising energy system for renewable energy technologies that accompany the necessary expansion of distributed energy resources, especially small-scale thermal and electrical and small-scale renewable energy. Such systems typically include: microturbines, fuel cells, photoelectric cells, solar thermal arrays and wind turbine installations, as well as accumulation regulation, load regulation, power and voltage regulation, and heat recovery must be grouped into a Microgrid system. Micro-grids can meet the costs, efficiency and environmental benefits; and the requirements for the safety, quality, reliability and affordability of on-site production are achieved by incorporating state-of-the-art controls and functioning with some autonomy [1].

For even more efficient use of such systems, the principle of multiagent systems can be used in their management [2].

The most relevant approach to creating highly adaptive distributed systems is the Multi-Agent Approach. Multi-agent system is an automated distributed control system consisting of independent (or partially independent) intellectual agents who control their own restricted branch of the system. Agents should be able to respond to external and internal changes, as well as share information with other agents to solve a common problem or problem.

The main principles of intellectual agents are:

- Activity - the ability to organize and execute actions

- Reactivity - the ability to perceive the state of your environment
- Communication - the ability to solve problems together with other agents of the system using advanced communication protocols
- Autonomy - the ability to work in relative independence from one's environment and the presence of some freedom of will in one's actions
- Purposefulness - the presence of clearly stated tasks and the mechanism for setting tasks and the scenario for solving them.

Agents can exchange information using any agreed language, within the constraints of system communication protocol, the approach can lead to overall improvement. Examples of implemented agent communication languages are Knowledge Query Manipulation Language (KQML) or Agent Communication Language (ACL).

This management approach not only automates the process of managing the system, but also allows you to accurately and quickly diagnose the causes of system failure, optimize the work to solve them. Therefore, applying a multi-agent approach to energy systems is a rather interesting and promising approach, as it has few implementations and requires further investigation of its main issues:

- Decision-making: what decision-making mechanisms are available to the agent? What is the relationship between their perceptions, ideas and actions?
- Control: what hierarchical relationships exist between agents? How do they sync?
- Communication: what messages do they send to each other? What is the syntax of these messages?

Fundamental research is currently underway on the challenges involved in implementing multi-agent systems and communication protocols. This system is usually used in telecommunications, the Internet and physical agents such as robots.

The study of multiagent systems has made progress in artificial intelligence, hardware and sensor technologies, which has led to agents' technologies being successfully used to solve real-world industrial problems. For example, the VOLTTRON project, which employs a multi-agent approach to managing network devices, was supported by the US Department of Energy to transmit the VOLTTRONTM software platform to Tranformative Wave. In addition, the department provides Tranformative Wave with technical support for the development of products and services that increase the efficiency of buildings and the resilience of power grids. This project indicates that the industry adopts agent technology.

III. Monitoring and controlling agent

The purpose of my research is to create a prototype of a system for monitoring the technical condition and control the modes of operation of the energy infrastructure using a multi-agent approach. Such a system must harmonize the processes of generation, transmission, distribution, transformation, accumulation and use of energy in real time, taking into account environmental, technical, physical, meteorological, social, economic factors and ensuring the most comfortable conditions for the energy consumer.

The first step in creating such system was to develop a software agent to monitor the technical state and control the operation mode of the energy system branch, with the end consumer (Fig. 1).

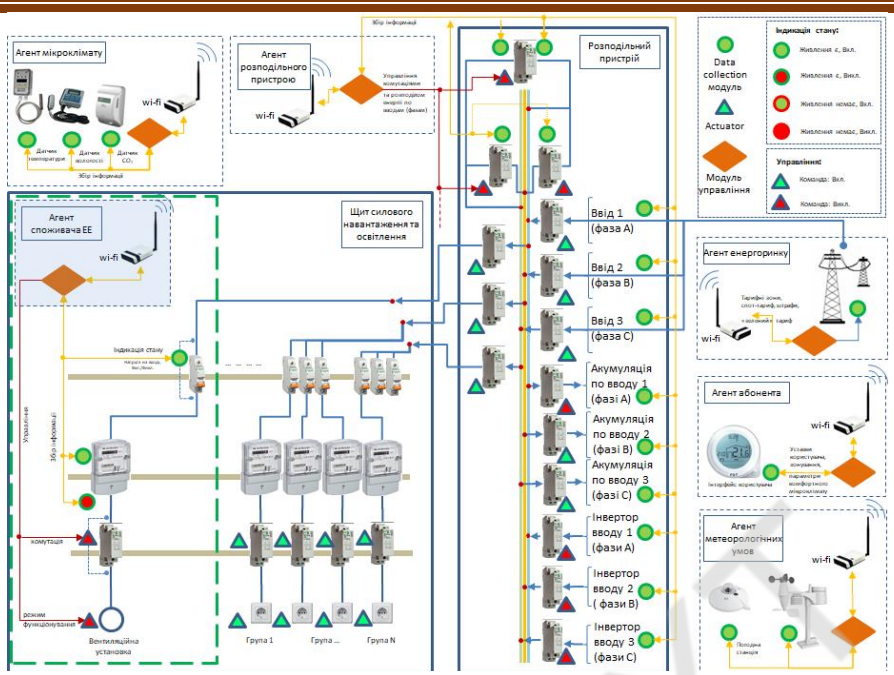

Figure 1. Multiagent system for monitoring and controlling energy system

The software agent monitors the availability of power on each individual link of the branch, the mode of operation of the means of protection and power switching (circuit breaker, starter), keeps a record of the consumed energy, diagnoses the technical condition of the consumer. In the event of an emergency or before an emergency, the agent fulfills the response in accordance with the developed scenario. If the deviation in the mode of operation "in the opinion of the agent" can be adjusted, then it makes such correction by making management actions. If the deviation does not lead to the development of the accident, but allows the use of the equipment is not at full capacity, then the agent translates the equipment into energy-saving mode - the mode of partial use of resources - and requests a service department to restore the technical condition of the equipment. If agents are unable to resume branch operations on their own, they request a service and repair service. Today, a hardware and software complex has been created in which all of the above functionality is implemented (Fig. 2).

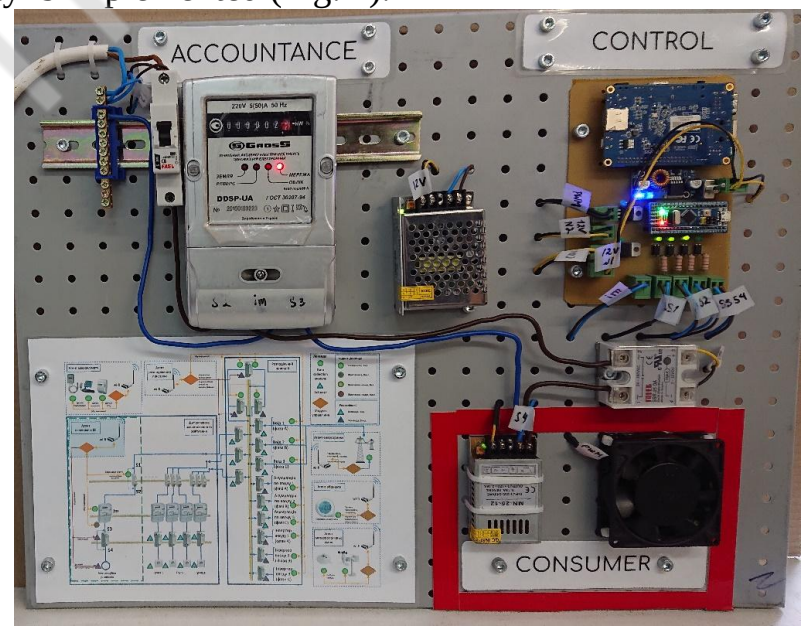

Figure 2. Created stand for testing and displaying agent's work process.

The creation of the agent consisted of two parts: the development of the physical part of the agent - a hardware complex connected to the monitoring and control of the branch, and the software for it - the intelligent agent. The hardware complex is based on the STM32f103c8t6 controller for sensor data collection and actuator control, and a single-board OrangePi PC that houses the main agent code. C, C ++, and C # languages were used for the development of different system modules.

IV. Research result

As a result of research, I was able to create an agent that can be connected via TCP / IP and monitor its mode of operation, give it commands to change the mode of operation, edit the behavior script through the developed remote user interface. By constantly monitoring the sensors on the network, the agent can detect the part of the branch that is experiencing problems and keep constant monitoring of electricity use. The agent also archives all events on the system into a log file and can generate reports on requests from external agents of the system.

The user interface includes 3 tabs, each of which is responsible for its function. The tab entitled "Stats" (Fig. 3) shows the current status of the power grid. In the scheme of the system, near the points where the current sensors should be, there are quadrilaterals that reflect the current value of the sensors: if the quadrilateral has a red frame, the sensor shows no current in this area. If the quadrilateral turns bright green, the sensor captures current in this area.

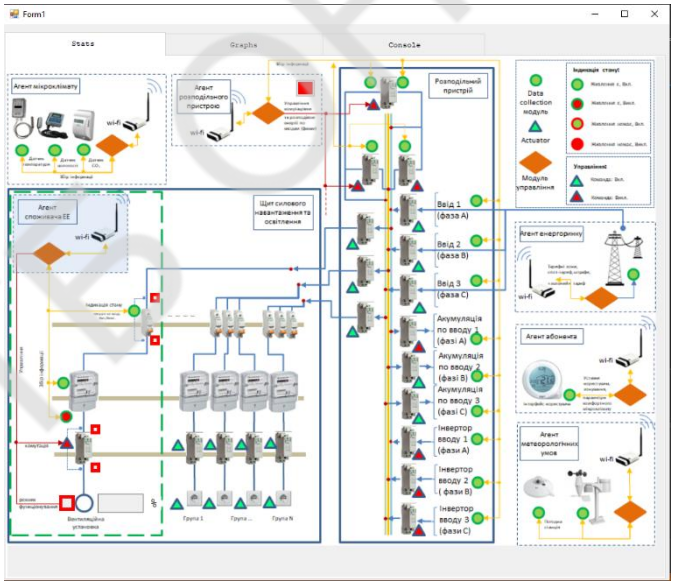

Figure 3. Tab “Stats”

The circle of the ventilation unit mark also includes a quadrilateral indicator that indicates whether the installation is currently on. On the other side of the label there is a text box that shows the current value (in percent) that is supplied to the ventilation system.

The following tab - "Graph" - contains a graph of the load of the grid. The chart changes in real time and displays the meter every second.

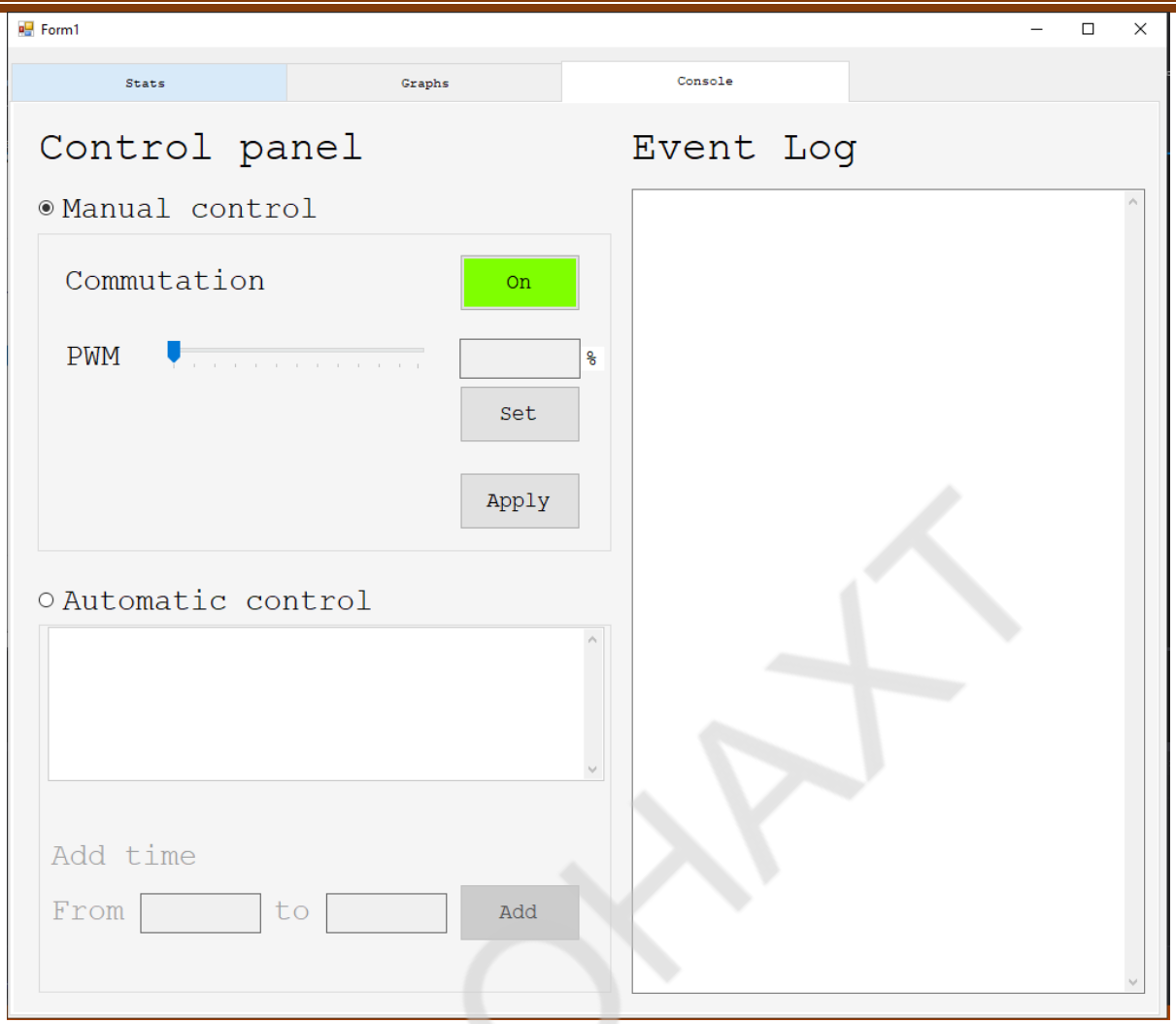

Figure 4. Tab “Console”

The Event log records all system changes and fixes errors. It can be used to conveniently track system events and detect bugs.

The automatic and manual control units cannot operate at the same time, so when selecting one or the other unit, the elements of the second are automatically locked until the unit is selected.

In the manual control unit, you can switch the installation on and off and set the signal strength of the installation. To send the command to the agent, press the button. The program will capture the values it will pass to the agent and send them to TCP / IP.

In the future, it is planned to create several agents that need communication with each other. This step is aimed at solving one of the most important issues of a multi-agent system - creating a convenient and easy-to-speak agent language. The developed system can be useful for both large industrial systems and small user systems.

V. Conclusion

The result of conducted research is the creation of a multi-agent distributed power and energy systems. It allows you to monitor systems’ technical state, integrate different devices and manage their work, overall management of power usage and its control.

This agent allows the multi-agent system to track electricity usage and manage system work according to that. This development has the greatest potential in facilities with high stable power requirement.

The introduction of such a control system will allow to effective usage of power resources, easy maintenance of PowerGrid nodes and gives complete control over all devices in system.

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HEAT LOSS MONITORING OF MULTI-STORY BUILDINGS USING MULTI-AGENT APPROACH

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Abstract. *In this paper, the problem of developing a multi-agent method for detecting the places of heat energy leaks on the multi-story buildings using machine learning is solved. Efficient data processing of scanning areas for the heat energy leak monitoring was achieved using the multi-agent monitoring system (MAMS) that can perform calculations in the cloud conditionally. Features of the monitoring system with the integration of an analytical model for presenting a heat loss map with an account of multiple autonomous separated UAV's for temperature measurements were contained. The MAMS reliability of the synchronization model between simultaneous localization and mapping method and generated heat loss map based on temperature measurements was confirmed. It has been experimentally proven that theoretical assumptions and accuracy for experimental usage during the multi-story building leaks analysis are sufficient.The recognition time of markers of the front of the building is in the range from 0 to 27 s. In this case, with the proposed model CNN, the CPU load during the execution of tasks did not exceed 26%.*

Keywords: *heat loss mapping, heat leak detection, machine learning, multi-agent system, GPS, pyrometer, UAV, MAMS.*

1 Introduction

Energy-saving experts provide heat loss calculations for different scenarios. It may be to ascertain the heat loss of a structure through the floor, walls, and roof, via the building fabric and by ventilation losses, it may be used to calculate heating loads, or it may be to demonstrate compliance with the building regulations. Building regulations required different methodologies depending on if the building is to be extended, renovated, or changing use. Different parts of the multi-story building must have effective thermal separation from the rest of the building. All parts of the multi-story building need to meet minimum requirements for the thermal elements, windows, doors, and building services.

There are several ways to demonstrate the above. To show heat loss management from the specification and drawings that the building's part meets the minimum requirements, with particular attention to the area of glazing. Experts provide area-weighted heat loss value calculations to show that the extension as planned is no greater than one that meets the regulations. Change of use by real estate developers shows compliance is to provide a report detailing the specification of the building, showing the heat loss values supported by area-weighted heat loss value calculations and this is a problem.

Again heat loss monitoring software should have report formats accepted for submission. Renovation of thermal elements of the building is usually linked to an extension or a change of use, but not always. Therefore the means to demonstrate compliance is the same as for those two, however, there are minimum requirements for upgrading thermal elements that are different to those for new elements. The area of the element to be upgraded is important to establish, likewise if by doing so it would have less than a 15-year payback. The main goal of the heat loss monitoring software is to calculate all of this for tenants and present in a written report for renovation's submission. So, if we have had an advanced methodology in gaining compliance with heat loss monitoring results by presenting the facts and calculations in a clear and consistent format that makes it easy for heat loss management to check the building's compliance criteria.

Not too long ago, UAVs were not much more than an ambitious, futuristic concept for data collection and aerial imagery. Now that the technology is relatively established, researchers and manufacturers are already looking for ways to build upon that foundation. Some avenues are more obvious than others. A natural progression is to shift from a single pilot controlling a drone to a single pilot controlling multiple drones. Or, eventually, multiple drones operating independently but cooperatively with a common purpose.

However, flying in formation to a preprogrammed sequence is one thing. Adapting on the fly to perform more complex tasks as a group is quite another. The latter implies communication within the group, as well as goals that are more dynamic than simple synchronized flight. Drone swarms could cut down the time needed to complete mapping missions for the heat loss monitoring of multi-story building to reduce costs for maintenance. AI and computer vision can be used to help drones determine their next move and perform tasks without crashing into the first obstacle they come across.

2 Analysis of the heat loss management systems

The general situation in the field of heating systems is that the main purpose of heat supply to consumers is dominated by the need for an efficient system. About 90% of all

Ukrainian high-rise buildings require measures to improve the functioning of the heat supply systems. Of these, 60-70% of the houses were built in the years of industrial construction in typical series who are currently faced with the problem of heat loss[1]. Heat loss at home is the amount of heat generated by a house on the street per unit of time. They are measured in watts (watts). Heat loss is affected by temperature differences inside and outside the house. This dependence is directly proportional - the larger the temperature difference, the higher the heat loss[2]. Also, heat loss depends on the design of the house. How strongly the external walls or windows impede the generation of heat characterizes the resistance to heat transfer. Between the resistance to heat transfer of building envelopes and heat losses there is an inversely proportional relationship - with increasing thermal resistance, heat losses decrease [3].

The Quick U-Building (QUB) method is a dynamic method developed to estimate the heat loss coefficient of a building in one night without occupancy[4]. Feasibility measurements and comparisons with various references have been done in earlier studies whatever numerically, experimentally in an ideal case, or experimentally in real cases [5,6]. This article presents a review of various perturbation methods developed to assess building thermal performance, details of theoretical understanding of the QUB method, and gathers experimental results obtained in many different configurations[7]. The heat loss coefficients estimated with the QUB method are in good agreement with experimental references and are reproducible. This demonstrates that the QUB method has a real potential to estimate the heat loss coefficient of a building in a short duration and with a reasonable accuracy [8].

The thermal imager is a modern device that analyzes the air circulation in the room, helps to identify structural defects and provide the customer with visual inspection results [9].

The device emits infrared light and picks up the electromagnetic reaction of the surfaces of the studied object. By measuring the intensity of such radiation, the thermal imager can calculate the maximum temperature of a surface and determine the place of heat leakage[10].

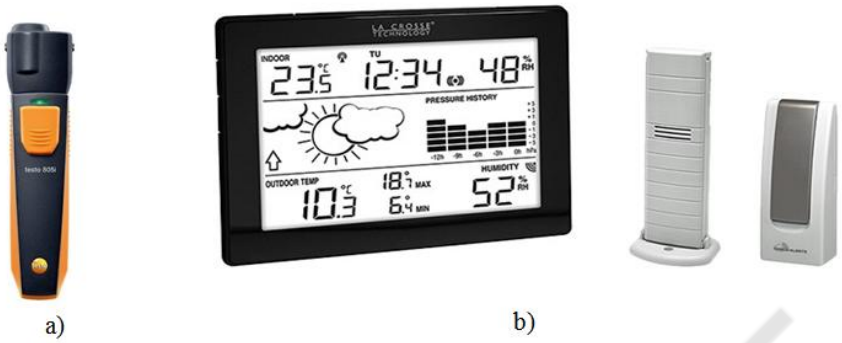
The device is able to analyze the input data and display a graph of temperature differences, as well as calculate the optimal performance for the object [11]. The thermal imager on its screen creates a thermogram - this is a spectrozonal picture of the circulation of warm and cold air in a room. The color scheme in the picture varies from saturated red to blue or blue.

The main problem in measuring heat loss is about a thermal imager is used for measurement, this is a high price for the device, data transfer complexity, averaging of readings along the edges of the measurement zones. In turn, the need for a high density of measurement points for the accuracy of the result is added to the pyrometer. Also a common problem will be low mobility, which is completely dependent on human capabilities. After processing the data, there is a problem with an error when averaging data during the collection, and then when calculating the heat loss of the region and reducing it to a heat map [12].

3 Heat loss measurement hardware

To implement idea for automated heat loss measurements list of equipment was analyzed. The testo 805i (see Fig. 1, a), for example, is a professional measuring infrared

(IR) thermometer from the Testo Smart Probes series, for use with smartphones/tablets with either Android or Apple operating systems. It is, however, worth drawing attention that you need to download and install free Testo Smart Probes App on your device before using the Testo 805i Infrared Thermometer.



a) b)

Fig. 1. Testo 805i Infrared Thermometer (a) and Crosse MA10006-BLA Wireless Weather Station with Gateway (b)

A La Crosse MA10006-BLA smart weather station with Mobile Alerts Weather Gateway MA10000 and Wireless Wifi Thermo-Hygro Transmitter TX29DTH-IT+ options can also be used as an instrument for detecting the heat leakage areas in multi-storey buildings and industrial facilities. And furthermore, the data obtained with the help of the weather station can be used to develop the Heat Leakage Detecting app.

Besides build-in weather stations features, such as 12-hour forecast, outdoor/indoor temperature and humidity sensors) the La Crosse MA10006-BLA is able to share weather data (indoor/outdoor humidity and temperature, wind speed, etc) via the Internet, as well. The weather data will further be available on any smartphone with necessary app installed.

a) b)

Fig. 2. Quadrocopter DJI Matrice 210 with thermal Zenmuse XT and video camera on board (a) and quadrocopter DJI Phantom 4 with TX29DTH-IT on board (b)

Moreover, it should be mentioned that up to 50 Mobile-Alerts sensors at the same time can be connected to the weather station due to the build-in Gateway MA10000 functionality (see Fig. 1, b). Thus, with the help of any drone being equipped with heat sensors it would be possible not only collecting walls temperature data necessary for heat mapping, but also receiving inside and outside temperature data for further comparison and subsequently more accurate detection of the heat leak rate.

The DJI with thermal imaging (see Fig. 2, a) or with the previously mentioned temperature sensor (see Fig. 2, b) can be used as transport means for the heat measuring equipment. An external sensor transmits the information to the weather station with the help of an IT+ technology (Instant Transmission technology) at 868 megahertz. IT+ technology advantages:

1. High Level System Security ;

2. The transmission distance is increased to 100 meters;
3. More economical (Cost-effective);
4. High-quality sensors;

Functional scheme, allow transmission distance is increased to 100m take sensors data on IT + on station, across cloud service Mobile-Alerts via ethernet – on mobile. So device must include a smartphone, with OS Android above 3.2. functional diagram system we can see on Fig. 3.

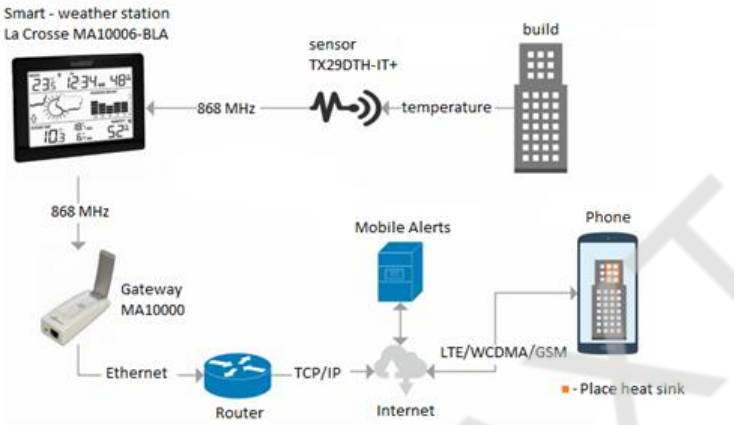


Fig. 3. Functional diagram for the heat loss measurement unit of MAMS.

At the current, the weather station can be upgraded to analyse the data to prevent the fungus formation. In order to protect the walls of houses from damaging, such as mold, fungus, fluctuations in temperature, the comprehensive approach is required, to be outlined in the next report. This upgrade can also help to prevent an occurrence of microcracks between floor panels and in the seams between walls.

4 Multi-agent monitoring system

To solve technical problems, a multi-agent monitoring system for the efficient control of the trajectories of many UAVs was proposed. The functional diagram of MAMS for scanning heat losses was presented (See Fig. 4). The DS^{HLS} set describes an array of UAVs that perform *HLS* heat loss scanning. Each HLS_j scanning path includes an *HLA* scanning area. Processing of the scan area by each DS_i^{HLS} UAV is implemented and based on a neural network, which is capable of detecting markers of the scanning area of building windows using the Deep CNN architecture. Positioning accuracy is ensured according to the SLAM algorithm.

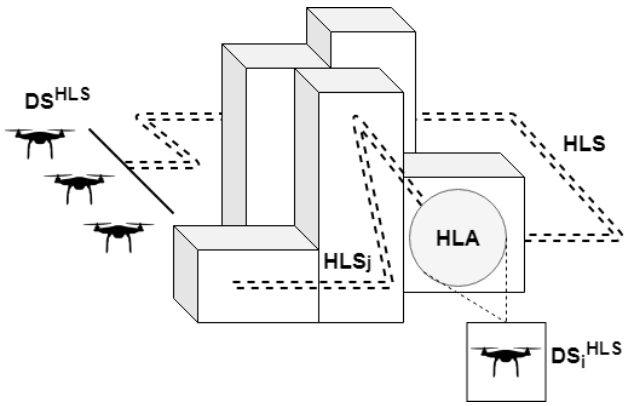


Fig. 4. The heat loss scanning process using MAMS.

The $SLAM^{TR}_{A_{MAMS}(i)}$ is a path mapping system for the $A_{MAMS}(i)$ agent and given as a set of *HLS* trajectories. A section of the trajectory TR_j is considered correct if, in the implementation of the SLAM algorithm, the region of the surrounding space $RG(TR_j)$ was defined. Displayed equations are described the model of the MAMS logic to control the UAVs set:

$$\begin{cases} SLAM^{TR}_{A_{MAMS}(i)} = \sum_{j=0}^{P} TR_j \left| DTC(RG(TR_j)) \in HLS; \right. \\ DCNN^{HLA}_{A_{MAMS}(i)} = \sum_{k=0}^{W} MD_{ACC}(HLA) \left| MD_L(HLA) < V_{THRБ}; \right. \\ ITP_{A_{MAMS}(i)} = T_{SNS} + T^{FLC}_{UAV} \cdot C^{ST}_{TR} \cdot C^{M}_{TR} + T_{WS} + T_{ETH} \cdot VL_{DT}; \\ HLS_{A_{MAMS}(i)} = K_e \cdot VIS^{HLS}(W^{DCNN}_x, W^{DCNN}_y, TMP^{ITP}(x,y,c), t). \end{cases} \quad (1)$$

The next condition for the correct operation of the model is adequate recognition of markers within the *HLA*. The $A_{MAMS}(i)$ agent entity that operating based on one or several UAVs must ensure the recognition of all *W* markers in the *HLA* scanning area with floating MD_{ACC} recognition accuracy at the MD_L recognition threshold. The total data processing time $ITP_{A_{MAMS}(i)}$ depends on the data transmission time from the temperature sensor, the processing time of the sensor signals by the system, the computing resources of which are occupied by the C^{ST}_{TR} stabilization commands and the recognition of window markers by the C^{M}_{TR} neural network. The dynamic dependence of the $HLS_{A_{MAMS}(i)}$ visualization map of the heat loss map taking into account the noise K_e has been determined.

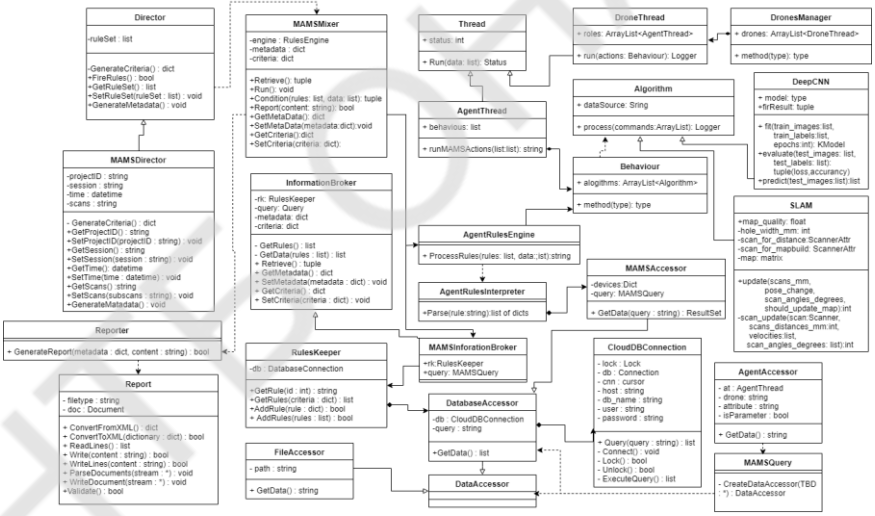


Fig. 5. Software architecture for MAMS included algorithms for scanning optimization.

The architecture of the MAMS software implementation with a multithreaded object-oriented model of managing functional agents was presented in Fig. 5. Abstractions of algorithms that optimize UAV positioning during scanning of the heat loss region were determined. This provides the flexibility to control processing in the MAMS-Mixer object based on the interpretation of the MAMSRulesInterpreter rules.

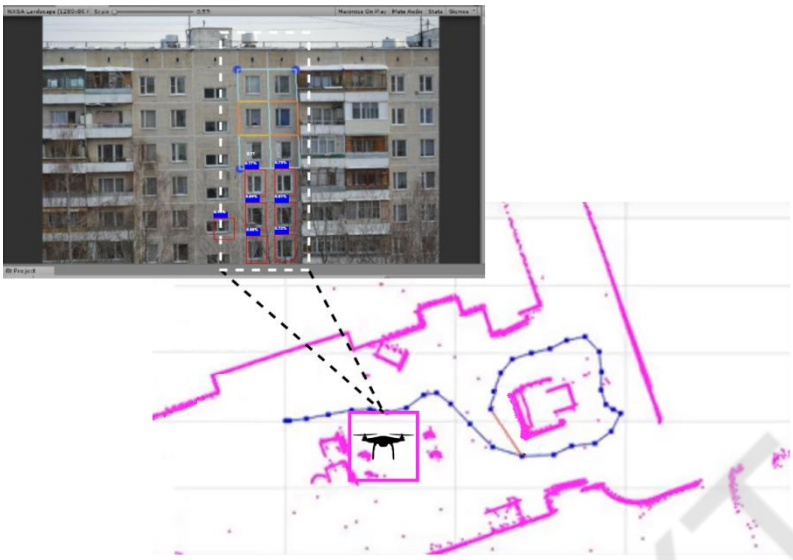


Fig. 6. The result of combination DCNN and SLAM algorithms inside MAMS for heat loss mapping.

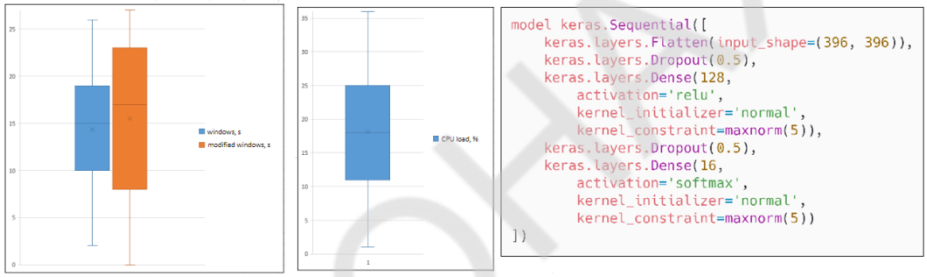


Fig. 7. Plot boxes diagrams of markers recognition time (a), CPU load percentage (b) and description for the proposed CNN model (c).

The software for determining the places of heat leakage of structural elements of buildings was developed. As can be seen in Fig. 7. the recognition time of markers of the front of the building is in the range from 0 to 27 s. In this case, with the proposed model CNN, the CPU load during the execution of tasks did not exceed 26%.

5 Video Streaming Service

The video system is responsible for getting video from the broadcaster agent A_b to our viewers. This includes the following core components: Video ingest is RTSP video in, and then transport it to the transcode system. Transcode system – we take the incoming RTSP stream from the broadcaster, and transcode it into multiple HLS streams. VOD – we take all of our incoming video systems and archive them for our VOD system.

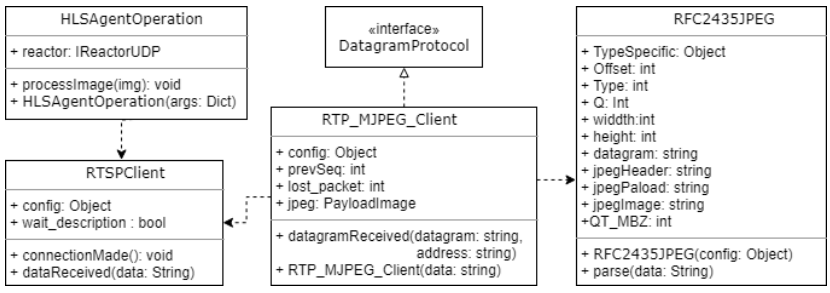


Fig. 8. Architecture of MAMS module for thermal elements quality detection via video stream .

The HLSAgent bevaviour's module in Fig. 8 consists of several files, main.py contains a callback function that processes the received images, it also starts the network transferring mechanisms and stores the parameters for connecting to the camera. Communication between the VLC layer and UAV camera was implemented and requests from the VLC to port 554 of the camera start with "RTSP / 1.0". If we want to receive only video, then from the audio data we ignore everything except the name of the track. We need it to configure the stream, but no one forces us to accept this stream, however, the camera refuses to work if you completely ignore the audio (if SETUP done only for the video track).

Different cameras will react if we neglect the port number for the audio stream (7878), because we specify it with the SETUP command. Next are two SETUP requests, indicating the ports on which we would like to receive video and audio streams. The first is the port for RTP, the second is for RTCP. The camera response contains information about the ports, you can consult them to make sure that everything is configured correctly. Session identifier to indicate it in all subsequent calls is need to be remembered. After the PLAY command, video will begin to be transferred to port 41760 and audio to port 7878 and by TEARDOWN broadcast will stop, the connection will be disconnected.

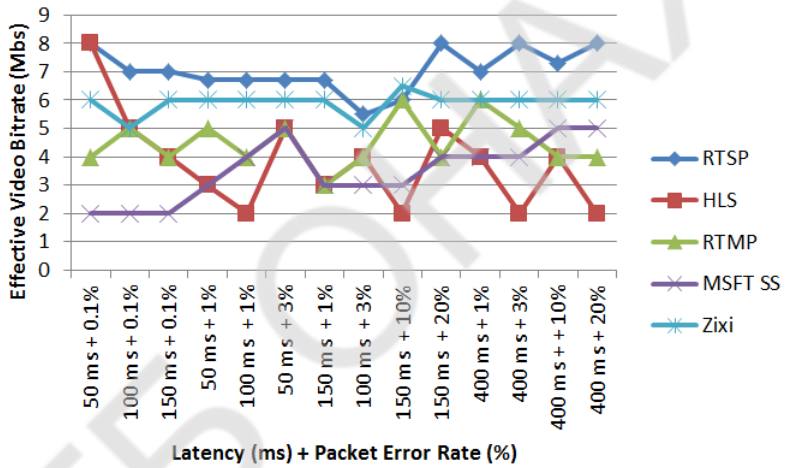


Fig. 9. RTSP performance compared with many of the popular streaming protocols.

Transferred one level of encapsulation above. Conversion the received video data into a full-fledged JPEG image is important. In the case of MJPEG over HTTP, everything is simple - we cut out a piece of the stream and work with it immediately as with a JPEG image. In the case of RTP, the image is not completely transmitted. The JPEG header is omitted to save traffic and must be restored independently from the attached data. The RTSP Payload for MJPEG specification is described in RFC2435.

RTSP video MAMS agent transfers video data via receiving module, but did not convert them to playable data. This problem is handled at the VLC layer so UAV's manager can perform a multi-story building monitoring to find the visual defects that affects the heat losses. It is only necessary to organize parsing similar to rfc2435jpeg. Audio data is easier because it is not fragmented. Each package carries enough data to reproduce. SS and RR types carry information about sent / received packets and about time delays. A graph of the performance of the RTSP transport protocol measured against others shown in Fig. 9 taking into account latency and packet error rate.

6 Conclusion

The functional scheme of the mobile system for detecting heat leakage through the elements of construction of a residential building is developed.

The developed mobile system connects up to 50 wireless sensors up to 100 meters away via the Mobile Alerts cloud server. External wireless sensors transmit information to the Smart Weather Station using IT + (Instant Transmission Technology) at 868 MHz.

The device includes a smartphone with Android OS version not lower than 3.2. System testing was performed using a mobile phone Xiaomi Mi A2 6/128GB. It is suggested to use a quadcopter to lift the sensors to the specified height UAV DJI Phantom 4. Performance comparison of the popular streaming protocols was analysed. RTSP protocol is more efficient than other and provides 7–8 Mbs bitrate in the latency range of 100–400 ms with average packet error rate 8.25%.

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STATUS AND PROSPECTS FOR THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGY IN GERMANY

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Abstract. *This research reveals the topic of the use of information and communication technology in Germany. The degree of involvement in country life and the main modern trends in application of this technology in different industries and community governing are reviewed. Germany is the country which has shifted its focus on digitalization as the main direction in its economic and social advancement. The government engages specialized institutions, leading universities, legislative and expert groups in developing policies, strategies and measures aimed at improving this area. The research provides a general overview and analyses of German large-scale IT projects which impact business and society. Extensive use of information and communication technology has some drawbacks, one of which is lack of security. The wider IT intrusion in life is, the more opportunities for cybercrime arise. This issue and other problems connected with the field under investigation are mentioned in our work.*

Key words*: information and communication technology, digitalization, innovation technologies, digital Germany, Industry 4.0.*

I. Introduction

Nowadays the dramatic rise and convergence of emerging new information technology causes rapidly and radically transforming in all spheres of society's life. The Internet has become increasingly important to users in their everyday lives. It creates new ways for citizens to congregate, store, transmit and retrieve the data and to communicate and share information with others. Ability to work with different computer programs is the skills that are increasingly important for everyone living in the digital age. New mobile and Internet technologies lead to the digitization of the economy and the emergence of new jobs based on the use of technologies such as artificial intelligence, virtual and augmented reality, biotechnology, Internet of things, cloud computing. Therefore, further development of information technology is inevitable.

II. Literature Review

The issue of country digitalization is one of the most vital in modern society. On the one hand, it needs to be studied in order to manifest the outcome of this process implementation, statistic reports, as well as follow the development and progress. On the other hand, exploration of this sphere is necessary to prepare a clear vision of prospects, follow trends, predict changes which might happen in future due to the use of information and communication technologies (ICT) in various fields. Use of ICT in business, science,

education, medicine and different industries is the subject to investigate for many professionals. As to ICT in Germany, researchers frequently pay close attention to overall digitalization of the country, its application in the industries which determine country's international specialization [3], [1] All of them emphasize.

Concerning digitalization, our time is considered to be the period of Industry 4.0. In his article on Germany digitization, Christian Fuchs reviews the main characteristics of the 4th industrial revolution and claims Industry 4.0 to be the new, digital German ideology. It is based on the idea of wide spread of all the Internet technology, big data, social media, cloud computing sensors, Artificial Intelligence, robotics, and the combination of these things into the production, distribution and use of goods on B2B and B2C levels [4].

Control over internal and international ITC market is one of the priorities for a country which set digital technology as the core for development. In order to ensure the effective functioning of the ICT market, it is necessary to constantly improve the digital policy of the country. European Digital Policy Officer Torben David and Head of Brussels Office Benjamin Ledwon conducted the research the results of which were published in an article by the German IT Association BITKOM *"Five measures for better policy-making in a digital Europe"* [2]. The authors note that EU countries must use five main measures to improve the regulation of digital processes.

There are other valuable resources which provide up-to-date information on the topic such as official reports and statistics websites, for example, Global Competitiveness Report [5], Market Monitor ICT Germany [13], the Directive on open data of the European Council [14], Eurostat [15] etc.

III. Object, subject and methodology of research

Information and communication technologies make up the *object* of this research.

The *subject* of this research is the degree of involving information and communication technology in business, economic and social areas in Germany.

To conduct this research, such methods have been used: study and critical analyses of scientific articles, statistic, regulatory and legislation sources. The search and study of local and international big projects within IT sphere in Germany were held. Based on the results of the analysis, the conclusions on the benefits from use of ICT in the Germans' daily lives and the technological development at country level were made.

IV. Results

These days, Germany is a world leader of innovation in business, private and public sectors. German scientists have taken the first place in the number of Nobel Prizes won in the world over the last century. Undoubtedly, their research works still rank among the best in the world. There is a large number of leading universities and research institutes in the country that ensure the steady development of information and communication technologies. The government policy of Germany focuses on developing digital infrastructure, digital economy, digital jobs, innovative public administration, and supporting digital environment in society, education, science, culture and media.

Germany has one of the world's largest information and communication technology (ICT) markets. According to the statistics, there are about 90 thousand IT-companies in the country with more than 1 mln people employed in IT industry [13]. In 2018, the ICT market of the country was $221.8 billion worth According to the German Association of Information Technology BITKOM, the market size of the sub-sectors in 2018 (in USD

billion) was the following: IT equipment – 30.2, software – 28.8, IT services – 47.1, consumer electronics – 11.2, telecommunications devices – 12.6 and telecommunications infrastructure – 8.3 [6].

Regarding the dynamics of the German ICT market, it performs the rising trend over the last years, despite losing general positions in the world in ICT adoption in 2019.

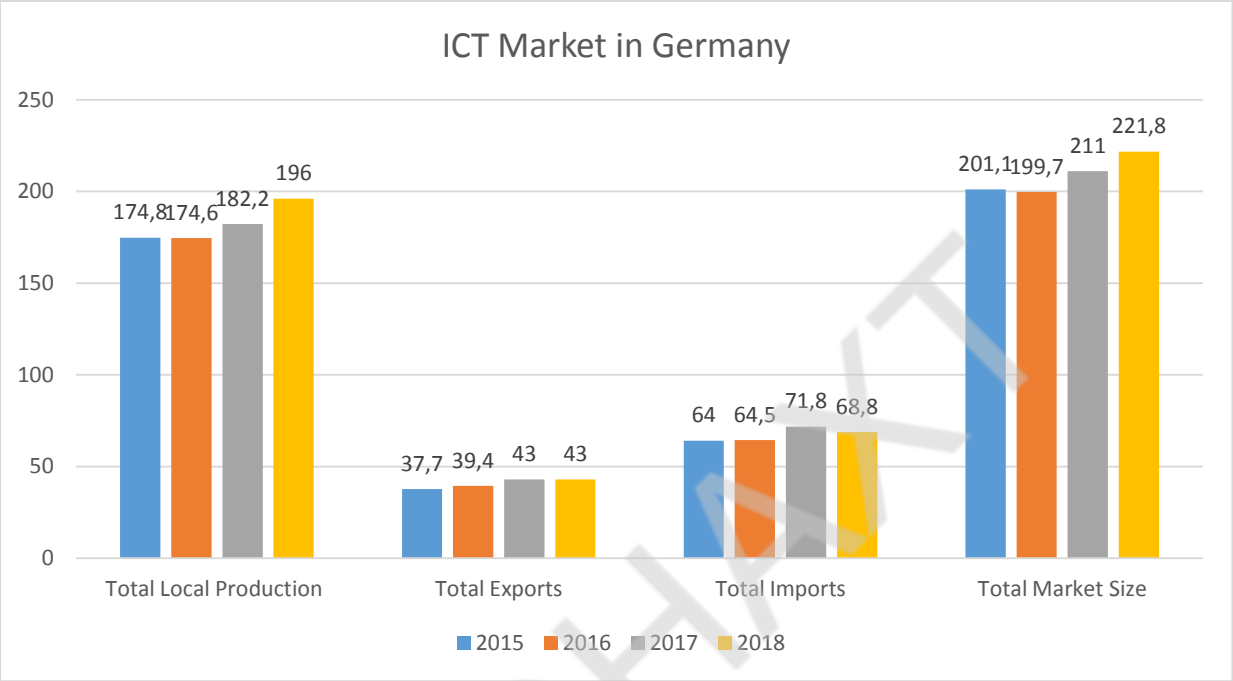

Fig. 1. ICT Market in Germany

Source: based on https://www.trade.gov/knowledge-product/germany-information-and-communications-technology

The main areas of ICT development in Germany are: IT security; healthcare IT; Artificial Intelligence; smart platforms for social business; equipment, infrastructure, services, technologies, databases and analytics; enterprise resource planning.

Online Shopping

According to the study e-commerce Market Germany 2019, amazon.de, otto.de and zalando.de are among the leading online shops in Germany. In 2018, amazon.de generated e-commerce sales of around US$11.0 billion, leading the ranking of the 100 largest online shops in Germany. Otto.de and zalando.de followed by a wide margin: the two German stores generated sales of around US$3.8 and US$1.7 billion, respectively [7].

Online shopping is one of hugely widespread applications of ICT worldwide. In some countries with highly developed digitalization, citizens can hardly remember the time queueing to pay for electronic goods, apparel, food supplements, beauty products, tickets etc. Germany is one of them. It became possible due to development of the Internet platforms which enable different kinds of selling and buying activities.

The e-commerce Market Germany 2019 study argues that the platforms https://www.amazon.de/, https://www.otto.de/ and https://en.zalando.de/?_rfl=de present the leading online shops in Germany. The 2018 sales of https://www.amazon.de/ reached about US$11 billion. It took the leading position in the ranking of the 100 largest online

shops in the country. Otto.de and zalando.de stores together generated sales of around US$3.8 and US$1.7 billion, respectively [7].

People in Germany can easily buy any kinds of goods and services. The most popular ones are household goods, clothes and sportswear, tickets for events, books and magazines, electronic equipment. According to Eurostat, the largest number of online orders in Germany goes to clothes or sports goods (67% of population) and the least to electronic equipment (25% of population). Moreover, the largest part of transport tickets sales is performed through digital services available on the Internet.

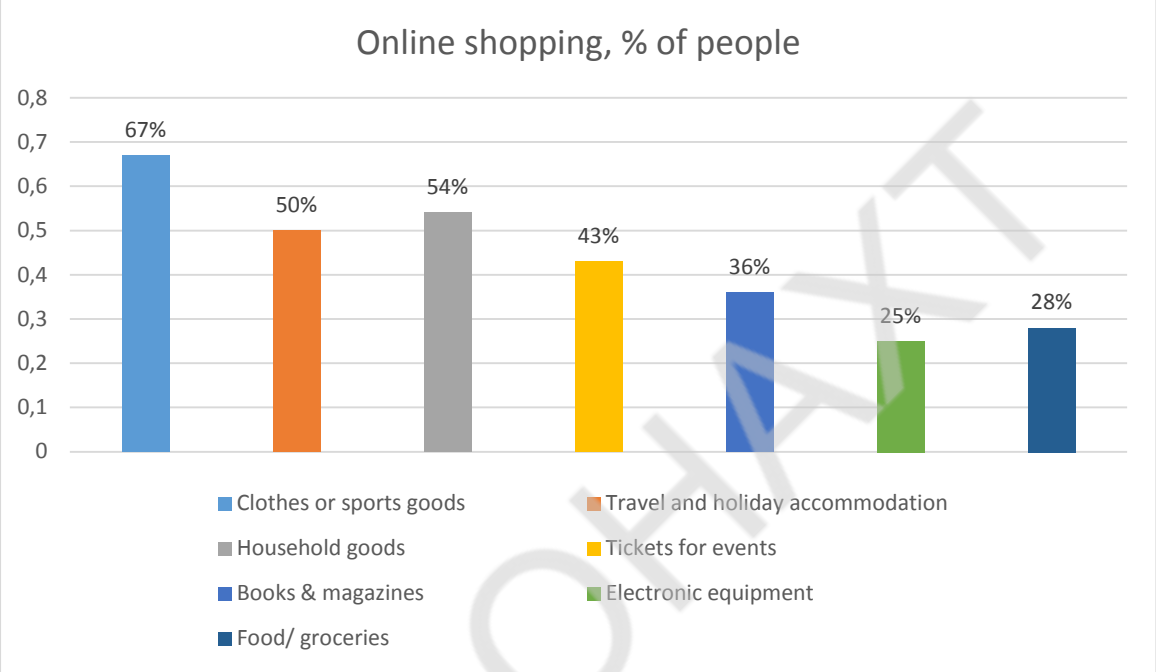

Fig. 2. Online shopping

Sources: based on https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/EDN-20191129-1

Use of ICT at work and activities performed

The biggest international companies use ICT in all their departments. This significantly minimizes labor costs. Eurostat has provided statistics showing that the highest percentage of ICT use at work belongs to individuals who use computers, laptops, smartphones, tablets, other portable devices or other computerized equipment or machinery such as those used in production lines, transportation or other services at work (54% of all employees) and the smallest percentage belongs to individuals who develop or maintain IT systems or software in their work (5% of all employees).

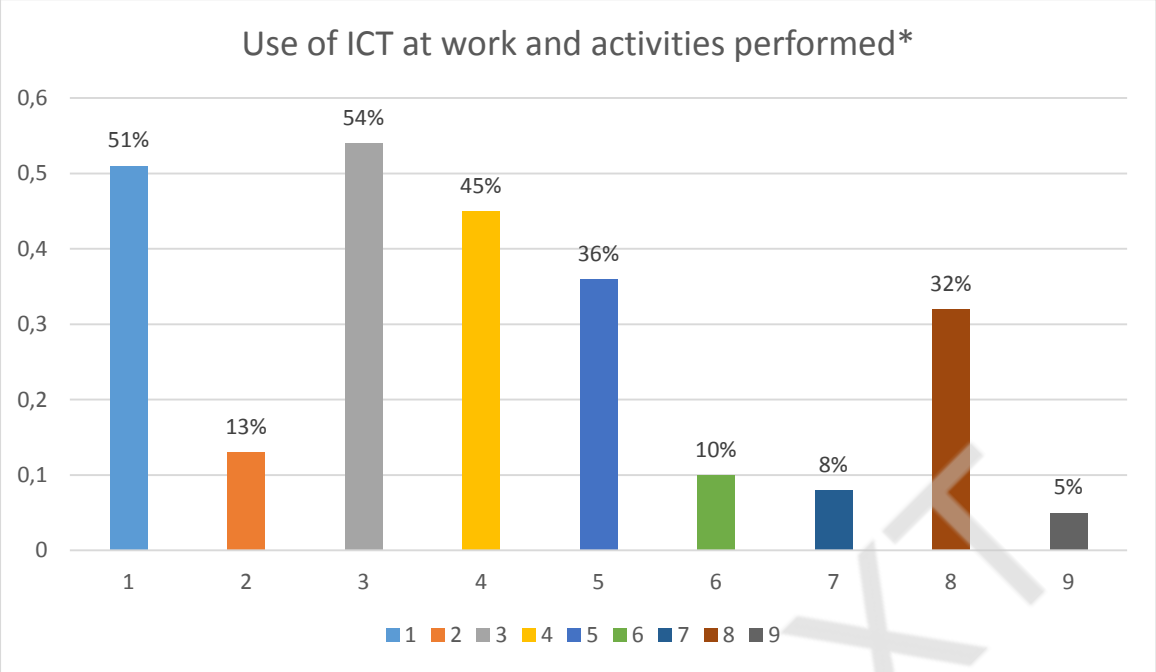

Fig 3. Use of ICT at work and activities performed

Source: based on
https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_iw_ap&lang=en

* 1– Individuals used computers, laptops, smartphones, tablets or other portable devices at work.

2 – Individuals used other computerized equipment or machinery such as those used in production lines, transportation or other services at work.

3 – Individuals used computers, laptops, smartphones, tablets, other portable devices or other computerized equipment or machinery such as those used in production lines, transportation or other services at work.

4 – Individuals exchanged emails or entered data in databases in their work.

5 – Individuals created or edited electronic documents in their work.

6 – Individuals used social media for their work.

7 – Individuals used applications to receive tasks or instructions in their work.

8 – Individuals used occupational specific software in their work.

9 – Individuals developed or maintained IT systems or software in their work.

ICT security

With the development of ICT, the risk of using them is increasing. Every day, hundreds of people are subject to theft of their data from the Internet. Many countries suffer from cyber infringements and, therefore, they are committed to developing cybersecurity to ensure the comfortable existence of the ICT market and consumers in general. In Germany alone, cybercrime causes nearly € 55 billion damage every year.

According to Eurostat, Germany also uses security measures in ICT- market.

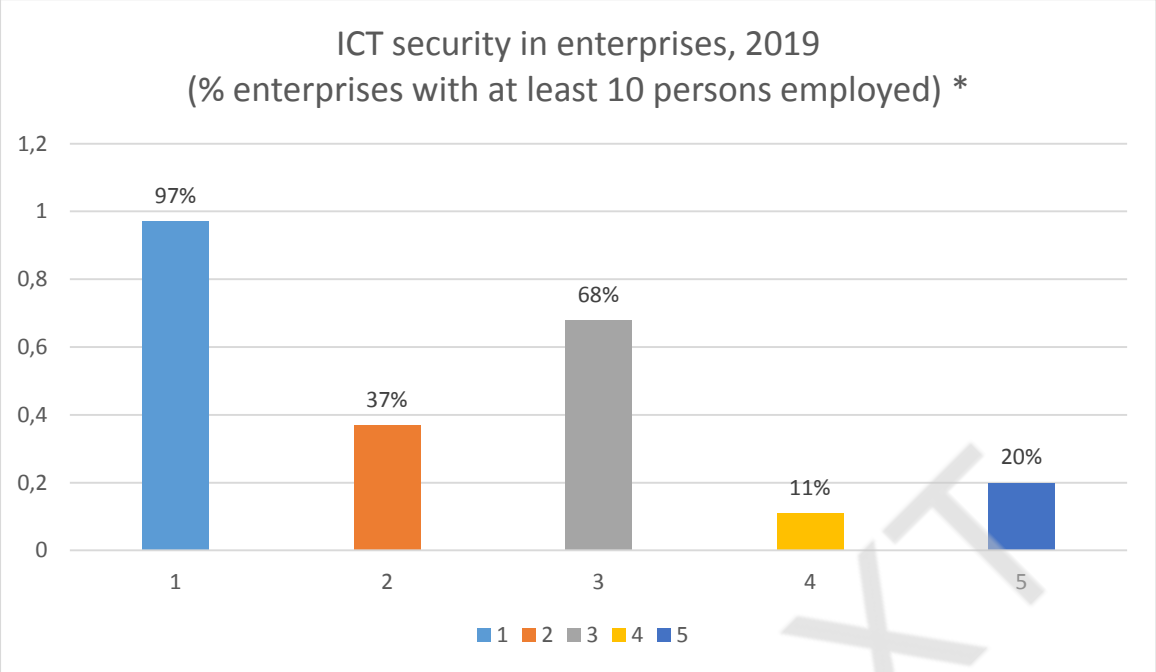

Fig. 4. ICT security in enterprises in 2019

Source: based on https://ec.europa.eu/eurostat/documents/2995521/10335060/9-13012020-BP-EN.pdf/f1060f2b-b141-b250-7f51-85c9704a5a5f

* 1 – Use at least one ICT security measure.

2 – Have documents on measures, practices or procedures on ICT security.

3 – Make persons employed aware of their obligations in ICT security.

4 – Experienced at least once problems due to ICT related security incidents in 2018.

5 – Have insurance against ICT related incidents.

IT industry in Germany is strictly regulated by the government. There are laws and legislative acts according to which the issue of security is maintained. One of the main documents is the IT Security Law reinforced in April 2017 [14]. In order to ensure security on the Internet, the German Government uses certain measures to limit or eliminate the activities of citizens in order to avoid Internet threats.

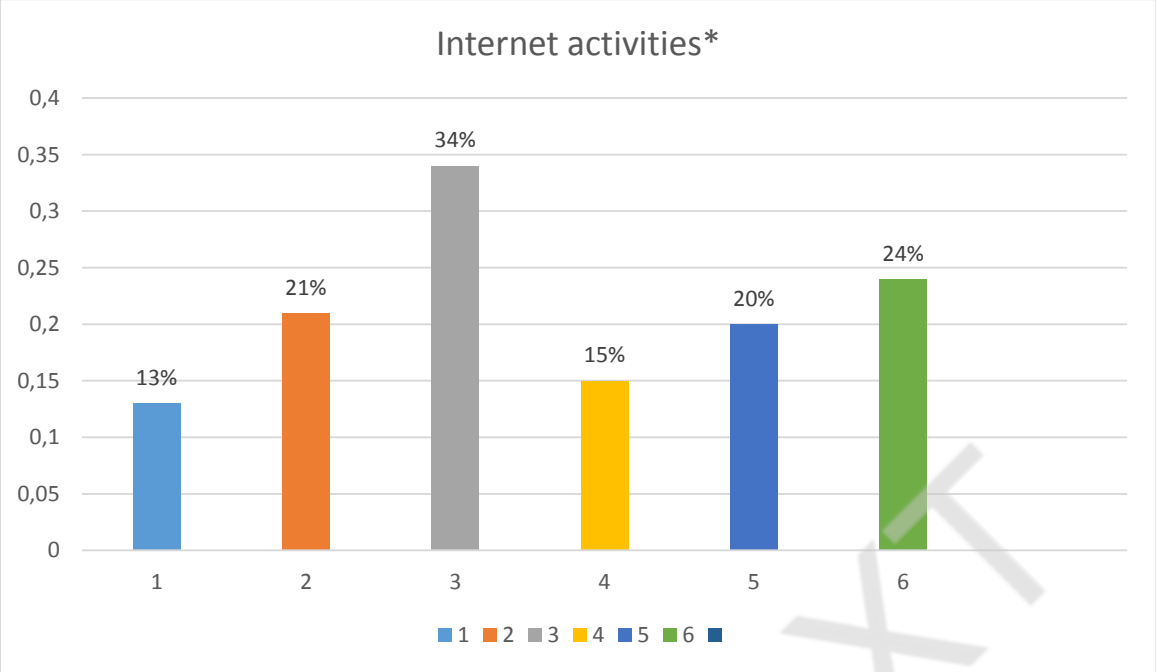

Fig. 5. Internet activities which were limited or avoided due to security concerns in the last 12 months (% of individuals aged 16-74, 2019).

Source: https://ec.europa.eu/eurostat/documents/2995521/10335072/9-16012020-BP-EN.pdf/30431c3f-cbce-6d2d-e9d1-4cf6b084b6af

* 1 – Ordering or buying goods or services.
2 – Internet banking.
3 – Providing personal information to social or professional networking services.
4 – Communicating with public services or administrations.
5 – Downloading software, apps, music, video files, games or other data files.
6 – Using the Internet via public WiFi.

Digital Europe Programme and ICT Proposers' Days

Germany is actively involved in international programs to improve Digital-Europe. Digital Europe Programme is a program developed by the EU for 2021 – 2027. Targeted consultation on the direction of the program development took place from July 25 to October 25, 2019. [8]. The total number of respondents was 960, the largest number was from Germany 125 (13%). The results of the consultation show that Europe is highly interested in using digital technology to create a clean planet (70.5% consider it very important) and increasing Internet security (54.9% very important).

The program also provides advice from other activities. For example, ICT Proposers' Days in Helsinki play an important role in establishing the program. This event was created for the international exchange of knowledge in the ICT field. Participants can be representatives of companies, universities and research institutes related to information and communication technologies. ICT Proposers' Days are held once a year to discuss trends in information and communication technology to make our lives easier. The last meeting was held on September 19-20, 2019.

The dynamics of the number of countries participating in the ICT Proposers' Day are presented in the bar-chart below.

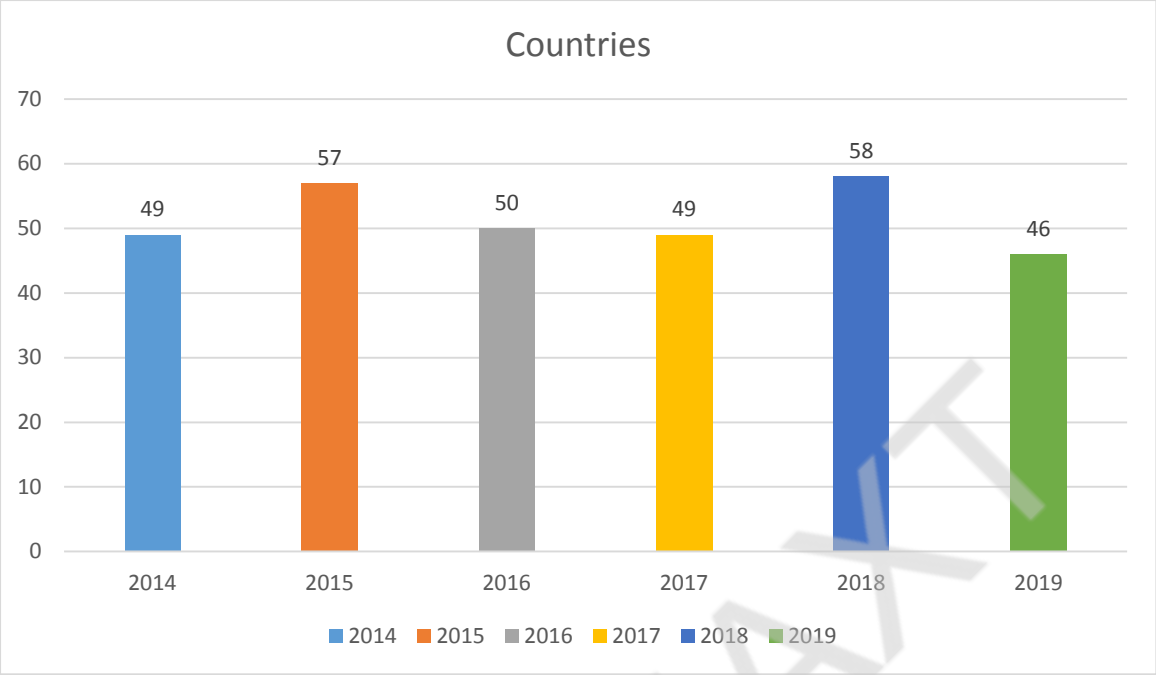

Fig. 6. Number of participants-countries of ICT Proposers'Day
Source: based on https://ict2019.ideal-ist.eu/home

Local and international ICT projects in Germany

Germany coordinates many ICT projects which are financed by the EU and supported by leading universities and research institutions in Europe. For the last years, the following large-scale projects have been the most important for the country.

The ***Flexnet*** project is an online platform called '*FlexNet Education and Training'* that provides information on lectures and courses, as well as the activities of the university/research institute in the industry. New materials, devices and systems are being developed to help make Europe a world leader in flexible, organic and large-scale electronics.

Another major German ICT project is ***SMErobotics***. The main activity is to develop a new type of production robot that is simple and intuitive to use, without the need for complex programming and with the ability to adapt to changes in production processes. The intellectual system does not rigidly adhere to a particular computer program, but "learns" as a result of interaction with a human employee.

The ***Diamond Project*** focuses on the development of technologies capable of creating materials at the level of single atoms. The focus is on the use of diamonds through their unique optical and magnetic properties, which allows one atom to be placed simultaneously in the diamond grid with nanoscale accuracy. This, in turn, can lead to the miniaturization of electronic devices to the size of individual molecules.

Whatever it is, a major public infrastructure project or a proposal for new legislation, citizens should be able to communicate their ideas to politicians easily and effectively. The ***Life + Gov*** project aims to create mobile *electronic government* ensure that policy makers and civil servants have realistic understanding of current societal issues

[9].

The ***M-ECO*** project deals with data mining, communication with citizens and social networks. Within its boundaries, researchers work on an advanced system of epidemic analysis and medical data to prevent epidemics. Initiators believe that the only way to limit a pandemic is to detect early signals and respond quickly.

The future of ICT in Germany

ICT is developing rapidly in Germany. Highly skilled workers in the ICT industry ensure the country's status as a world leader in the ICT sector. Experts predict that the ICT market will increase to 25% of the entire European market. In 2020, it will become the largest ICT market in Europe. The country's government supports security technologies through the High-Tech Strategy for various projects [10].

Germany government has prepared "A Digital Strategy 2025". It describes 10 steps toward the digital-future of Germany [11].

Problems and Further Prospects

Despite the fact that Germany in one of the leading country in developing ICT and providing IT solutions for business and finance, it has lost its leading position in the world in ITC adoption in recent years. According to Global Competitiveness Report 2019, the country has the 36th place in the worlds ranking, where the leader is South Korea [5]. ICT adoption consists of such subcategories as mobile-cellular telephone subscriptions; mobile-broadband subscriptions; fixed-broadband Internet subscriptions; fiber internet subscriptions, all of them per 100 pop. While developing data-mining and analytical part of IT industry can be efficient, losing world position in ICT adoption can affect the country negatively. To overcome problems which can arise from this, government professionals and experts in related industries are constantly developing new ways to improve the situation.

V. Conclusion.

New Internet and mobile technologies tend to change the economic and social space of each country, become the driving force in shifting the essence of the basic professional activity infrastructures, promote the emergence of new and modifications of existing jobs, expand the scope of scientific research and development of each citizen's personality.

Through scientific research we noticed the rapid entry of ICT into the lives of the Germans. Information and communication technologies help Germany citizen in different areas, such as health industry, education, business, government policies and others. Despite general success of the country in this field, a range of problematic issues requiring effective solving still exist. For this reason, a number of professionals work on finding solutions. The information mentioned above leads to the conclusion that ICT development and implementation in various spheres of German life has huge potential.

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ROBOTIC SEARCH SYSTEM FOR PEOPLE

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Supervisor: Sergiy Tereshchuk
Pavel Tychyna Uman State Pedagogical University (Ukraine)

The robotic platform is designed to detect people in buildings during emergencies.

Introduction

In an era of man-made development, humanity is exposed to harmful or life-threatening factors. In the last decade, a number of man-made and natural hazards ha come to terms with people, demanding new methods of detected casualties. It prompted we to prototype a work platform that would be able to reach a large, don`t accessible or hazardous area, where there are victims and give for basic medical care. The basis is taken a 4x4 wheel platform (fig.1) .

fig.1

The use of this platform made it possible to prototype the robotic platform with high throughput. The platform has devices installed that will find a person, be able to measure his vitality (heart rate) and signal the location of a living object. Robotic platform, for better control, can be equipped with an IP camera, manipulator and first aid kit.

In his work it is planned to use a metal platform on crawler motors. This enhancement preserves all design features, reducing the blind platform clearance, you can install extra payloads, install equipment for finding people, breathing equipment, a radio device for communication between rescuers and victims.

It is planned to install a GPS tracker to guide the evacuation route or to advance the rescue crew. The passing properties are due to the paired operation of the left and right wheels. Maneuverability is explained by the work of wheels "on a caterpillar type".

Use of robots in rescue operations.

Robots have long been used to save people's lives. They are used in surgery as laboratory assistants, assistants, pharmacists [1]. From the second half of the twentieth century robots are used to eliminate accidents and dangers created by human activity [2]. Many concepts for robots have been developed to search for humans, including the robot snake [3]. Its advantages are as follows:

- mobility.
- high cross.
- pipe extension available.

Disadvantages:

- there is no importance between the victims and the rescuers.
- short battery life.
- no verified credentials.
- drug delivery available.
- it is impossible to transmit signals to the victims.

In recent years, robotic platforms have been developed to address the effects of fires. Also work is used for delivery of medicines, cargoes, ammunition, etc. They allow to get the fire-fighting equipment to the most accessible places. For search and rescue, human and animals are mostly used. The goal was to create a simple robotic platform that would allow you to reach inaccessible places. The following criteria were assigned to the design of the robot:

- Simple design. The reduced number of mechanical moving parts increases the reliability of the platform. And also a small number of components will reduce the load on energy resources, which will allow to extend the battery life of the device.

- A minimal set of sensors will allow you to remotely evaluate the situation around you, which will allow you to assess the chances of surviving victims and the possibility of their evacuation.

- Built-in human condition sensor. Namely, the built-in heart rate sensor will allow you to remotely evaluate the basic human vital mill.

- Possibility of remote control and autonomous operation in case of departure work beyond the perimeter of the remote control signal.
- High permeability in difficult conditions.
- Maneuverability.
- Lightweight construction designed to reduce pressure on the chassis of the robot and on the material of the surface (in the case of loose surfaces) to reduce the possibility of slipping and burial.
- Ability to alert when a live object is detected.
- Ability to install remote video equipment.

The design of the search engine and the main aspects of design

The robotic platform was based on the Arduino Mega platform based on the ATmega2560 chip. Wheel base in the prototype of the platform used standard acrylic two-deck platform 4x4 (fig. 1). In the future, it is planned to replace the aluminum platform with a caterpillar type. The L298d collector motor driver is used to control the motors (Fig. 2).

Fig.2

Fig.3

Fig.4

Engines are started in parallel on each side. This inclusion method offers significant benefits:

- Engines run on a crawler type.
- The friction between the wheels and the road surface increases.
- Increases maneuverability and reduces arc radius when turning. Possibility to return in place.
- even distribution of traction on the undercarriage of the chassis.
- Uniform load on all wheels of the platform.

A built-in power stabilizer located on the driver plate provides power up to 20 volts. The driver also allows you to control the speed of the left and right wheels. This will allow the platform to maneuver smoothly. To study the state of the air on the subject of toxic substances in the robot provided the use of a gas sensor (fig. 3).

The sensor is configured in a reference atmosphere, such as in the open air, where a source of harmful gases is brought to it. The sensor calibration takes a few seconds, after which it is ready for operation. The robot uses sonar HC-SR04 for space orientation. Thanks to it, the robot can measure the distance to obstacles and objects.

To measure the noise level and to find the source of the sound, a microphone is mounted on the platform in a directional case, which gives a more accurate method of finding the objects that emit sound. The platform also has a PIR motion detector. The use of this sensor made it possible to apply the method of finding an object along a thermal trace while moving the object itself or when the object engages some part of its body, such as a limb. After detecting a living object, the robot approaches it, if it is shallow, and uses

an optical sensor to measure the pulse of the victim. This data is transmitted via radio to the computer of the rescue team operator, who can also contact the person in need of assistance via a negotiating device (which can be further mounted on the platform). An individual first aid kit and individual respiratory protective equipment can be placed on board. After completing all instructions, the operator commands to activate the alarm device, which will allow rescuers to identify the victim faster.

The alarm device is an active piezoelectric and ultra-bright LED. This approach will allow you to look for a victim faster in heavily smoky rooms. Optionally can be equipped with a GPS tracker platform, which in turn will allow you to get the exact location of the rescue object, and the robot will be able to continue the search.

Platform test results.

The following aspects were considered during testing:

- Passability.
- Maneuverability.
- Communication.
- Data transfer.
- Autonomy.

Permeability.

The robotic platform was tested on the following surfaces:

- Sand.
- Soil.
- Asphalt.
- Crushed stone.
- Carpet.
- Linoleum.
- Tile.

Results:

The platform has the best passability on abrasive surfaces [4], such as soil, asphalt, carpet. When tested on the sand on the platform was observed layer of deposits of dust, but no significant change in the operation of the systems did not make. When moving on sandy surfaces, there was a slight burial of the platform, but the use of all-wheel drive made it possible to avoid slipping and jams. When moving on the carpet and linoleum, there were slight slippage moments during the start, but there was no significant effect on the movement of the platform.

With respect to sloping surfaces. The maximum surface angle the platform can overcome:

When starting from the bottom of the platform with full engine forcing - 35^0

When accelerating from a distance of 1m with full forcing of engines - 45^0

Maneuverability

In the study of maneuverability, the work achieved the following results:

- The full rotation for 360^0 by engine forcing , with the motors moving in opposite directions.
- Changing the radius of the arc of rotation by changing the speed of rotation of the engines.

- Smooth rotation - 360^0, provided the motors move in opposite directions and use the ability to adjust the speed of the motors.

Communication / data transmission.

The platform is equipped with two types of radio communication:

HC-06 bluetooth and nrf24l01 + radio module. Data was transmitted via bluetooth. The data from the sensors were transmitted to the terminal on the PC. Stable outdoor data transmission continued at a distance of 30m with an additional solder antenna. The nrf24l01 + module was used for remote control. Stable signal reception was taken at a distance of 60m. In the event of a signal loss, the robot stopped and rode backward until communication resumed.

Autonomy

Work on a single charge is 1.5 hours when driving on rough terrain, resulting in a drive of 1.3 km.

Conclusions

The results of the tests and the work done give a positive result. This confirms the feasibility of using such platforms in search and rescue operations. The advantages of this method are:

- Ability to reduce human risk during searches.
- The ability to reach inaccessible places.
- Ability to provide medical assistance remotely.
- Inspection of buildings with toxic substances, smoke.
- Establishing a person's whereabouts.
- Simple design.

When designing the final device, it will be possible to use cheap and reliable accessories. The very price issue of robotic rescue platforms does not contribute to the dissemination of their ambulance workers. The big advantage of such devices is that they are built on the basis of ARDUINO, which means that such devices can be developed by students of technical universities. The prerequisite here is that it will:

- reduce the cost of the device.
- to provide educational material for students / students.
- to encourage the learning of the languages of programming.
- Encourage students to study and develop materials for device construction.
- to organize work in colleges. Etc.

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IMPLEMENTATION OF ROBOTICS FOR OCEANS AND SEAS CLEANING

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Abstract. In this work, I considered the problem of ocean trash. Everybody knows that patches of trash are growing. But as for me, there are still not enough projects to clean up the oceans and coastal areas. The idea is inspired by NASA Space Apps Challenge. The solution proposed can help to get rid of micro- and macroplastic in the oceans.

Keywords: ocean trash, trash patches, oceans without plastic, robots for cleaning up trash, jellyfish, coastal areas, seas without trash

I.Introduction

Human civilization largely depends on the oceans. They affect the weather and climate of the entire planet. That is why the pollution of the oceans has become a serious environmental problem of our time. If we loose the ability to use the resources of the oceans, the economy will stop, and the world will plunge into chaos.

The development of civilization has led to increased pollution. The situation was worsened by the development of the chemical and oil refining industries. Nowadays, several types of pollution can be distinguished:

- physical (garbage, especially plastic). 80% of this garbage got into the oceans from the land, 20% - from the ships.
- biological (foreign bacteria and microorganisms);
- chemical (chemicals and heavy metals);
- oil;
- thermal (water from power plants);
- radioactive.

One of the main types of pollution is plastic waste. They form entire islands on the surface and threaten marine life. Plastic does not dissolve or decompose. Animals and birds take it for something edible and swallow glasses and plastic, that they cannot digest, and die. Under the influence of the sun, plastic is crushed to the size of plankton. And then it participates in food chains.

Many countries have attempted to rectify the situation or minimize the harm that human activities cause to the oceans. At the initiative of the UN, many important international agreements that regulate the use of ocean resources were signed.

II.Analytical review

The amount of global trash is expected to rise every year. Mostly plastic, chemical sludge, wood pulp, and other debris are grouped into trash patches. Despite the common public perception of the patch existing as giant islands of floating garbage, its low density (4 particles per cubic meter) prevents detection by satellite imagery, or even by casual boaters or divers in the area. This is because the patch is a widely dispersed area consisting primarily of suspended "fingernail-sized or smaller bits of plastic", often microscopic, particles in the upper water column.[1] The five biggest ocean garbage

patches are located across the globe, found in the Pacific, Atlantic, and Indian Oceans. While the North Pacific patch (the Great Pacific garbage patch) is the most discussed, explored, and evaluated, the other four patches also contribute to global pollution on a major scale.[3] The Great Pacific Garbage Patch, a collection of plastic, floating trash halfway between Hawaii and California, has grown to more than 600,000 square miles, a study found. That's twice the size of Texas.[2] Precise measurements of the North Atlantic Garbage patch are unknown but scientists think it is hundreds of miles in size. The patch likely has a particle density somewhere around 7,220 pieces per square kilometer. The South Pacific Garbage Patch is estimated to have a surface area of 1 million square miles (2.6 square kilometers) and a particle density of approximately 396,342 particles per square mile in the center of the patch. Due to its remote location, the Indian Ocean garbage patch is difficult to study. Some studies estimate its size at 843,046 square miles (2,183,480 square kilometers), although some put it as high as 2 million square miles (5 million square kilometers). The South Atlantic Garbage patch is fairly small in comparison to other patches. This patch covers roughly 276,263 square miles (715,520 square kilometers), has a particular density of 40,000 pieces per kilometer, and contains about 2,860 tons of plastic. [3] Ocean trash is counted in three ways: through beach surveys, computer models based on samples collected at sea, and estimates of the amount of trash entering the oceans. The most recent counts involved computer modeling based on samples taken at sea. The models may not account for all of the trash, scientists say; nonetheless, the new numbers are helping address some of the questions.[4]

In spite of people's awareness, there are still not enough solutions to clean up the oceans.

II.1 Ocean CleanUp

Dutch inventor Boyan Slat founded The Ocean Cleanup at the age of 18 in his hometown of Delft, the Netherlands. The Ocean Cleanup's team consists of more than 80 engineers, researchers, scientists and computational modelers working daily to rid the world's oceans of plastic. Their headquarters are located in Rotterdam, the Netherlands.

The Ocean Cleanup is designing and developing cleanup systems to clean up what is already polluting our oceans and to intercept plastic on its way to the ocean via rivers.

A significant percentage of the plastic that enters the oceans from rivers and other sources during a transfer that can take many years, drifts into large systems of circulating ocean currents, also known as gyres. Once trapped in a gyre, the plastic will slowly break down into microplastics and become increasingly easier to mistake for food by sea life.

Going after the plastic in the garbage patches with vessels and nets would be costly, time-consuming, labor-intensive, and lead to vast amounts of carbon emission and by-catch. That is why The Ocean Cleanup is developing a passive ocean cleanup technology, that moves with the currents – just like the plastic – to catch it. By deploying a fleet of systems, The Ocean Cleanup has estimated to be able to remove 50% of the Great Pacific Garbage Patch every five years.[5]

But this construction has some minuses:

- it is very expensive;
- it is used only in the Great Pacific Garbage;
- it collects only macroplastic.

Image 1 - Ocean CleanUp construction

II.2.Ocean Ride

Ocean Ride is a microplastic collection system that works differently than others. There are two main products: first use as a dockable object on any boat and in addition is a fixed platform strategically positioned in the areas of sea currents that is where has the largest flow of these materials.

They will use thousands of existing vessels that make trips around the entire maritime territory, docking our collection system to take advantage of the sea routes and use them to our advantage and helping to clean up the ocean. Moreover, on fixed platforms, we will take advantage of the sea currents that converge to a strategic place that throws the waste towards the positioning of our platform.

The economic viability will make companies embrace our solution while enabling sustainability and cleanliness of the ocean, which will provide additional profit for ship companies. In addition, NASA will have a low cost to implement.

Van Der Graff's generator principle is the heart of the project, and it is responsible for all the attraction of microplastics across a specific field to attract only that plastic. The device works similar to a magnet. In addition, there is a conveyor belt that will be electrified and attract the debris, when it comes into contact with the Van Der Graff generator orb. A blade mechanism with a maximum hole size of 5mm. will be inserted into the treadmill.

Right after the process of attracting the microplastic, waste will be stored and compacted to optimize as much space as possible.

When the maximum storage capacity will be filled, this waste will be removed at the destination of the vessel or if it is the fixed platform there will be a vessel responsible only for changing containers, removing the full and replacing for another one.[6]

The only minus is that the project is not implemented yet.

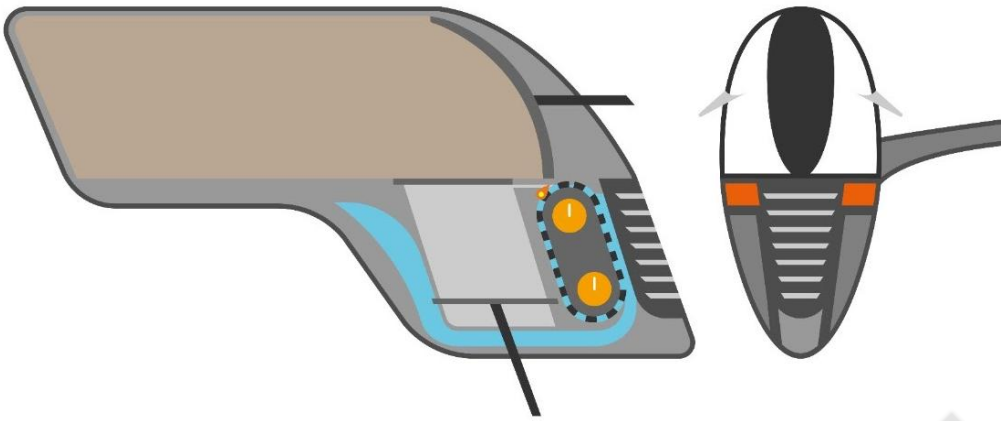


Image 2 - Ocean Ride device inside

III. Object, subject and tasks of research

The object of research is to rid the oceans and seas of plastic.

The subject of research is solutions for cleaning up oceans from micro- and macroplastic.

Goals of research work:

- find weaknesses of existing solutions;
- make an interactive way of the plastic collection;
- design and explain a new solution.

IV. Results of work

I analyzed all the collected information and all the disadvantages and difficulties of existing developments. And I came up with a solution that fights against large and small plastic. The first version of the design looked like a jellyfish, for which it got its name.

What is Jellyfish?

Jellyfish is a system of plastic collection that can be managed from your phone. I actually designed 2 versions of how we can use Jellyfish: in the ocean space and in the coastal areas. Now I want to show you the second one.

Jellyfish for coastal areas

Jellyfish consists of 2 parts. The first part is the control unit. The logic of the construction is concentrated here. It consists of:

- Raspberry Pi 3 Single Board Computer;
- solar panels, which provide the energy necessary for the operation of a computer;
- additional battery;
- camera;
- sonar device;
- ultrasound device (to scare away marine life);
- small motor to manipulate the Jellyfish;
- Bluetooth - receiver;
- GPS - receiver.

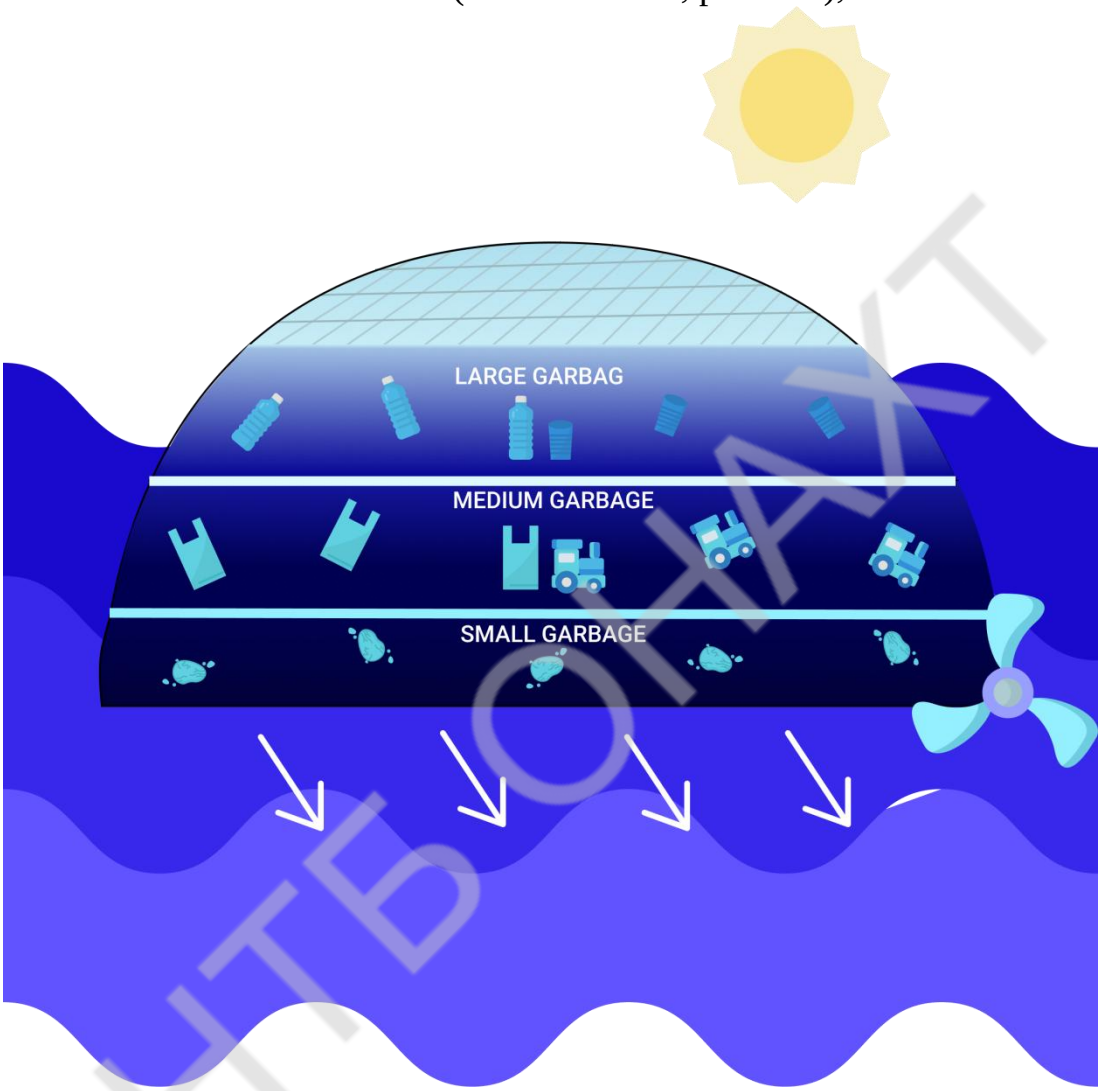
The second part is focused on the filtration and collection of garbage. The system uses 3 stages of plastic filtration. It consists of:

- “wings” to increase the angle of captured flow of contaminated water;

- section for large garbage (fishing nets, bottles, plastic bags, etc.);
- section for screening medium debris (things in a state of plastic splitting);
- section for requesting small plastic with mesh on roller shutters (microplastic).

All of the sections for plastic are equipped with nets, but the difference between them is the size of the net's cells.

You can also add other sensors to monitor water indicators (temperature, salinity, etc.), indicators for weather stations (wind direction, pressure), etc.



That is how Jellyfish looks like.

How to manipulate?

The robot has 2 control modes: manual and automated.

Manual mode: you can manipulate the robot with a mobile application. If necessary, you can turn the camera on and off, track the path of the robot on the map, and track the occupancy rate of the garbage compartments.

Automated mode: all control is taken over by the computer, and with the help of Machine Learning it can recognize garbage and collect it. You can track his path, connect to the camera, etc.

By connecting other sensors, you can also track their measures in real-time.

How the app will look like.

V.Conclusions

The designed construction is aimed at cleaning coastal waters from plastic, which can be very dangerous if it becomes a part of the food chain. The implementation and integration of this robot in a water treatment program will help the environment quickly and interactively. The captured plastic can be recycled or independently used in your ideas, including art. Also, you can use additional modules for tracking indicators if you want to make researches.

The robot is designed for people who worry about the environment, pollution of the oceans and coastal zones, and the future of the planet.

During the design of this product, the following tasks were solved:

- engaging users interactively;
- separation of the control unit from the filters and collectors;
- automatic sorting of micro- and macroplastic.

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DEVELOPMENT OF MODELS AND SOFTWARE SOLUTION For THE PROBLEM OF DIAGNOSTIC OF FINANCIAL STATES OF IT-ENTERPRISE

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Abstract*. Currently, the Ukrainian economy is relatively volatile, so enterprises require efficient management, which requires knowing what the management state is. Solving the problem of diagnosing the financial state of an enterprise in the future will allow developing an apparatus of effective management decisions that will help maintain the enterprise at the proper level of functioning and ensure further development of both the enterprises and the economy as a whole.*

The problem is in the need to obtain a more accurate solution for the problem of diagnosing the financial state of the enterprise with the parameters that characterize the financial situation best of all. The main objective of the research was to solve the problem of diagnosing the financial state of an IT company, using a model that implements a certain approach in order to obtain a qualitative conclusion about the state of a company. A method based on the use of a fuzzy logic apparatus, namely, production models with a Mamdani fuzzy inference algorithm is proposed for solving the problem. In order to determine the financial position, input parameters were estimated, which were used to evaluate the financial state and represent the quantitative and qualitative indicators of the company's activity for the selected period. The obtained results explain what indicators and how they affect the financial position of the company and can be used to solve the forecasting problem. Implementation of the research results will help to accelerate the diagnosis of financial status at the enterprise and make a management decision in time, which is the relevance of the research.

Keywords*: diagnosing, financial state, financial indicator, fuzzy logic, production model.*

I Introduction

Today, the economy of Ukraine is in a relatively unstable position; therefore, Ukrainian enterprises require effective management. But in order to effectively manage the business, you need to know in what state it is in order to take certain actions in the future. Thus, the task of diagnosing the financial state of the enterprise plays an important role.

The urgency of solving the problem is obvious, since a precise determination of the financial position gives an adequate idea of the situation, and in what direction to move and what actions should be taken in order to maintain the enterprise at the proper level of functioning and to ensure its future development.

Thus, an important task is to solve the problem of diagnosing the financial condition of the enterprise. The problem is the need to obtain an accurate solution to the problem of diagnosing financial conditions in order to form effective management of the enterprise, as well as the lack of software that can solve this problem, and takes into account the parameters that characterize the financial situation best of all.

Therefore, in the current conditions of information technology development, there is a need for the availability of approaches and software solutions for automation of the diagnosis process, as it will significantly improve the efficiency of the enterprise, and, consequently, its profitability and competitiveness.

Timely and accurate determination of the financial status of an enterprise is one of the basic conditions for its successful activity. Therefore, the purpose of this work is to solve the problem of diagnosing the financial status of an IT-company, using models that implement certain approaches.

The subject of the study is the approaches to determining the financial status of the enterprise, on the example of the object of study of the IT-company in truncated form, namely in the context of the process of diagnosing the financial condition.

II Analytical review of literature

2.1 Analysis of the problem, its relevance, the essence of the problem of diagnosis

Now enterprises of Ukraine require effective controls to prevent bankruptcies, which in turn can cause a sharp economic downturn. It should be noted that among a number of tasks that are solved in the field of effective management, such as the task of identification, the task of optimal management, etc., the task of diagnosing the financial states of the enterprise plays an important role. The relevance of the research is reflected in the application of the results obtained for the prompt and effective management.

Analysis of Ukrainian and foreign literary sources showed that the existing models and methods of diagnosis do not take into account the parameters that are important enough in the current conditions, because they are not put into consideration, therefore, the financial situation can not be determined with sufficient accuracy.

The task of diagnosing the financial state of the enterprise is characterized by difficulties in obtaining information, large amount of data, multicriteria, so the solution of the problem requires a lot of processing time, which causes a rather high cost of the diagnostic research.

This work is aimed at the development and implementation of the practical side of diagnosing the financial condition of the enterprise, which is expressed in the following:

1 It is planned to construct a model of diagnosing financial condition of the company such that it is possible to consider the optimal number of basic indicators that have a significant impact on the accuracy of diagnosis;

2 It is suggested to use different methods of diagnosis, which allows to be sure of the result as the task is quite important and difficult.

Diagnosing is the process of determining and studying indicators, which characterize the state of an object. It consists in certain research methods, analysis of the obtained results and their generalization in the form of a conclusion (diagnosis) to determine possible deviations and prevent disturbances in the normal functioning of an object. The main purpose of diagnosis is to obtain a small number of key, most informative indicators that give an objective and accurate determination of the financial condition of the company [2].

Financial state is the most important characteristic of the economic activity of the enterprise, a set of economic and financial indicators that characterize the enterprise's ability to sustainable development [1].

The financial position is determined on the basis of a number of indicators that most objectively reflect trends in the financial position, as a rule, they consist of four groups: indicators of liquidity, indicators of financial stability, profitability indicators, business activity indicators.

Diagnosis allows to identify cause and effect relationships in management dysfunctions, and then move on to building explanatory and predictive patterns of functioning [4].

Analysis of the existing software solutions to the problem of diagnosing financial conditions showed that they all have and advantages and disadvantages, such as high cost, the need to use a large number of parameters, etc.

2.2 Approaches to solving the problem of diagnosing the financial state of the enterprise

2.2.1 Classic approaches to diagnosing financial state

All current methods can be divided into two main groups: financial analytics methods and intellectual methods. Methods of financial analytics based on mathematical and economic apparatus (traditional methods). At present, quite stable traditional approaches have developed, which can be divided into four main groups of methods:

Transformational techniques. Transformational techniques for diagnosing financial condition are primarily intended to transform reporting into a more readable format. However, these techniques do not have an analytical function and do not directly lead to any conclusions and recommendations [3].

3 Qualitative techniques. Qualitative methods of assessment of financial condition are divided into methods: vertical analysis, horizontal analysis, analysis of liquidity balance, formalized questionnaire schemes.

In vertical analysis, it is difficult to interpret the current structure of funds unambiguously. Horizontal analysis is also rather limited due to changes that characterize the effects of past periods, and there is no reason to believe that they will be retained in the future. Balancing liquidity analysis and existing formalized questionnaire schemes face limitations as they offer formulations that are difficult to quantify [5].

Thus, the techniques presented in the block of qualitative analysis also do not lead to practical conclusions and recommendations.

1 Coefficient methods. Coefficient analysis is one of the most common tools in financial and analytical practice for assessing financial condition, but its relevance to user goals raises some doubts. [5].

2 Integral techniques for diagnosing financial condition. Integral techniques for assessing financial condition involve synthesizing financial indicators into complex constructions in the following areas: bankruptcy regression models, bank credit ratings, fuzzy set analysis, and consolidated rating models [5].

2.2.2 Modern methods of diagnosing financial state

With the development of information technology, a number of intelligent methods of diagnosis have been proposed, for example:

1 Based on the application of neural network technology. Neural Networks – a very powerful modeling method, allows to reproduce extremely complex dependencies, nonlinear in nature. [6].

The main appeal of using artificial neural networks is the ability to use a large number of different input parameters – financial data over a certain past period. The

expediency of transition to algorithms for diagnosis based on neural networks, due to the need to significantly accelerate the computational experiment, the need to reduce the cost of creating software implementation models [6].

2 Based on the apparatus of fuzzy logic. Often, raw data and knowledge about a managed object when setting the task of effective management contains indeterminate or fuzzy information that cannot be processed by traditional quantitative methods. [7].

Fuzzy productive diagnostics are particularly effective when processes are very complex to analyze using conventional quantitative methods, or when the raw data is interpreted inaccurately or uncertainly. Fuzzy production models are quite complicated to implement compared to fuzzy and conventional neural networks [8].

Therefore, based on the above and based on a critical review of existing mathematical approaches to solving the problem and the need to automate the process, it is proposed to use:

1) the classic coefficient method with the calculation of the rating;

2) apparatus of fuzzy logic, namely production models using some fuzzy inference algorithm (Mamdani algorithm).

III Object, subject matter and methods of research

The object of the research and the possible further implementation of the results of the work is the enterprise – an international IT-company working in the field of software development outsourcing. To diagnose the financial state of the company use indicators of financial reporting forms of the head office. The goals of the company are as follows: development of information technologies within the framework of business, support of the company in working condition, saving of funds due to the use of new management systems. Thus, the subject area is the financial side of the enterprise, and more precisely the process of determining the financial state of the company, which is necessary to further solve the problem of effective management of the enterprise.

To diagnose the financial condition of a company, a set of ratios (financial multipliers) is used. Based on the degree of compliance of the calculated indicators with the permissible standards of indicators of a certain financial condition, the financial state of the company is concluded, and the coefficients that go beyond the recommended limits indicate the "weaknesses" of the company.

To improve the system, we need to find out the content and results of its operation. The performance of the company can be represented by a model, which will be characterized by the following selected input parameters:

- y_1 – current liquidity ratio;
- y_2 – quick liquidity ratio;
- y_3 – absolute liquidity ratio;
- y_4 – the ratio of collateral to own current assets;
- y_5 – autonomy ratio (equity concentration);
- y_6 – the coefficient of maneuverability of equity;
- y_7 – financial dependency ratio;
- y_8 – the ratio of debt to equity;
- y_9 – profitability index of products (sales);

– y_{10} – an indicator of return on assets;

– y_{11} – an indicator of return on equity;

– y_{12} – an indicator of overall profitability;

– y_{13} – asset turnover ratio;

– y_{14} – an indicator of working capital ratio;

– y_{15} – turnover of equity ratio;

– y_{16} – inventory turnover ratio.

The primary financial ratios for the above indicators are taken from the financial statements of the company – the balance sheet and the statement of financial performance.

The resulting output parameter will characterize the financial condition of the enterprise as excellent, good, normal, bad or critical.

The process of diagnosing a company's financial position at the time of subject matter research can be presented as diagrams in IDEF0 and DFD notation. These diagrams are intended to formalize the process of diagnosing the financial state of the enterprise, that is, to explore the existing process and to present it in a convenient way.

The main task of this work is to solve the problem of diagnosing the financial status of an IT-company, using models that implement certain approaches, the development of algorithmic software that embodies these approaches, their implementation in the developed software solution.

The subject of the study is approaches to determining the financial condition of the enterprise, on the example of the object of study – the IT-company in truncated form, namely in the context of the process of diagnosing the financial condition.

The purpose and task of the work is to analyze the financial performance of the company and to accurately determine the financial state with their help on the basis of the selected method of diagnosis on the example of the model of the IT-company under study, to develop a software solution for the automated solution of the task to improve the efficiency of the financial department and the company as a whole.

To solve this problem, we must solve the following subtasks:

1) analyze the object of study, the subject area and the essence of the problem;

2) consider known methods of diagnosis, identify their shortcomings;

3) choose the most appropriate methods of solving the problem, taking into account the various advantages and disadvantages;

4) to develop algorithmic software and software solution that implements an automated process that will allow to diagnose financial condition and will meet the necessary requirements;

5) check the decision on a test case on specific data, analyze the results.

Thus, the need for accurate diagnosis of the financial condition of the company is due to economic reasons and cause needs make correct and effective management decisions.

3.2 Research methods

3.2.1. Diagnosing of financial state in the classic way

The classic coefficient method is designed to provide a fairly complex approach to the analysis of the financial condition of an enterprise, which results in a comprehensive assessment of the financial condition. Sources of information for the analysis of the

activity of the company are the financial statements: balance sheet (form number 1), statement of financial results (form number 2). The application of the methodology is to carry out the analysis on the basis of analytical tables [9].

Financial ratio (index) – a relative index, calculated as the ratio of certain balance sheet items and their combinations [9].

The financial indicators that most objectively assess the financial position are selected. From each group of indicators, several commonly used metrics are selected. Thus, 16 financial ratios (presented above) are selected, which will be calculated on the basis of primary indicators and are components of quantitative assessment of the financial state of the enterprise.

The coefficients characterizing the liquidity, financial stability, profitability and business activity of the company are calculated using known formulas.

Then, using the method of comparing the coefficients with industry recommended standards, formed the idea of solvency, financial stability, profitability, level of business activity, on the basis of which the conclusion is made about the state of the company as a whole.

Rating is necessary in order to summarize in a word the financial condition of the enterprise. This indicator includes the calculation of the most important coefficients. A state gradation from F- "bad" to A- "excellent" is used to display the result.

The algorithm of the coefficient method with the calculation of the rating consists of the following sequence of steps:

1 In the first stage, the actual values of each coefficients for all four groups of indicators are determined in accordance with the known calculation formulas;

2 Next, a comparison of the actual and normative values of the individual coefficients, and each actual coefficient receives a corresponding score: 3 – “excellent”, 2 – “good”, 1 – “satisfactory”, 0 – “unsatisfactory”;

3 In the third step, a quantitative actual estimate of each group of indicators is calculated by the formula

$$C_i = \frac{\sum_{j=1}^{n} b_j}{n}, \quad i = \overline{1,4},$$

де b_j – is the coefficient score obtained in the previous step; n – the number of coefficients in the metric group; C_i – the actual score of the metric group.

4 Then, a quantitative assessment of each group of indicators is given, taking into account the importance of each group, by the formula $K_i = C_i \cdot w_i$, $i = \overline{1,4}$, where C_i – the actual score of the metric group, w_i – the importance of its group of indicators, K_i – a quantitative assessment of each set of metrics based on importance.

5 At the last stage, a rating of the financial and economic state of the enterprise is formed by the formula

$$S = \sum_{i=1}^{n} K_i,$$

де n – the number of indicator groups; K_i – a quantitative assessment of each set of metrics based on importance; S – obtained evaluation.

The above scheme can be used to derive a rating and to draw a conclusion about the financial position of an economic entity.

3.2.2. Diagnosing of financial state with fuzzy logic

When evaluating the activity of the company sometimes we have to operate with non-numerical data, such as: "low" – "high", "bad" – "good", etc. Many financial indicators do not have clear rationing and are highly dependent on the scope of activity of the enterprise, in such cases often resort to expert estimates. [8].

Fuzzy production models are the most common type of fuzzy models used to describe, analyze, and model poorly formalized complex systems and processes.

A fuzzy logical conclusion for a model that reflects the functioning of a company is called approximation of dependence $Y = f\left(y_1, y_2, ..., y_{18}\right)$ using a fuzzy knowledge base and fuzzy operations.

As input linguistic variables using variables, defined on the basis of selected primary financial indicators of the company (obtained from the financial accounting of the company). They are combined into two large groups:

1 $Z_0 = f(Z_1, Z_2, Z_3, Z_4)$ – quantitative indicators of financial position, where:

1) Z_1 – group of liquidity ratios, which including y_1, y_2, y_3;

2) Z_2 – group of indicators of financial stability, which including: y_4, y_5, y_6, y_7, y_8;

3) Z_3 – group of profitability indicators, which including: y_9, y_{10}, y_{11}, y_{12};

4) Z_4 – group of indicators of business activity, which including: y_{13}, y_{14}, y_{15}, y_{16};

2 Z_5 – is quality parameters, which including:

1) y_{17} – professional abilities of managers (point);

2) y_{18} – the level of wages and social protection of employees (point).

З метою отримання можливості оцінки і обробки лінгвістичних показників, формуємо єдину шкалу з п’яти якісних термів: ДН – дуже низький рівень показника, Н – низький рівень y_i, С – середній рівень показника y_i, В – високий рівень y_i, ДВ – дуже високий рівень показника y_i.

In order to be able to evaluate and process indicators $y_i (i = \overline{1, N})$ that can characterize a company in terms of financial condition, we define a single scale of three quality terms: VL – a very low level of indicator y_i, L – a low level of indicator y_i, M – a middle level of indicator y_i, H – a high level of indicator y_i, VH – very high level of indicator y_i.

Y will be used as the output linguistic variable. It is the financial state of the company. The obtained output parameter Y allows us to characterize the financial state of the company as: E – excellent, G – good, N – normal, B – bad, C – critical.

Next, we determine the possible range of change of controlled parameters y_i, and the output variable Y, specify the type of fuzzy term membership functions for different parameters, which indicate the degree of belonging of each element to different qualitative terms. In our case, input indicators may correspond or do not match to recommend or standard values, which are presented in the form of some established intervals. Therefore,

the trapezoidal membership function will be used to solve the problem, because it allows us to specify the basis of a fuzzy set as an interval and is simple to set [7].

We reflect the ranges of change of parameters y_i, to a single universal set y in order to constructing the five membership functions of five fuzzy terms of the input variable {VL, L, M, H, VH}. Three fuzzy subsets are set whose membership functions are shown in Figure 3.1.

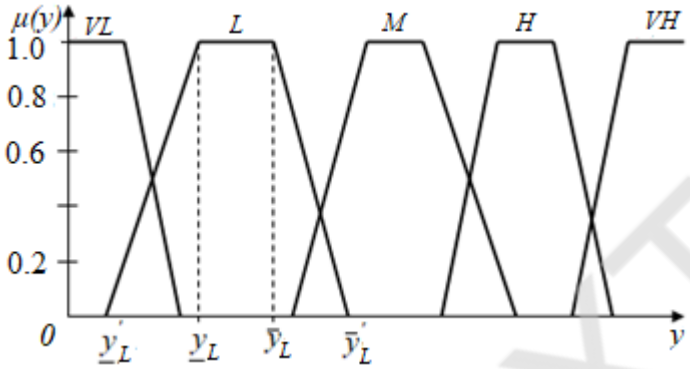

Рисунок 3.1 – Fuzzy variable y with trapezoidal membership function

The membership functions of other fuzzy terms of the input variable y and output variable Y are constructed by similarly way.

A system of fuzzy knowledge should include a mechanism of fuzzy inference. Therefore, the necessary stage of analysis is the formation of a system of rules [7]. Rules are provided for each level of the system. An example of a decisive rule is: IF the quantitative indicators are very high AND the qualitative parameters are middle, OR the quantitative indicators are high AND the qualitative parameters are very high, OR the quantitative indicators are high AND the qualitative parameters are high, THEN the state is normal.

The mathematical form of recording the decisive rule by means of membership functions is represented as:

$$\mu^N = \mu^{VH}(Z_0)\cdot\mu^M(Z_5)\vee\mu^H(Z_0)\cdot\mu^{VH}(Z_5)\vee\mu^H(Z_0)\cdot\mu^H(Z_5),$$

де $\mu^Y(Z_0,Z_5)$ – membership function of input variables vector (Z_0,Z_5)) to the output variable Y; $\mu^{a_i}(Z_i)$ – parameter membership function Z to fuzzy term a_i.

Both criteria Z_0 and Z_5, which represent the complex values of the specified groups of indicators, are presented in the form of mathematical dependencies on input variables. The entire knowledge base is formed similarly and a system of fuzzy logical equations is displayed. The levels of all terms of each indicator $y_i, i=\overline{1,18}$, enterprises are set in accordance with the normative values of the classical criteria [7].

Components of fuzzy product models may be implemented differently, which determines the fuzzy inference algorithm, such as the Mamdani, Sugeno, Larsen, or Tsukamoto models. [8].

The most common method of inference in fuzzy systems is the Mamdani algorithm, which is given below

3 The predicate rule base is formed in the subject area, for example, using the full enumeration method; next action is checking the input variables: if the variables are precise sets, then go to the next step, which is called the fuzziness introduction stage – fuzzification [10];

4 The fuzzification procedure is performed: each value of a separate input variable is associated with the value of the membership function of the corresponding term of the input linguistic variable by the formula $\mu_1(y), \mu_2(y), \ldots, \mu_n(y)$, where $\mu_1(y), \ldots, \mu_n(y)$ – membership functions for variable y [10];

5 Aggregation of prerequisites in fuzzy production rules. Paired fuzzy logic operations are used to find the degree of truth of the conditions of each of the rules of fuzzy products by the formulas:

$$\alpha_1 = \min\{\mu_{A_{11}}(y_1'), \mu_{A_{12}}(y_2'), \ldots, \mu_{A_{1n}}(x_n')\}$$

$$\alpha_2 = \min\{\mu_{A_{21}} y_1'), \mu_{A_{22}}(y_2'), \ldots, \mu_{A_{2n}}(x_n')\}$$

.....

$$\alpha_m = \min\{\mu_{A_{n1}}(y_1'), \mu_{A_{n2}}(y_2'), \ldots, \mu_{A_{mn}}(y_n')\},$$

де n – number of variables; m – number of rules in the base [10].

6 The activation procedure – finding the truncated membership function for the output variable, which is made according to the formulas:

$$\mu_{B_1'}(Y) = \min\{\alpha_1, \mu_{B_1}(Y)\}$$

$$\mu_{B_2'}(Y) = \min\{\alpha_2, \mu_{B_2}(Y)\}$$

.....

$$\mu_{B_m'}(Y) = \min\{\alpha_m, \mu_{B_m}(Y)\} .$$

7 The procedure of accumulating or combining the found truncated functions in order to obtain the final fuzzy set for the output variable and the resulting membership function, which is performed according to the formula $\mu_{B'}(Y) = \max\{\mu_{B_1'}(Y), \mu_{B_2'}(Y), \ldots, \mu_{B_m'}(Y)\}$ [10].

8 Defuzzification, or bringing to precision. Most often, the Mamdani model uses defuzzification by the centroid method, when a precise value of the output variable is defined as the center of gravity for the curve:

$$Y' = \frac{\sum_{i=1}^{n} Y_i \mu_{B'}(Y_i)}{\sum_{i=1}^{n} \mu_{B'}(Y_i)} ,$$

де n – the number of single-point fuzzy sets, each of which characterizes a single value of the considered output linguistic variable; Y' – financial condition of the company [10].

By having a rule base and using the above algorithm, you can get the result of a fuzzy conclusion – the financial state of the company.

IV Work results

4.1 Formation of input data

For this task, a test case was calculated using the methods of the classical coefficient method with the calculation of rating and fuzzy production model using the developed software solution and MATLAB environment. The financial ratios – input parameters and qualitative indicators were calculated On the basis of primary financial indicators.

Using the selected methods, we will determine the financial position according to the balance sheets and the financial statements for each 4 quarters of 2017, 2018.

4.2 Results of diagnosing the financial state of an IT-company

The calculations using the developed software use the primary indicators derived from the financial statements.

Then the calculations are made and the result of the diagnosis is determined by two methods at once. Similar actions are performed for the other initial data of each quarter, calculating quarterly, we obtain the results shown in Figure 4.1.

Thus, on the basis of numerical studies, the financial state of the company for the 8 quarters of 2017-2018 was diagnosed with the help of the developed software solution.

Дата	y1	y2	y3	y4	y5	z1	z2	z3	z4	z5	Результат
2017-03-31 at 11:52:59	3.78	8.032	2.798	0.456	0.709	4.52	3.078	0.687	2.539	2.75	NORMAL
2017-06-30 at 12:02:48	15.259	12.355	11.504	0.267	0.816	4.52	2.914	0.687	2.481	3.978	NORMAL
2017-09-30 at 12:06:35	5.383	7.094	6.914	-0.458	0.855	4.52	1.768	0.687	1.693	4.795	BAD
2017-12-30 at 12:07:41	68.589	71.398	69.964	0.086	0.756	4.52	2.581	0.687	2.536	3.978	NORMAL
2018-03-31 at 12:09:14	25.179	18.927	18.351	0.342	0.808	4.52	2.575	0.687	2.542	3.978	NORMAL
2018-06-30 at 12:11:44	29.171	14.398	14.398	0.484	1.198	4.52	2.585	0.687	1.692	2.75	NORMAL
2018-09-30 at 12:12:51	198.985	126.576	107.83	0.418	1.78	4.52	2.577	0.687	1.994	3.978	NORMAL
2018-12-30 at 12:14:19	51.762	47.72	47.022	-0.095	1.034	4.52	1.769	0.687	3.012	3.978	BAD

Figure 4.1 – The result of diagnosing of states for 2017-2018.

Next, we will diagnose the financial state of the IT company with the help of a fuzzy production system using the tools of MATLAB. For carrying out the numerical study the 16 quantitative indicators and 2 qualitative indicators ($y_1 - y_{18}$), which were described earlier were calculated.

The fuzzy system has one output variable Y – financial state of the company. Each of the variables is characterized by a set of terms of the following form:

$$y_n = \{"Very\ Low","Low","Middle","High","Very\ High"\},\ n = \overline{1,18},$$

$$Y = \{"Critical","Bad","Normal","Good","Excellent"\}.$$

Using the MATLAB software and its Fuzzy Logic module, a fuzzy production rule system was learned with the Mamdani fuzzy inference algorithm.

All parameters were broken down into the following groups: liquidity ratios, financial sustainability ratios, profitability ratios, business activity ratios, and quality indicators. Each group is applied the Mamdani fuzzy inference algorithm and builds its own rule base. Further, by performing similar actions for the common metrics for each group, we obtain a common quantitative metric and a total qualitative metric, for which we again formulate a rule base and apply the Mamdani fuzzy inference algorithm.

The value of the output variable is calculated as the weighted average of the output of each rule, since the Mamdani algorithm is used.

As the input values we set the values of the calculated indicators: the absolute liquidity ratio is 3.7802, the current liquidity ratio is 8.0319, the quick liquidity ratio is 2.7984. Output variable - total liquidity ratio is 4.53.

Similar steps are taken to obtain intermediate values. Calculating intermediate indicators, we get the final result – the company's financial state. In this case, the resulting value of the financial state is 2.96, which corresponds to the qualitative characteristic "normal". The results of the calculations are shown in table 4.1.

Table 4.1 – Obtained results

		z_1	z_2	z_3	z_4	y_{17}	y_{18}	z_5	Y_{fl}	State
2017	I quar.	4.53	3.08	0.676	2.54	7.75	5.61	2.75	2.96	Normal

4.3 Analysis of the results

Research has shown that qualitative indicators also affect the financial position of an enterprise, but to a lesser extent than quantitative indicators.

This conclusion can be drawn from the fact that the result calculated by the classical method, which uses only qualitative indicators, is somewhat different from the result obtained by the use of fuzzy logic, which includes both qualitative and quantitative parameters.

As a result of the research we can say that fuzzy logic techniques are more effective in diagnosing the issue, but if necessary analyzing only quantitative parameters, the classical method of calculation of the rating is also acceptable to use.

As a result of the conducted numerical studies, we obtained data on the financial state of the company for the 8 quarters of 2017-2018. Some results are presented in table 4.2, where z_1 – the general indicator of liquidity ratios group, z_2 – the general indicator of financial stability ratios group, z_3 – the general indicator of profitability ratios group, z_4 – the general indicator of business activity ratios group, z_5 – general indicator of quality parameters, Y_{cl} – financial state obtained by the classical method with the calculation of the rating, Y_{fl} – financial state by the method of fuzzy production rules system. As the table shows, the financial state of the enterprise is usually normal, but in some circumstances it may deteriorate, the analysis of such circumstances should be done by an expert.

Comparing the results for the first quarter of 2017, obtained with the developed software solution and with the MATLAB package using the Fuzzy Logic tool, we can see that the results are almost identical, except that MATLAB rounds the results.

Comparing the classical method and the fuzzy system method, it can be said that the majority still prefers the classical method since it is much simpler and requires only ordinary mathematical knowledge. While the fuzzy system method is more complicated and takes more time to prepare data, calculations, analysis, numerical experiments and requires special knowledge, and the use of special mathematical packages. Therefore, the use of scientific methods based on fuzzy logic, for example, is justified only in developed

information systems, where ordinary employees do not need to understand the intricacies of using these methods.

Table 4.2 – Obtained results

	2017					2018			
	I		II	III	IV	I	II	III	IV
y_1	3.7802		15.258	5.382	68.58	25.179	29.17	198.98	51.76
y_2	8.0319		12.354	7.09	54.84	18.926	14.39	126.57	47.72
y_3	2.7984		11.503	6.914	53.41	18.351	14.39	107.82	47.02
…	…		…	…	…	…	…	…	…
y_{16}	13.0897		7.402	15.588	7.41	9.673	1.490	0.4909	1.537
	I		II	III	IV	I	II	III	IV
	ПЗ	Matlab							
y_{17}	7.713	7.75	7.721	9.336	9.276	7.713	5.475	6.704	7.704
y_{18}	5.583	5.61	7.713	9.336	7.713	6.704	7.721	7.713	7.713
z_1	4.52	4.53	4.52	4.520	4.520	4.520	4.520	4.520	4.520
z_2	3.078	3.08	2.914	1.768	2.581	2.575	2.585	2.577	1.769
z_3	0.687	0.676	0.687	0.687	0.687	0.687	0.687	0.687	0.687
z_4	2.539	2.54	2.481	1.693	2.536	2.542	1.692	1.994	3.012
z_5	2.750	2.75	3.978	4.795	3.978	3.978	2.750	3.978	3.978
Y_{cl}	Norm.	–	Norm.	Norm.	Norm.	Norm.	Norm.	Norm.	Norm.
Y_{fl}	Norm.	Norm.	Norm.	Norm.	Bad	Norm.	Norm.	Norm.	Bad

V Conclusions

The problem and its relevance was analyzed, the subject area and the process of functioning of the IT company were conducted in the work. In order to formalize the process of operation, namely the determination of financial state, diagrams were developed in IDEF0 and DFD notation.

As a result of the analysis the main task was formulated, the existing approaches to its solution were considered. As a result of the survey, approaches based on fuzzy production systems and the classical coefficient method with the calculation of the rating were selected.

To solve the problem, a mathematical model was developed that reflects the process of functioning of the enterprise, as well as algorithmic support, which implements the selected approaches to solving the task, was developed.

As a result of the work the requirements for automation of the decision of the problem of diagnosing the financial state of the company were determined, on the basis of which the software was designed and developed.

Thus, software that automates the process of solving the task was developed. It was used to perform a test example on specific data and analyze the results compared to the example in MATLAB.

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DEVELOPMENT OF A PROTOTYPE OF AN ACTIVE TRACTION PROSTHESIS

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Abstract. *The analysis of the current prostetic market was made. Features, advantages and disadvantages of the forearm prostheses were described. The urgency of this research was shown.*

The prototype of prosthesis was chosen. Drive type has been selected with the selection rationale. The prosthesis control method has been developed. Kinematic scheme was drawn up.

Driving power of the prosthesis was calculated. The corresponding drive has been selected.

***Keywords**: prosthesis of forear, Four-bar Linkage,Arduino Nano, Kinematic diagram of fingers, Hand Mechanism Desig, 3D Printing, DC motor*

I Introduction

Prosthetics is the restoration of lost forms and functions of individual organs or parts of the body. The development and manufacture of artificial technical means of restoration is engaged in prosthetics.

Now registered in the Odessa region is 15 thousand people with disabilities in need of prosthetic and orthopedic care. The largest number of amputations on the upper limb - amputations at the level of the forearm (50.5%). Persons with disabilities who have undergone such amputation lose their ability to self-care in the first place, and in most cases they also lose their profession. Therefore, the goal of prosthetics of the upper extremities is to return the disabled person to the possibility of self-care and to work.

The main task of prosthetics is the creation of a technical device capable of maximally replenishing the lost functions, that is, returning the disabled person the opportunity to make basic domestic movements. Such movements are: capture and manipulation of the subject.

With amputation at the level of the forearm, full movement is maintained in the shoulder and elbow joints, which is sufficient for very accurate positioning of the artificial hand in space without the need to compensate for the mobility of the wrist joint.

To implement the grip, a special technical device is needed, a very simple structural solution of which is now widely used and is a mechanical prosthesis. The most common control methods are: traction mechanical, myotonic and bioelectric methods.

The aim of my work is to develop a domestic prototype of a bionic prosthesis, which during modernization will not be inferior to European counterparts.

To achieve this goal it is required to solve the following tasks:

1) to perform an analysis of the current prostheses presented on the modern market;
2) to develop a constructive prototype of the prosthesis;
3) select the type of drive;
4) to develop a method for controlling the prosthesis;
5) make a kinematic diagram of the brush;
6) calculate the brush drive power;
7) select the appropriate drive.

II. Analysis of the current prostetic market

By the principle of work prostheses on:

1. Traction (active, mechanical);
2. Mioelectric (bioelectric, bionic);
3. Cosmetic (Workers);

2.1. Cosmetic prostheses

The first, currently existing type of prosthesis, the main task of which, as the name implies, is to maximize the exact reproduction of the appearance of a lost limb (pic.1).

Pic.1 Cosmetic prostheses

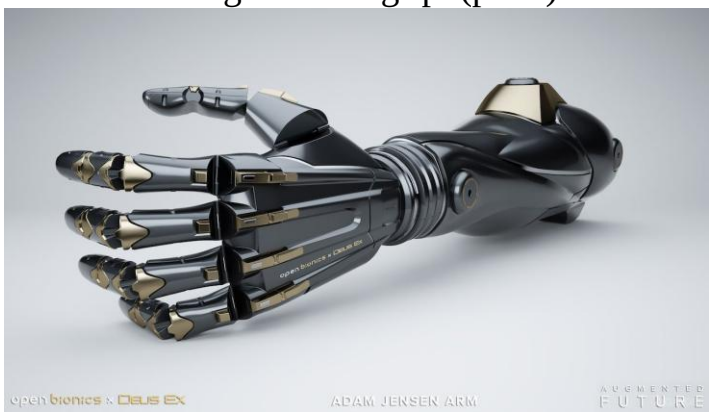
Pluses:	Minuses:
Aesthetic appearance Fingers can be put in the desired position due to the fact that they are made on metal fittings Possibility of use in a humid environment (unlike mechanical and electrical)	Almost complete lack of ability to perform any manipulations The fittings wear out quickly and microcracks begin to appear in the cosmetic layer Leakage due to changes in stump shape during use of the prosthesis

The cost of manufacturing a cosmetic forearm prosthesis in Ukraine is about 4-5 thousand hryvnias. Warranty period not more than a year.

2.2 Bioelectric prostheses

Bioelectric, also called myoelectric or bionic prostheses - these are some of the most modern and advanced hand prostheses. Management in myoelectric prostheses is carried out due to the signals arising from the contraction of muscles that read EMG sensors.

Myosensors are integrated in the stump receptacle, which capture the change in electric potential. This information is transmitted to the brush microprocessor, and as a result, the prosthesis performs a certain gesture or grip. (pic.2)



Pic.2 Bioelectric prosthesis

General properties:

Advantages	Disadvantages:
Aesthetic appearance Does not require additional straps for fastening, unlike mechanical Returns muscle stump inherent function of contraction and relaxation, which contributes to the normalization of stump tissue and improve blood circulation in them Physiology. The management principle is based on the principle of functioning of a healthy limb. Such management does not require unnatural from a disabled person compensatory movements for grasping, as opposed to mechanical prostheses Ability to grab / open when any hand position	High price Sensitivity to environmental parameters: humidity, temperature, the presence of electromagnetic fields The prosthesis is controlled only two commands: start or stop the movement, that is, the brush after the start of the movement will compress with constant force until the time comes to command stay. The complexity of the control is that there is no way to control the force of pressure on the object, and therefore, stop the movement of the grasp at the right time Needs constant recharging the battery

2.3 Traction prostheses of the upper extremities.

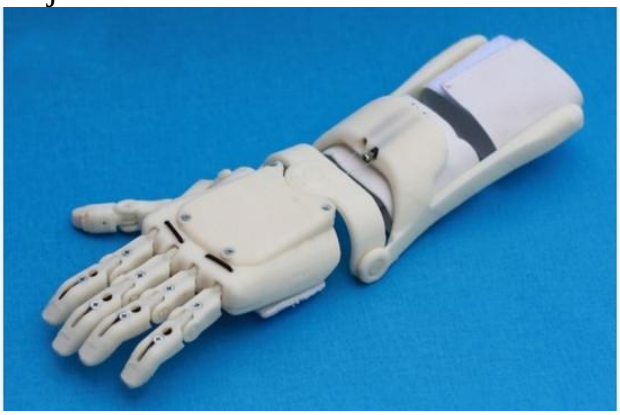
These are active manipulators controlled by the physical forces of their own body. The motor function of the prosthesis is carried out by means of a traction bandage. The advantages of this type are simple mechanics, the possibility of prolonged contact with water and low prices for prostheses of the lower limbs and upper.

Active (traction or mechanical) prostheses of the hand and forearm

The active prosthesis is controlled by rods and is completely controlled by the efforts of the person himself without any electronics.

The principle of operation of a mechanical prosthesis is very simple, therefore, such prostheses are installed from a very early age. Modern active prostheses are made even for children from 2 years old with injuries at the level of the hand and forearm.

The strength of this mechanism is the ability to control the force. When performing a grip, the user himself determines the compression force, its speed and can feel resistance when the brush rests on the subject. Pic.3



Pic.3 Active traction prosthesis

Advantages:	Disadvantages:
Reliable in use More moisture resistant than electrical Relatively inexpensive Ability to control force	Tension spring exerts significant pressure on the stump and, therefore, such prostheses can only be used on significant time elapsed since amputation when stump begins to lose sensitivity

III. Prototype development

3.1. As a prototype (executive manipulator), it was decided to use a Bebionic prosthesis suitable for both traction control and the installation of an electric drive.(Pic.4)

Pic.4 Prosthesis Bebionic

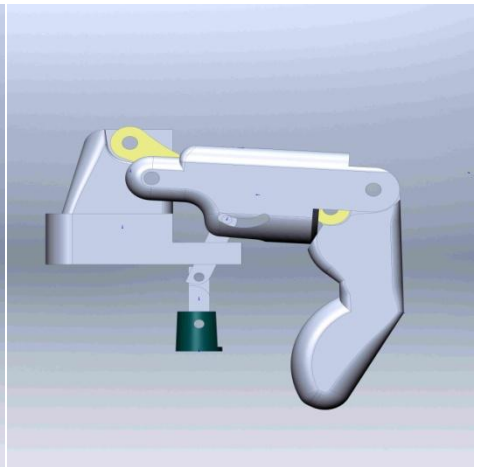
3.2. Drive Type Selection

Based on the general requirements for portable (wearable) equipment, it was decided to use DC electric motors with a low-noise metal gearbox and high torque as a drive, since they have considerable traction power with small dimensions and light weight, they are represented by a wide model range and have an affordable price

3.3. Mechanics and construction

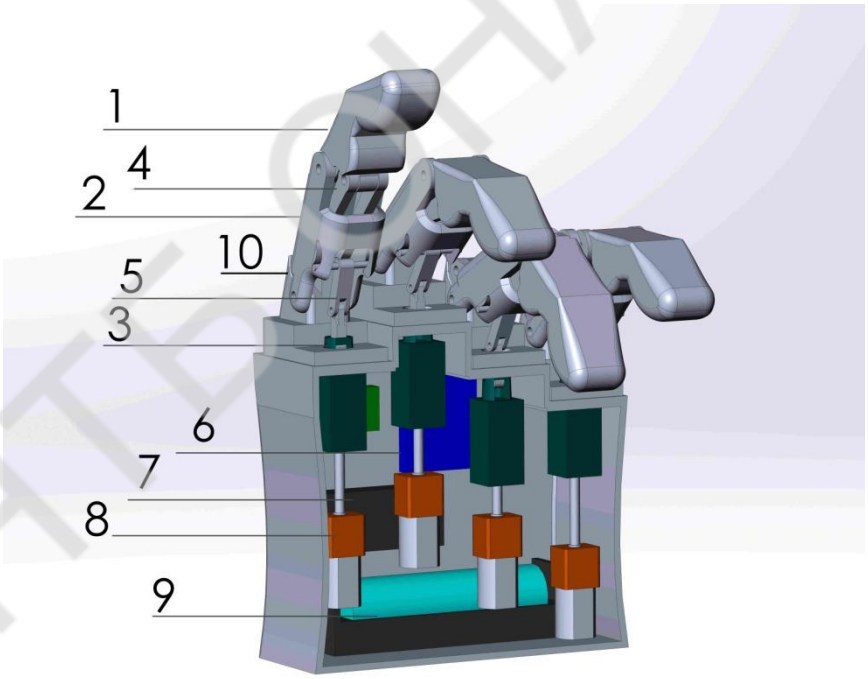
The selected device diagram is five-finger. Each finger consists of two phalanges that are interconnected on one axis, also a spring is fixed on this axis, which provides the finger with reverse movement (fixes it in the upper position 1).(Pic.5)

Pic.5 Position 1



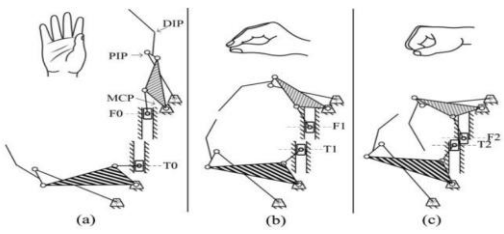
Puc.6 Position 2

The lower phalanx (2) is attached directly to the base of the prosthesis (10). It also has a slot for the shaft of the stem (5), which is the pulling mechanism of the structure. The rod is connected to the part (3), which transmits the translational motion to the stem from the motor shaft. from rotation of the motor shaft is carried out by transmitting the screw nut (in my case it is a brass sleeve soldered into the part (3)).



Pic. 6 General assembly

A guide (4) is fixed on one of the axes of the upper phalanx, which is part of the four-beam communication system of the so-called four-bar linkage. Bebionic hand uses four-bar linkage with a linear motion plastic rod connected to distal link.

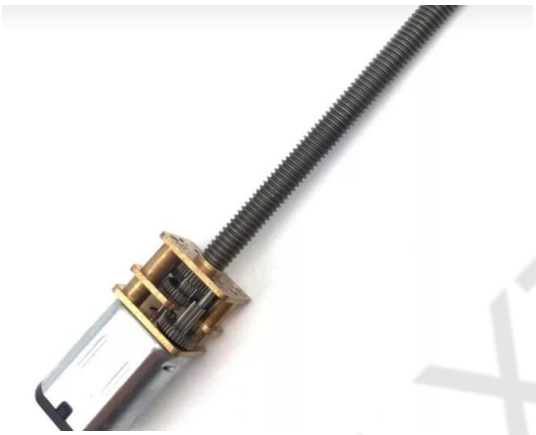


Kinematic diagram of fingers and thumb mechanism. (a) Open hand position, (b) Precision grip position, (c) Power grip position.

3.4. Electronics.

The main controller will be the Arduino Nano 328 controller (Pic.6 (7)). One of the major advantages of choosing this card is its small size and the convenient mini USB output for programming, which greatly facilitates device setup, eliminating the need to use additional devices or attach a large number of wires each time.

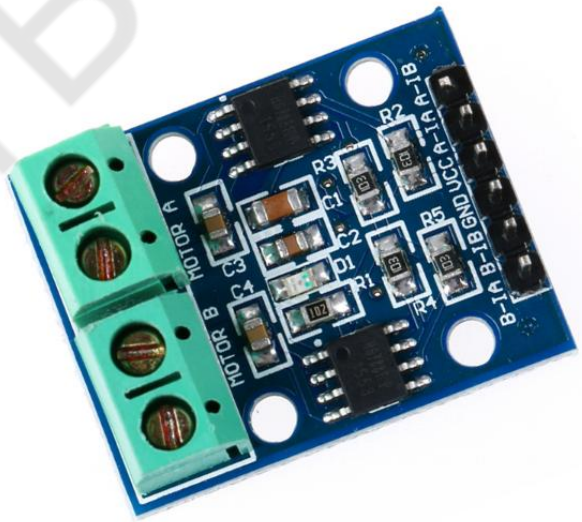
To drive the gripping device selected DC motors and gearboxes, in miniature format (pic 7). (Pic.6 (8))



Pic.7 DC motor reducer

Among the main advantages of this engine is its size, power, metal gear wheels that allow you to withstand intense loads, and the convenience of mounting, both the engine itself and the pulley on the shaft, due to the presence of a fly.

To control driver driven data (Pic.6 (6)). Since the motor is powered by a DC power supply, it is enough to change the voltage to control the speed, and to change the direction of rotation - the polarity of the power supply. For this purpose, the conventional transistor assembly drivers should be used in the experimental model

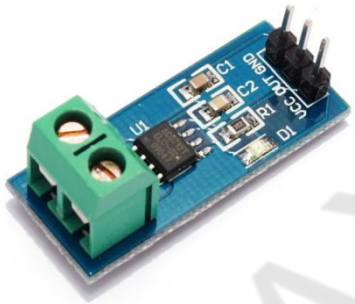


Pic. 8 Engine driver HG 7881

Advantages include small size, terminal block removal, ease of operation and connection. Ability to control 2 engines with one board. The ability to deliver current of 800 mA to each output, which allows them to be applied with the selected motors. Since the device uses 4 motors it is necessary to use 2 drivers.

The system must have feedback. The microcontroller should know when to turn off the motors. Due to the small size and specificity of the chosen design, it is not possible to use mechanical switches as system response elements. Therefore, it is appropriate to use current sensors that will measure its performance during engine operation. By using these sensors, you can control the grip force.

Current force sensor (pic 9) ACS712 compact, it allows to measure current in the network of both direct and alternating current. For the selected engines, select a sensor designed for a maximum current of 5A. Since in this case the change of the analog signal at the output reaches 185 mV / A. Which in the case of our control system and low engine current will improve measurement accuracy. The output of this sensor is analog.



Pic 9 Current force sensor

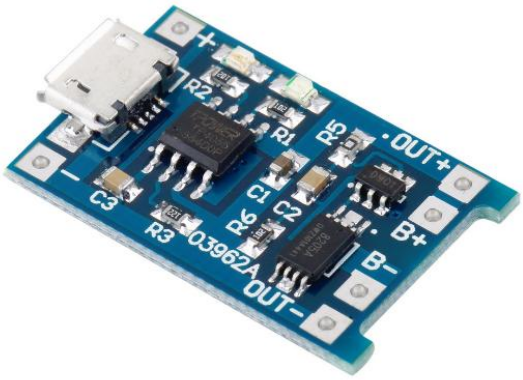
The device must have a power system. The designed model should be equipped with a battery, a voltage regulator, and a battery discharge controller.

The primary battery will be a 18650 lithium-ion battery with an operating voltage of 3.6 V and a capacity of approximately 1500 mAh. (pic 10These batteries are widespread and have great size characteristics. (Pic.6 (9))

Pic. 10 Battery 18650

For convenience of replacement of the discharged battery we use special «holders».

Be sure to use lithium-ion batteries with the charge / discharge controller. For this we will use a special fee



Pic. 11 Charge / discharge controller ACB

The last element of the system is a voltage regulator that will increase the voltage to the required 6V motors and will support it during the discharge of the battery. (pic 12).

The Arduino microcontroller will be powered via a built-in voltage regulator.

Pic. 12 Voltage stabilizer

4.Software

Arduino series microcontrollers have their own programming software. You can program the board in different ways:

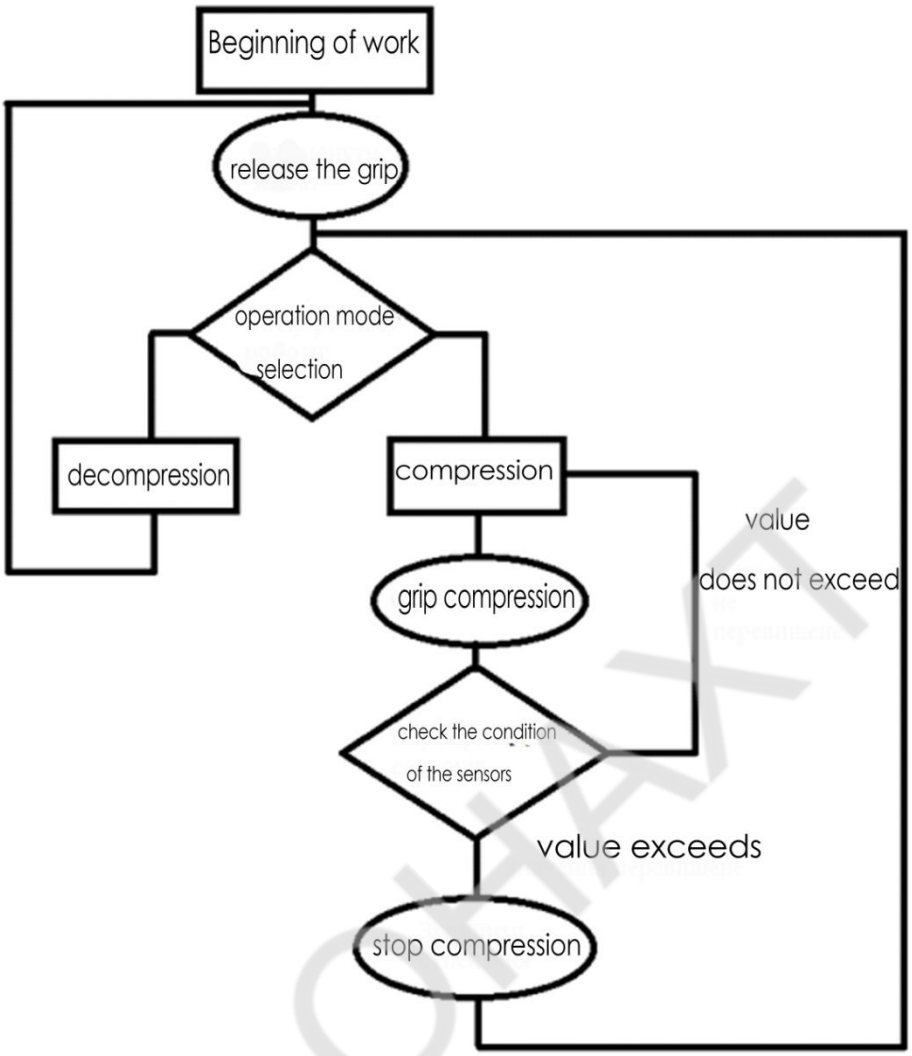
1. Block programming.
2. Programming elements of the scheme.
3. Code programming.

For Arduino programming, code writing is developed by the company. It's actually an add-on for C ++, but with the addition of features and libraries that make it easier to control engines and process information from sensors.

The objectives of the management program:

The capture device software must control 3 motors. Change the direction of rotation of the device to compress and open the device accordingly. All 4 drives must be controlled independently as the unit is adaptive. The control program must switch off the motors when the entire phalanx is in contact with the gripped object to prevent damage to the mechanism and the motor. To do this, they should analyze the signal of the current sensors on each engine and, in the event of a rise, switch off the engine and wait for the next command. The program must switch the compression mode, the compression mode by pressing the appropriate buttons.

The algorithm of the control program is given on pic 13.



Pic 13 Management program algorithm

5. 3D printing

Modern 3D prostheses use industrial 3D printing technology with plastic, metal and composite materials to facilitate prosthesis design and performance. Material - PLA plastic, as it meets the required parameters and is environmentally friendly material.

Pic 14 Management program algorithm

IV Work results

According to the goal of working on the development of a prototype of an active traction prosthesis, the following tasks were solved during the work: the forearm prostheses presented on the modern market were analyzed, the prototype of the prosthesis was selected, the drive type was selected, the device's block diagram was developed, the prosthesis control method was developed, and the kinematic was compiled brush scheme, a functional diagram of the program control system is formed, the corresponding drive is selected, the manufacture of a prototype on the basis of components from biological plastic PLA for 3D printing.

V Conclusions

A prototype of an active traction prosthesis with a formed control system was developed and implemented. The main components in the assembly are considered. With the improvement of technical means and the use of more modern components, further improvement of technical characteristics is possible: weight and size indicators, degrees of mobility, ease of control, positioning accuracy, etc.

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SYSTEM FOR STORING AND ANALYZING DATA OF THE WATER HEATERS PLANT

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Abstract. The given project of this system of data storage and analysis for generating reports. The system has interfaces for users and interfaces for changing the plan and production time. The database system stores information regarding finished products at the plant for the production of water heaters..

Keywords: database, reporting, barcode scanning, production automation, production parameters

I. Introduction

Scanners for barcodes are devices that allow you to get various information about the product, which was originally laid down in the database of the information system. When scanning, the device emits a sound signal, every inhabitant of the planet, standing at the checkout counter in the nearest store or supermarket, hears about the successful reading of product information from the storage medium.

The reason for the appearance of scanners can be considered an increase in the range at retail outlets and customers. If before the seller knew the information about each product and its value, then as a result of the growing diversity of positions, it was already impossible to keep this information in mind. Scanners identifying the cost came to the rescue, as well as other details about the product, when holding the reader to the barcode.

A database is information structures containing interconnected data about real objects.

Features of this data set are:

• sufficiently large amounts of information;

• maximum possible compactness of data storage;

• the ability to extract from the database various information in a specific subject area;

• user-friendly appearance and form of information is drawn;

• high speed access to data;

• reliability of information storage and the ability to provide authorized access to data for individual users;

• convenience and simplicity of user designing of queries, forms and reports for data sampling. Creating a database, its support and ensuring user access to it is carried out using a special software tool - database management system

Databases are very simple and convenient way to have access to information that you need to work with every day. No need to record large data sizes by hand and keep information in mind. This is very important for enterprises, since the time saved is always cost-effective.

II. Analytical review of the literature

The history of databases in the narrow sense considers databases in the traditional (modern) sense. This story begins in 1955 when programmable recording equipment appeared. The software of this time supported a file-based record-processing model. Punch cards were used to store data.

Online network databases appeared in the mid-1960s. Operations on operational databases were processed interactively using terminals. Simple index-sequential record organizations quickly evolved to a more powerful set-oriented record model. For his leadership of the Data Base Task Group (DBTG), which developed a standard language for describing data and manipulating data, Charles Bachmann received the Turing Prize.

At the same time, the concept of database schemas and the concept of data independence were developed in the Kobol database community.

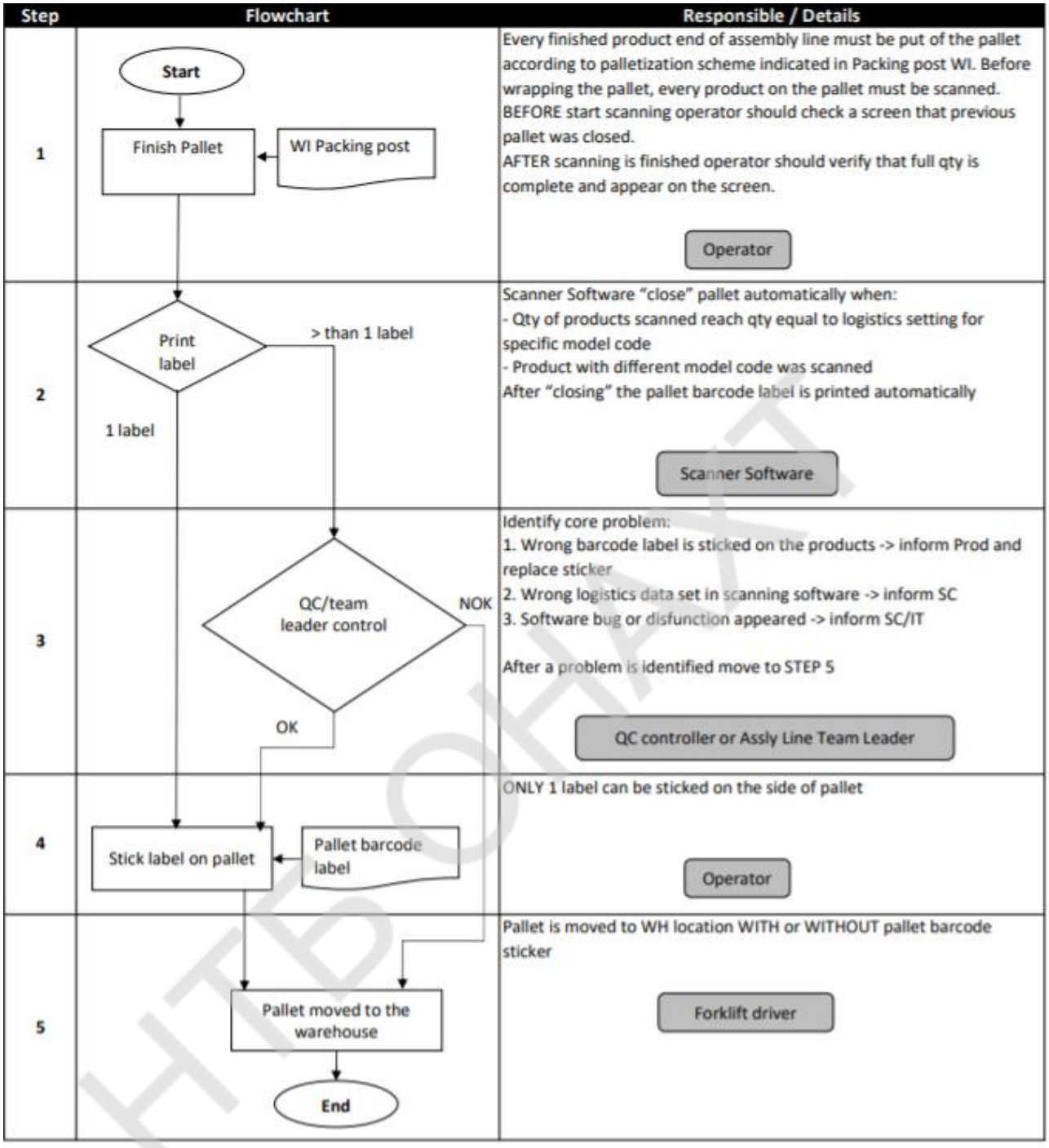
III. Object, subject and research methods

The main reason for creating a data storage system and its analysis is the need to reduce the time for accounting for finished products, as using traditional accounting with paper and pen inconvenience and a big loss of time. Also, the human factor that forget can be unprofitable for the enterprise.

The object of the study is an information system that allows using additional hardware, such as a barcode scanner (Picture 1), to enter the necessary data on the manufactured products and, according to some procedures, process them to generate reports and stock accounting, print stickers and other things.

Picture 1 – External view of barcode scanner

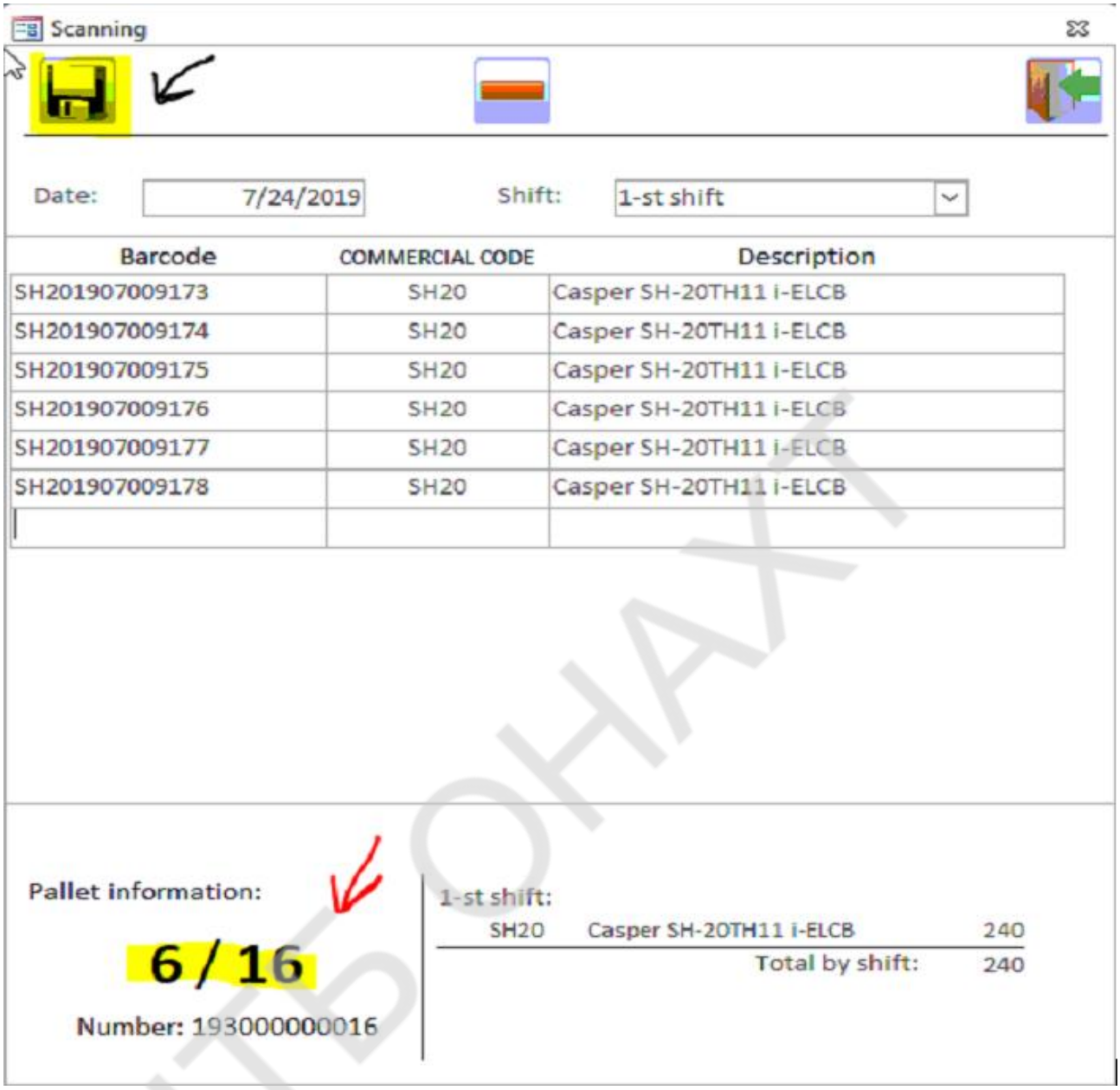
According to the scheme shown in Figure 2, production works after the introduction of this system.



Picture 2 – An example of a data storage and analysis system

IV. **Work results**

An interface has been designed for the operator's, in which scanned product positions are displayed (Picture 3). Each reference has its own quantity on a pallet. The pallet closes automatically if the right amount of product is scanned. You can also close the pallet manually if you not need to keep all positions.

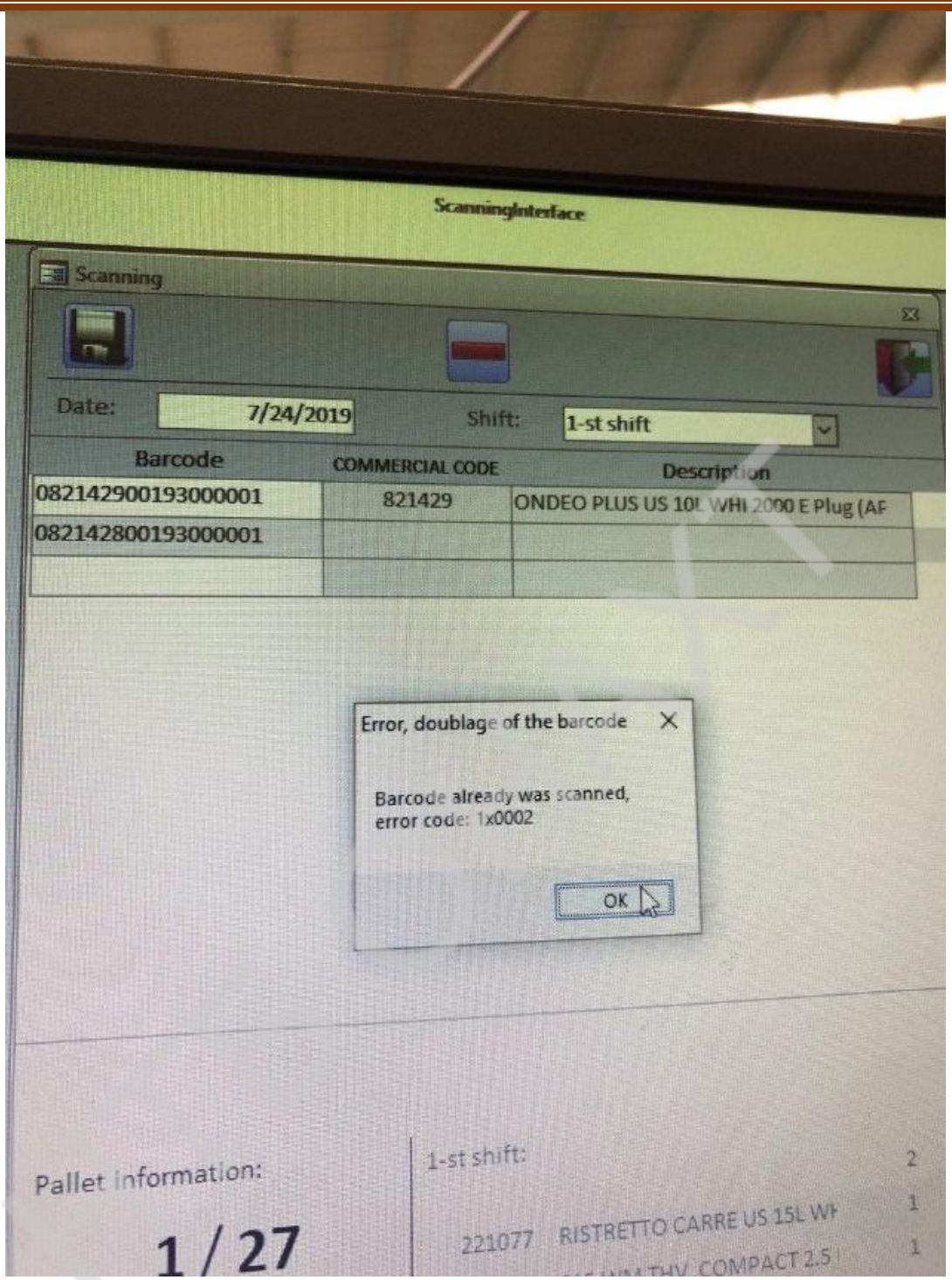


Picture 3 – Interface for operator

The operator's workplace where the scanner and monitor with the interface for scanning are located is shown on the Picture 4.

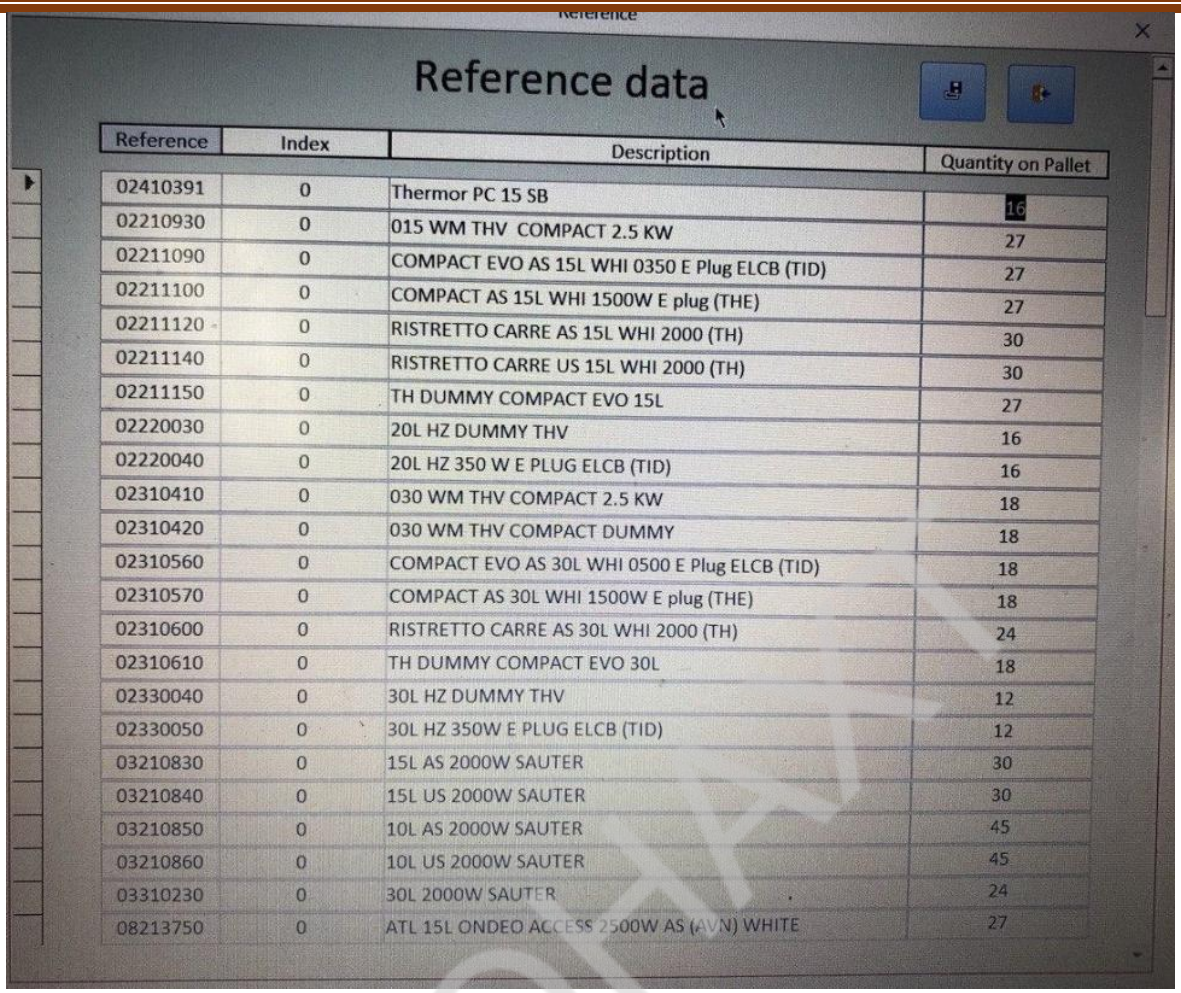
Picture 4 – Operator's workplace

If the source barcode enters the database, then it cannot be scanned again thanks to the control system (Picture 5). Thus, you can be sure that the scanned products will not be duplicated and there will be no errors in the formation of the report.



Picture 5– Duplicate error

There is also an interface with all product positions. There you can add new positions or edit current ones. In additional tabs you can find tools for setting the working time and the start of the shift (Picture 6).



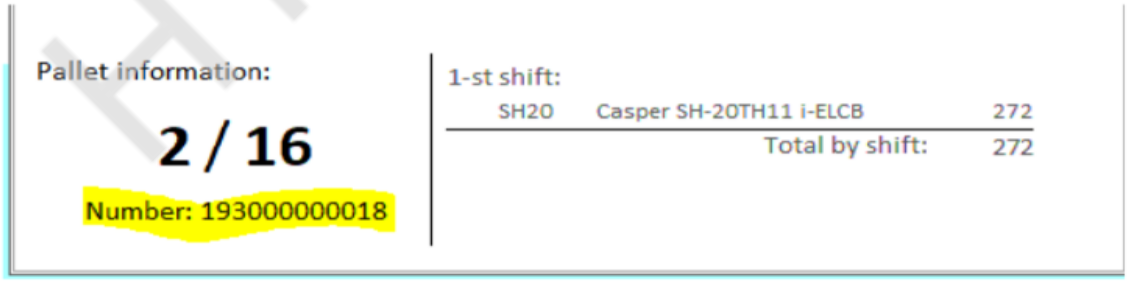
Reference data

Reference	Index	Description	Quantity on Pallet
02410391	0	Thermor PC 15 SB	16
02210930	0	015 WM THV COMPACT 2.5 KW	27
02211090	0	COMPACT EVO AS 15L WHI 0350 E Plug ELCB (TID)	27
02211100	0	COMPACT AS 15L WHI 1500W E plug (THE)	27
02211120	0	RISTRETTO CARRE AS 15L WHI 2000 (TH)	30
02211140	0	RISTRETTO CARRE US 15L WHI 2000 (TH)	30
02211150	0	TH DUMMY COMPACT EVO 15L	27
02220030	0	20L HZ DUMMY THV	16
02220040	0	20L HZ 350 W E PLUG ELCB (TID)	16
02310410	0	030 WM THV COMPACT 2.5 KW	18
02310420	0	030 WM THV COMPACT DUMMY	18
02310560	0	COMPACT EVO AS 30L WHI 0500 E Plug ELCB (TID)	18
02310570	0	COMPACT AS 30L WHI 1500W E plug (THE)	18
02310600	0	RISTRETTO CARRE AS 30L WHI 2000 (TH)	24
02310610	0	TH DUMMY COMPACT EVO 30L	18
02330040	0	30L HZ DUMMY THV	12
02330050	0	30L HZ 350W E PLUG ELCB (TID)	12
03210830	0	15L AS 2000W SAUTER	30
03210840	0	15L US 2000W SAUTER	30
03210850	0	10L AS 2000W SAUTER	45
03210860	0	10L US 2000W SAUTER	45
03310230	0	30L 2000W SAUTER	24
08213750	0	ATL 15L ONDEO ACCESS 2500W AS (AVN) WHITE	27

Picture 6 – Interface with information about products

After closing the pallets, a new one is formed.

A sticker with the pallet number and product information is also printed, which is glued to the pallet and sent to the finished goods warehouse (Picture 7).



Picture 7– New one pallet number is formed

All barcodes are scanned from the sticker, read and verified with the database system (Picture 8).

Picture 8 – An example of sticker

If this position is not in the database or the number of characters does not match the required number, then the barcode simply will not get into the database due to mismatch errors.

The next stage in the development of the system is the addition of a panel where the operator will apply a pass card (Picture 9). This is necessary in order to identify the person who worked in this area for a certain period of time.

Picture 9 – Access card

Another important addition to the system is the replacement of a conventional monitor with a monitor with a touchscreen (Picture 10). Ordinary "mice" very often break

down in production, especially where there is a lot of dust. It will also help save time for the operator.

Philips 222B9T / 00 SmoothTouch monitors were purchased for production. They have protection against moisture and dust, and also uses a projection-capacitive sensor system.

Picture 10 – Touchscreen

V. **Conclusions**

The possibilities of using an information system in production were investigated, the advantages for automating the creation of reporting documentation were shown, a database with several interfaces and a dozen different tables was developed, which stores information about the reference, logical codes and the number of products on one pallet. A separate interface has been designed for the computer in the workshop, where operators scan the finished product using a barcode scanner. A separate interface has been developed for the logistician, where based on the scanned stickers of water heaters you can make reports, thanks to which you can make operational management decisions to optimize production and stock.

The system of storage and analysis of the data of the plant for the production of water heaters, which I proposed, was successfully put into production and is now actively used at the plant in Thailand.

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DEVELOPMENT OF A MONITORING SYSTEM SEYSMOAKTYVNOSTI CONSTRUCTION WORKS

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Abstract. Objective is to increase the efficiency of monitoring and analysis of seismic activity rise buildings by automating the process. The system consists of a database and web applications, all of which allow you to achieve this goal. The results can be used by engineers, seismologists during construction and operation of multi-storey buildings.

Keywords: Monitoring, seismology, earthquake, magnitude, seismic seismological observation LAN, seismological instrumentation channel frequency response of seismic, tectonic faults, information technology, database, web application.

I. Introduction

The negative social consequences and losses from natural disasters, including from earthquakes and accompanying dangerous secondary effects can be significantly reduced with proper training to them. Results of monitoring seismic regions of Ukraine used to address important fundamental objectives of the study geodynamics, tectonics, seismic risk of settlements, buildings, environmentally and technologically dangerous objects and to solve applied problems of public safety and the economy.

Given the high potential seismic hazard the southern regions of Ukraine, developing them fairly dense network of seismic and engineering-seismological stations is a priority needed to address problems with cheap but highly effective, seismic protection, environmentally dangerous and economically important object ' objects.

Information technology allows much faster to analyze the results of the ongoing seismic monitoring south-western regions of Ukraine and neighboring areas to identify ways of further development of the observation network of seismic and engineering-seismological stations as the most important components of seismic monitoring, providing reliable empirical data to solve not only the problems of seismic protection but the important fundamental objectives of geodynamics and tectonics.

Monitoring and analysis of seismic activity rise buildings is one of the urgent and needs new, modern software development. It is clear that using only standard, mechanical ways to solve this problem is impossible and ineffective. So now it was necessary reorganization process monitoring during construction and subsequent operation based on modern information and communication technologies.

II. Analytical review of the literature

In Ukraine, according to the Institute of Geophysics of the National Academy of Sciences, the seismic danger may soon worsen. However, to prevent seismic disasters should regularly verify that the design values of seismic vibrations from the actual values of land and conduct dynamic testing.

In Transcarpathia the magnitude of the disaster may reach 8 points. The most dangerous areas of the country is considered to district Vrancea Zone - Carpathian Mountains - and west Odessa region

In zone 6 points entering the following cities and strategically important objects: Chernovtsy, Odessa, Nikolaev, Zaporozhye and the Zaporozhye NPP Yuzhnoukrainsk. When 6 balls pictures falling from the walls, break off pieces of plaster, minor damage to buildings.

In the area get 5 points: Kherson, Dnepr, Krivoy Rog, Poltava, Cherkassy, Vinnitsa, Zhitomir, Khmelnitsky, Ivano-Frankivsk, Ternopil, Lviv and Kyiv and Kyiv region. At 5-magnitude earthquake observed cracks in walls and plaster.

In zone 4 points would be: Uzhgorod, Lutsk, Rivne, Chernihiv, Sumy, Kharkiv, Lugansk, Donetsk, Simferopol and Sevastopol. 4-magnitude earthquake felt only by people indoors but does not cause damage. [3]

During the construction of buildings to ensure the structural safety problem becomes especially high priority. One of the new elements of the safety of buildings is the development and implementation of automated systems for monitoring the technical condition of building structures. Monitoring buildings - a long time observing the shift of one or more buildings with complex research, engineering and geological methods in construction in cramped urban conditions. According to DBN V.1.2-14-2009 "General principles of reliability and structural safety of buildings, structures and foundations" objects of class effects (liability) SS3, the destruction of which could lead to catastrophic consequences, must be equipped with automated monitoring systems and control (ASMU).

• primary devices for information on repositioning (moving) and class (strain, temperature, etc.) of the observation;

• Secondary devices for processing information received (eg, computer system analysis of the object that contains the control standards and rules of decision-making)

• signaling devices;

• link between the devices and devices.

Modern information technology is defined as continuous processing, storage, transmission and display of information for the effective use of information resources, computer technology and data management systems in the different classes. Information technology affect all areas studied seismology, significantly increasing the degree of automation that can accelerate the study of the subject area. Computer modeling of seismic waves allows us to study the structure and dynamics of the Earth with unprecedented accuracy. A few minutes later the computer makes many calculations, no matter how many people had to do over a hundred million years. Also, information technologies enhance the quality and efficiency of research using computational experiments

The main task performed IT:

- Transmission of information to any distance in limited time.
- The flexibility of the process of changing data and setting objectives
- The ability to store large amounts of data on storage media.
- Reducing development time, complexity and cost of scientific research.

In the developing world seismic systems of different sizes. For example, a consortium of research institutions in the field of seismology has developed the most seismological monitoring system in the world - GSN. This network, which interacts with most of the international and national seismic systems. This modern seismic observation network uses the latest information technology. One of its major achievements is the standardization of data and research results. Dozens of disparate data collection and

storage can be integrated into a single international seismological computer system using their system worked out standards and formats. [3]

The next step in the development of information technology in this subject area was the establishment and commissioning of the seismological system SeisComP in Germany. It was the first truly automatic collection and storage of seismological information that covered the whole territory of Europe.

Currently, information software tool has become a powerful factor in the intensification and deepening of seismology studies, unlike mechanical collection, processing and analysis of information, which makes it fast and accurate results. Indeed, thanks to the improvement and introduction of systems such as GSN and SeisComP there are new data available in real time, contributing to the rapid development of seismology, enable advance warning of emergencies and help engineers during construction.

In the study of seismology used massive amounts of data. Seismology makes it possible to solve such problems, earthquake prediction, choice of search strategy and mineral deposits, etc. Processing of geological and geophysical data is an important step in the analysis of experimental data. During geophysical studies usually collected a huge amount of diverse information that can be provided in the form of text, graphs, tables, maps, etc.

The human factor influences the accuracy, timeliness or completeness of information processed. At long monotonous data entry fatigue during a person begins to make mistakes, miss data rearrange their places.

When performing verification of data in order to find errors in input data, and processing to correct and adjust errors found. It was found that the majority of errors resulting from human factors.

For this reason, it becomes very important use of databases for organizing, organizing, storing and analyzing large amounts of geophysical data. [2]

Organizing data - Combining, mixing groups of similar features for some units to some kind of functional purpose on the basis of existing ties between them and the outside world is an important stage of work. It involves the organization of data in a form suitable for storage and further treatment for her. In practice, usually little time given to training and systematization of data, while training is an important step for efficiency. Incorrect data preparation can make analysis difficult and impossible. In that case, when you have to work with huge amounts of data, preparation of data becomes an independent task which can take considerable time and effort.

Information technology can organize the available geological and geophysical information and on the basis of existing data to reveal the relationship between the studied parameters.

When the information is a lot of her hard work, even if it is well systematized. Much more difficult to find the right and highlight important to see relationships and trends and making decisions, it is impossible to consider every fact. At this point helps to cope with the problem of data visualization. Modern data visualization with high functionality and rapidly evolving from conventional reporting tools to the decision support systems. This enables us to analyze real-time large amounts of data with the possibility of deep study and prepare a structured reporting in a visual form. Through visualization users more convenient and easier to understand what is happening, to find the necessary information, correlation and dependency, draw conclusions,

When considering the visual images one sees not simply a group of individual, unconnected dots and lines, he sees a well organized group of objects. In order to accurately determine the specific numerical values necessary to include symbols or text in the image. As part of data visualization uses standard imaging techniques quantitative indicators in schematic form (pie charts, diagrams of regions, line graphs). Similar methods are universal and apply to the view of systematization, comparison and analysis focused on the issues, ideas, plans, concepts.

Information technologies allow for visualization and interactive analysis of seismic data. Developed software that make it possible to display subduction zones, separation zones bulk tectonic earthquakes typical characteristics boundaries of tectonic plates. There is also a tool for data visualization with testing seysmotomohrafiyi group of volcanoes using volume rendering. Displaying different types of seismic data in the same context, on the basis of the globe can analyze dependencies between data. [3]

III. The object, subject and research methods

The object of study - earthquakes associated with modern active tectonic structures of the platform in Ukraine

Subject of research - geological and geophysical data requiring processing.

Research methods. Method cascade development. Conduct seismological observations with the software solution. Modern methods of obtaining, collecting and processing digital seismological information. Methods of pattern recognition to identify local earthquakes. Analysis of the current active tectonic structures. Methods of analysis and comparison.

IV. The results

Information model, shown in Figure 1, shows how the system interacts with the user and receives data. User System - Engineer seismologist. It is via web application will prompt the system. Web application displays the database required user data (with the ability to export in format Excel), arriving every minute of sensors that were previously connected.

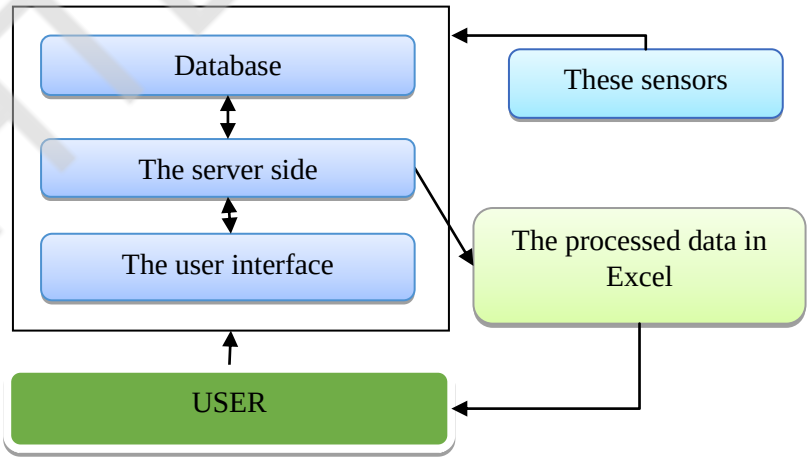

Figure 1 - Information system model

The database stores all the information necessary to complete the system. It consists of 6 tables, 4 of which are related. The base is given to the third normal form, subject specialization system requirements as evidenced by bonds, which are indicated in Figure 2.

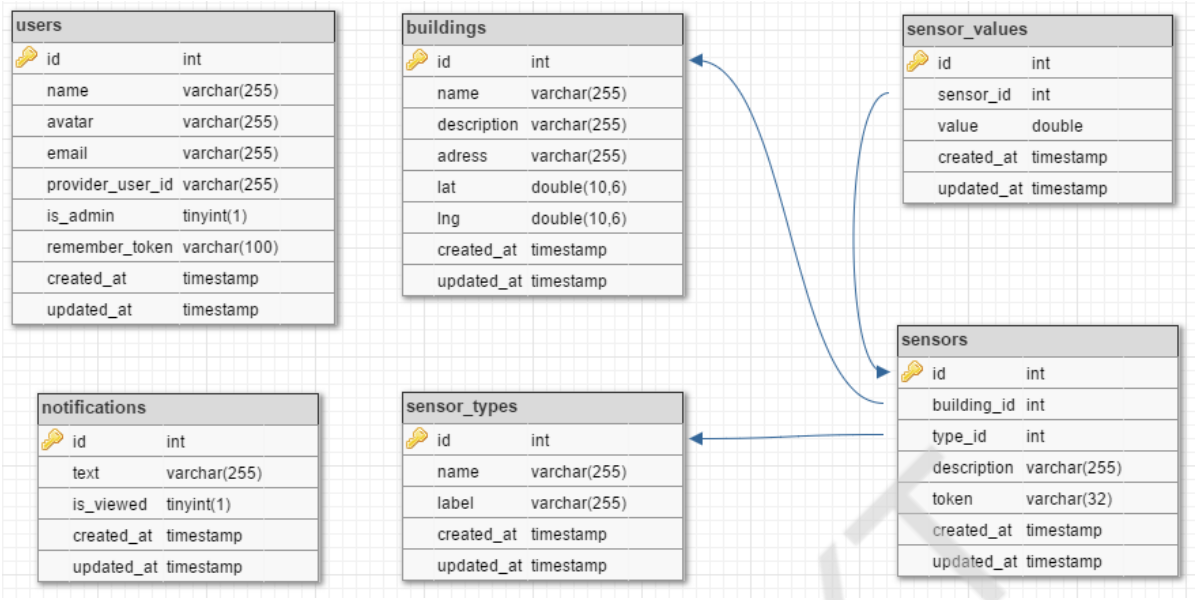

Figure 2 - Scheme database

System requirements for the database server: RAM - 1GB, free disk space - 4.76 GB, OS - Windows 7, Windows 8.1, Windows 10, Linux. System requirements for the software: poeratyvna memory (RAM) - 256 Mbytes, free disk space - 150 Mbytes, the operating system - Windows 7, Windows 8.1, Windows 10, Linux.

To gain access to further work with the system must authorize and have the right of access provided during implementation. After passing the authentication menu appears with new features (Figure 3), namely:

– add new buildings to the system;
– adding new sensors;
– message window.

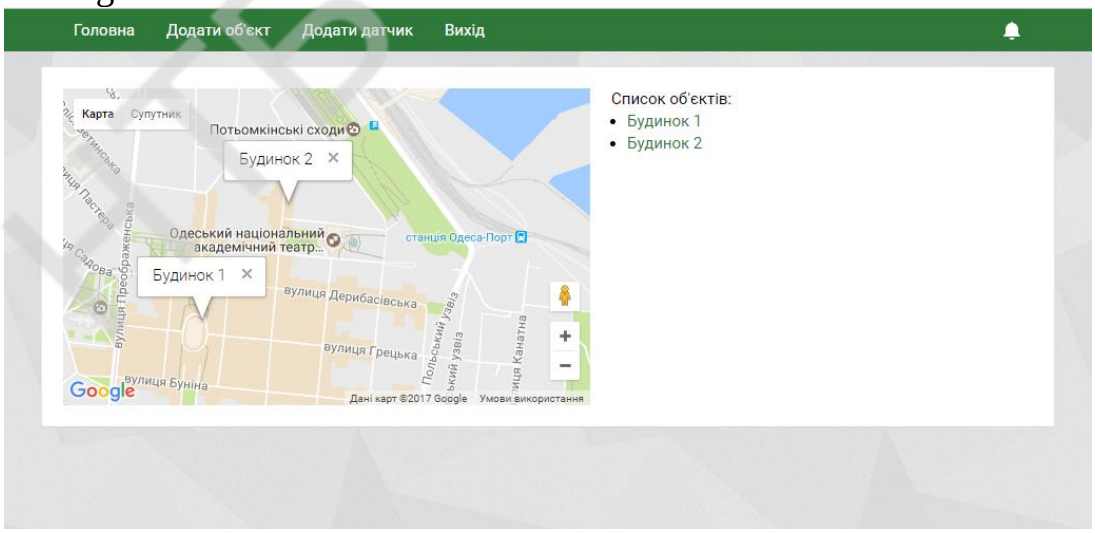

Figure 3 - Starting window

To add a home in need click "Add item". A window in which to specify a title, description and address of the building (Figure 4). To specify the address drag the marker to the place where the house on a map and web application form for himself by using coordinates. Formed address can be edited. After clicking "Add" building will be added to the system.

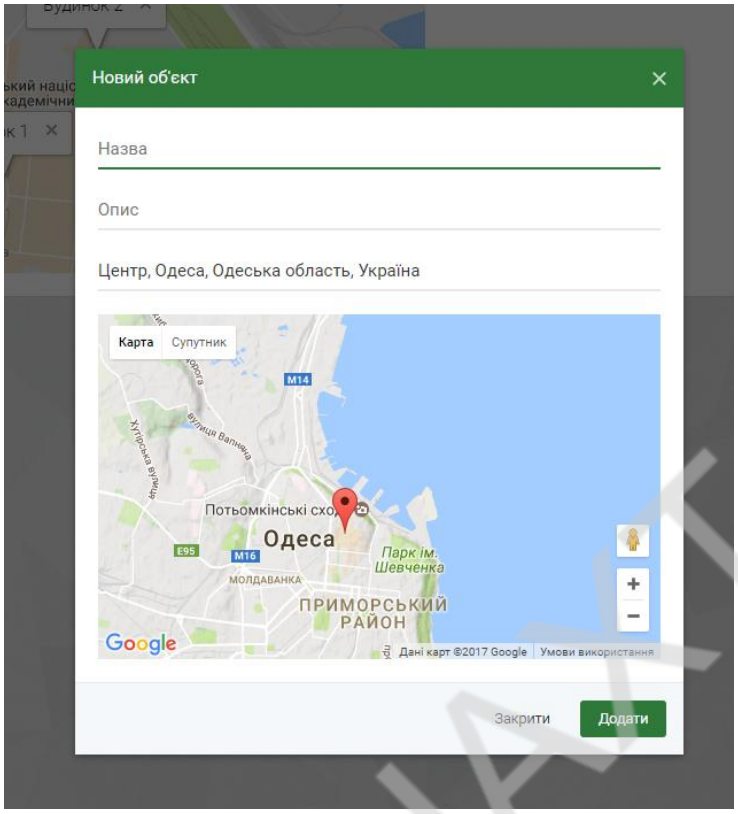

Figure 4 - Window "new facility"

To add a new sensor must click "Add Sensor". A window (Figure 5), which must choose a house where it is installed, the sensor type and if necessary to conduct some description. House type sensor is selected using the lists reflect all the options in the system. After clicking "Add" sensor is added to the system.

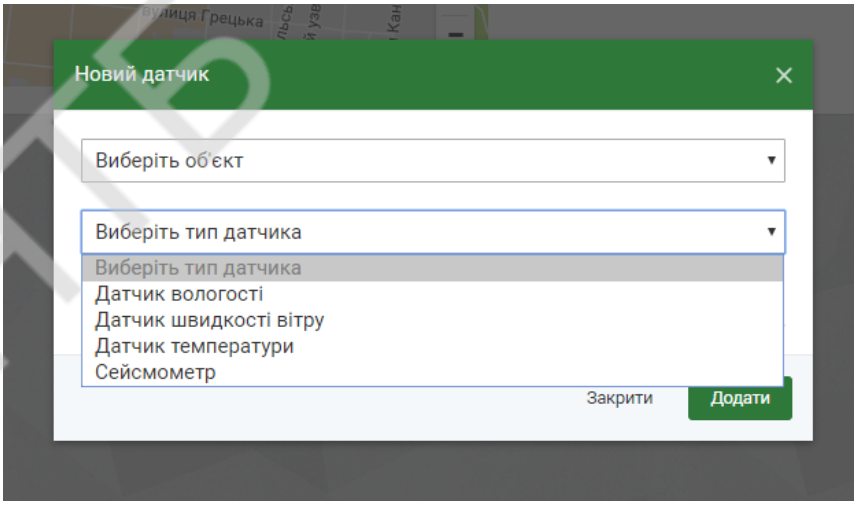

Figure 5 - List of available types of sensors

Each house has its own page that displays all the related information (Figure 6):

– name;
– location;
– description;
– sensors installed in the house.

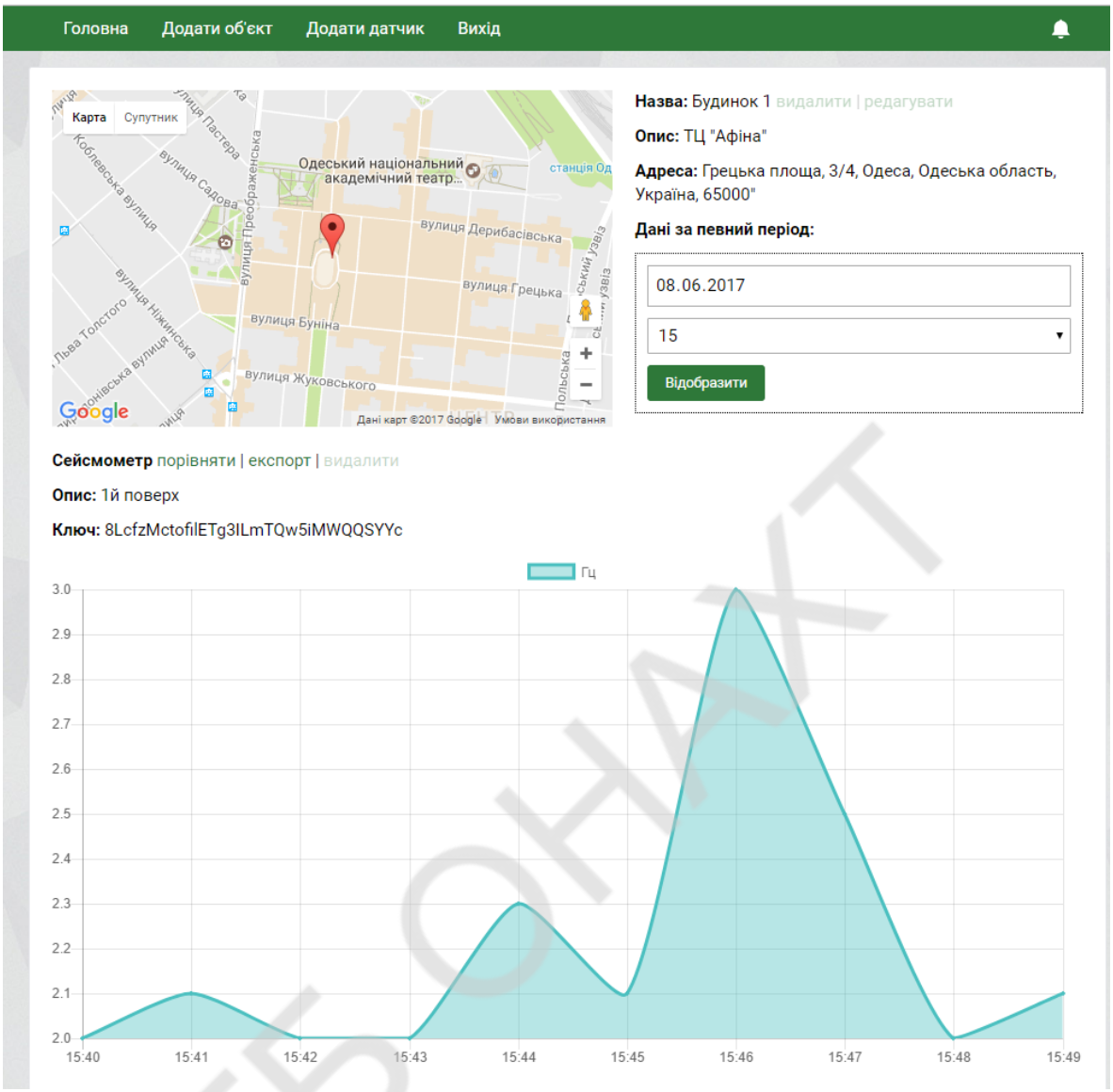

Figure 6 - Home Page Favorites

On the home can edit the required information about it or completely removed. Editing takes place similar to adding a new home in, but the field is automatically substituted the existing data and to prevent accidental deletion when you click "Delete" window appears in which you must confirm.

To view a detailed text message should open messages

To view all messages created a system should click "Show all" in the message window. After you open the system page with all the messages and the date they were created (Figure 7).

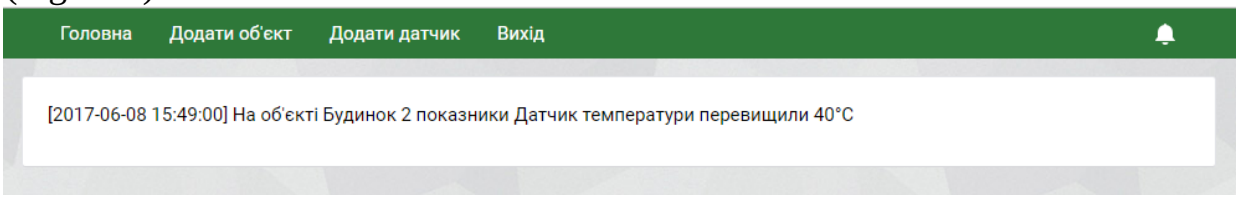

Figure 7 - Page Posts

One of the important features web application is the ability to compare similar sensors installed in different buildings. Often it helps to make the picture complete seismicity of the region, which monitored. For comparison, you must select the first sensor

and press next to his name the "compare". A window appears where you must select the building and its sensor (Figure 8) with which to compare.

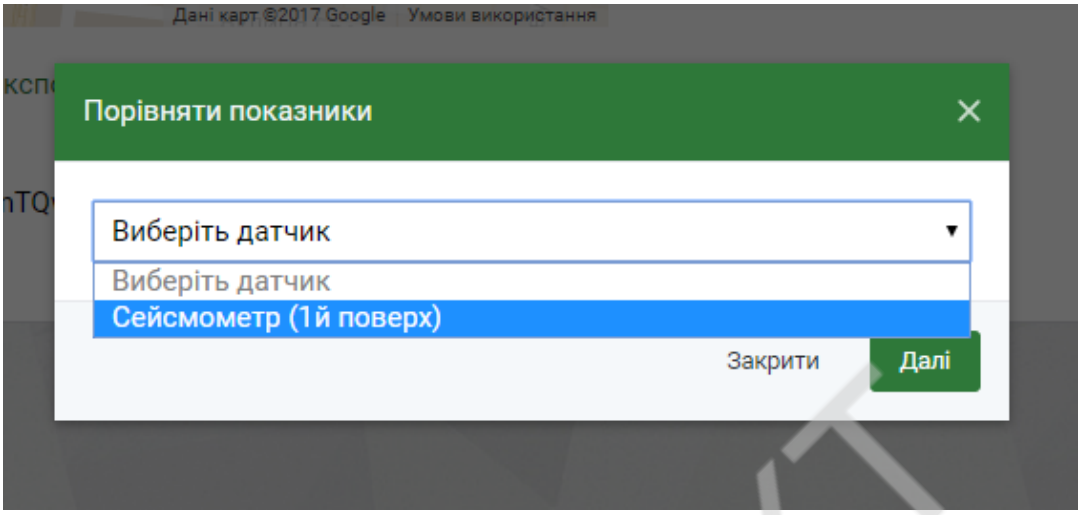

Figure 8 - Select sensor to compare

After selecting the required parameters to compare a window to the schedule, which will be selected performance sensors (Figure 9):

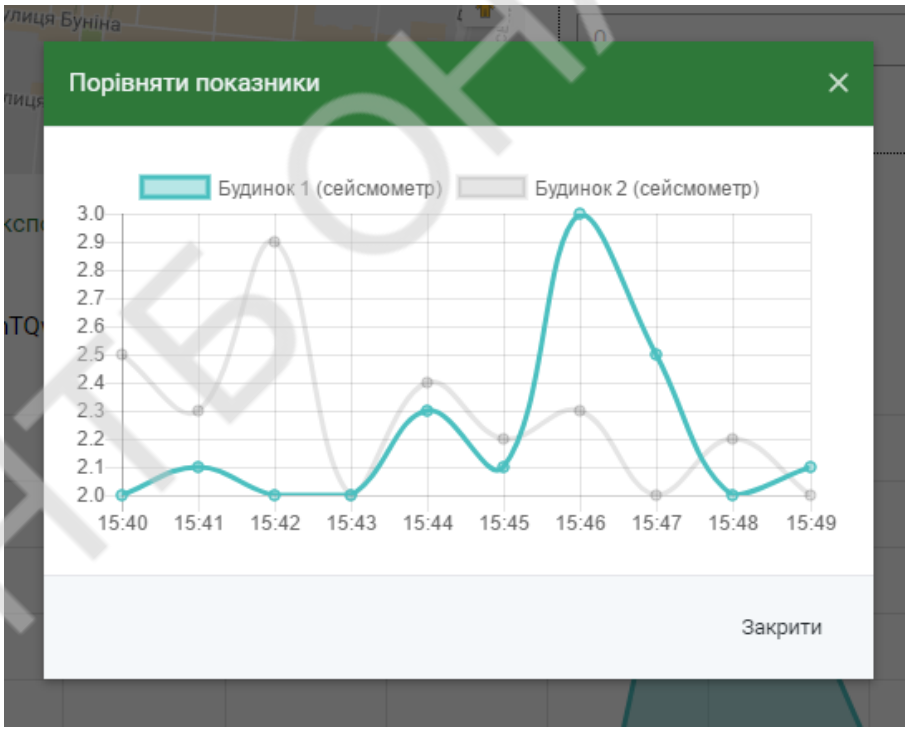

Figure 9 - Comparison of two sensors

The information obtained from the sensor for the required period can be exported into a document format excel, pressed the button "Export" which is the name of the white sensor (Figure 10).

	A	B	C	D	E	F	G	H	I	J	K	L
1		1	2	3	4	5	6	7	8	9	10	
2	Час	15:40	15:41	15:42	15:43	15:44	15:45	15:46	15:47	15:48	15:49	
3	Показники	2	2,1	2	2	2,3	2,1	3	2,5	2	2,1	
4												
5												
6												

Figure 10 - The exported data in Excel document

According waves can postroyity graph that displays the chosen data. On the left panel we can select the sensor, and data that you want to show in the graph (Figure 11). It is also possible export graphics in PNG format image with the choice of its location.

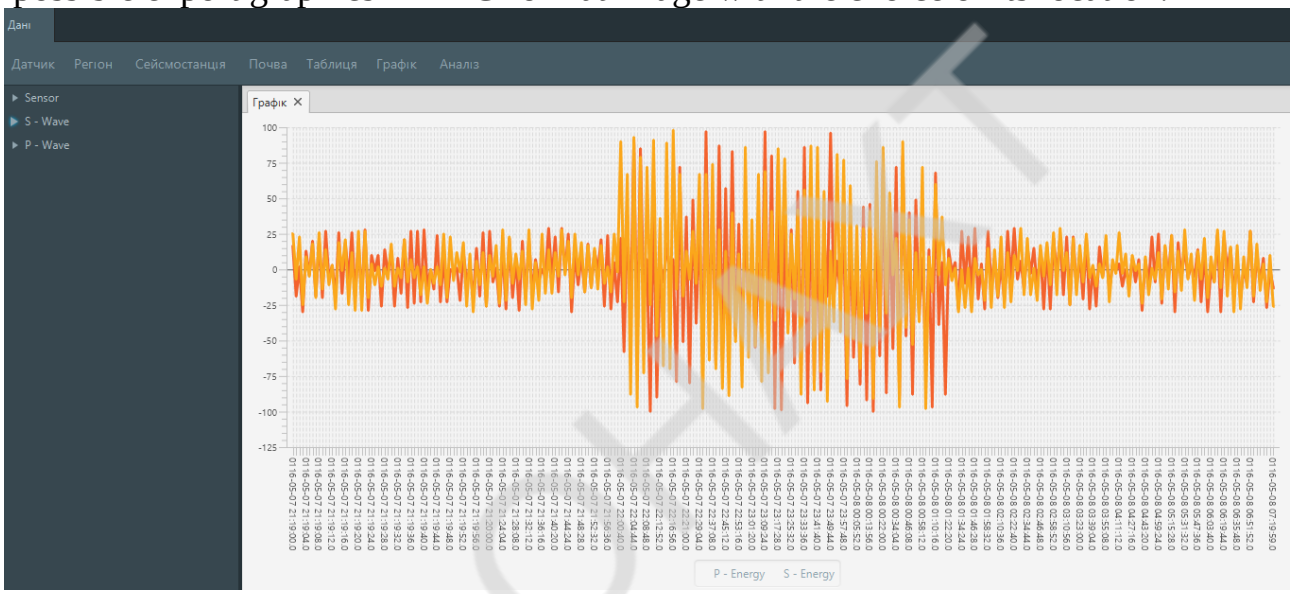

Figure 11 - "Schedule waves with multiple diagrams"

V. Conclusions

The system allows:

• monitor and adapt local seismic situation online;

• assess the potential impact of seismic waves on the stability of the controlled objects;

• timely develop measures to reduce seismic risk, improve security engineering facilities, improving the safety of controlled objects;

• build new buildings increased risk given the necessary margin of safety;

• disseminate experience in preventing man-made effects on other stations.

Automated seismic monitoring provides:

• automatic measurement and registration options fluctuations soil;

• automatic processing and evaluation of signals of seismic events;

• mapping the epicenters of earthquakes;

• automatic generation of instant notifications.

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MODELLING OF THREATS OF ECONOMY DIGITALIZATION

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Abstract.*An analytical review of scientific research of foreign scientists on realization of the digital transformation trend is conducted, as well as on the methodological apparatus for assessing the digital economy development, a series of regulatory acts concerning digital changes in Ukraine and the experience of modelling individual risks of economy digitalization.*

An analysis of scientific literature on the specifics of the interpretation of the definition "digitalization" is carried out. It is generalized that the interpretation of "digitalization" is conditioned by the subject providing the definition, and this leads to ambiguity in the understanding of the concept under study.

It is clarified that digitalization of economy provides effective bilateral interaction of the state, society, business and person by means of digital technologies if all the participants of communication have the appropriate digital competencies.

It is substantiated that the implementation of digitalization into economy creates a number of threats, the main of which is an increase in the level of cybercrime. The main types of cybercrime are defined.

The dynamics of the main threat to the digital economy development – cybercrime – are modelled to optimize the management of economic systems. The statistics show that the growth rate of cybercrime will accelerate.

The main types of cybercrime that will carry the highest risk are foreseen. It is found that the main violations are crimes in the field of payment systems. Preventive activities are suggested.

Keywords: *globalization, digital transformation, digitalization, digital economy, digital technologies, cybercrime, cybersecurity, modelling.*

I. Introduction

Relevance of the topic. The world has entered a new era of digital globalization which is defined by continuous data flows that contain information, knowledge, ideas and innovations. Developed countries, having completed industrialization, are successfully digitalizing their economies, accelerating the development of innovative technologies where artificial intelligence, automation and digital platforms dominate.

The realization of information and communication opportunities and advantages of the latest technologies, the need to acquire leading positions and strengthen the competitiveness of economic sectors in a globalized digital world require the government's prudent policy on digitalization, liberalization of regulation, adaptation of the regulatory framework, stimulation of investment for the digital economy promotion with account for their own traditions and relying on the scientific basis of theories and concepts of economic development.

The information base of the research work includes: official statistical, informational and analytical materials, publications of research institutes, materials of international and regional scientific-practical conferences, scientific works of domestic and foreign scientists and specialists in the field of economy digitalization.

The scientific novelty is the further development of the ideas concerning modelling of economy digitalization.

The practical importance of the received results consists in the developing of tips for preventing problems and risks of the implementation of economy digitalization.

Some ideas of the research are published in the form of conference abstracts:

Rudyk S.A. Modelling of economy digitalization. Materials of the IV student university scientific conference (Vinnytsia, November 12, 2019). Vinnytsia: VTEI KNTEU, 2019. P. 77-79

II. Literature overview

The issues of the digital economy formation, its implications for the society and state, the realization of the digital transformation trend have become the object of scientific research of foreign scientists, experts of the international digital economy and society index [19-23].

In recent years international organizations have been evaluating certain segments of the digital economy, in particular, today there is a sufficient methodological apparatus for assessing the digital economy development: Digital Economy and Society Index, Digital Evolution Index, The UN Global E-Government Development Development Index, ICT Development Index, Networked Readiness Index, E-Participation Index, The Global Innovation Index, Global Connectivity Index.

In Ukraine, the issues of digital changes are implemented in the order of the Cabinet of Ministers: "On Approval of the Concept of Development of the Digital Economy and Society of Ukraine for 2018-2020 and Approval of the Plan of Measures for its Implementation" of January 17, 2018 №67-p [14] and the resolution of the Cabinet of Ministers "Some Issues of Digital Development" of January 30, 2019 №56 [5]. The creation of conditions for the digital economy development is enshrined in the draft law "On the Digital Agenda of Ukraine" [18]. In November 2018, the law of Ukraine "On Electronic Trust Services" came into force, aimed at reforming the regulatory framework

in the field of digital signatures which makes it possible to accelerate the development of the digital economy with compulsory digital participation [13].

Among domestic scientists, O. Vinnyk [2], N. Kraus, O. Goloborodko and K. Kraus [10], V. Lyashenko [12], M. Rudenko [15], N.Tkachuk [2] paid attention to the investigated problems and threats of digitalization [2]. Modelling of individual risks of digitalization is investigated in the works [2, 4, 7-9, 16-17].

However, we believe that further research on modelling of threats of economy digitalization is needed.

III. Object, subject and methods of study

The object of the research is the process of economy digitalization.

The subject is modelling of economy digitalization and threats caused by its development.

The aim of the work is to model problems that may arise in the process of digital transformation of the economy in Ukraine.

To achieve the aim a number of tasks are completed:

- the essence, principles and concepts of the analysis of economy digitalization are investigated;
- basic economic and mathematical models that can be applied to predict the risks of the digital economy, including the rise of cybercrime, are studied and summarized;
- the dynamics of cybercrime as a threat to the development of the digital economy is modelled to optimize the management of economic systems.

IV. Results

In the research of M.Rudenko the multifaceted nature of the category "digitalization" is interpreted from four positions – of the state, scientists, practitioners (entrepreneurs) and the society, since the definition of the foregoing concept varies greatly depending on the scope of its application, the category of people who suggested the definition and the ultimate aim of suggesting it [15].

Economy digitalization is interpreted by scientists T. Yudina and I.Tushkanov in the narrow and broad sense. In particular, in the narrow sense, it means creating at different levels of economy (global, mega, macro, meso, micro, nano) information and digital platforms and operators, due to which various tasks can be solved, including strategic ones: the development of medicine, science, education, transport, new industrialization, state regulation of the economy; in the broad sense it is a change in the nature of industrial or economic relations, a change of their subjective and objective orientation [19]. During the digital transformation, the productive forces of society and (or) factors of production get changed.

Digitalization is saturation of the physical world with electronic and digital devices, means, systems and establishment of electronic communication traffic between them, which actually makes integrated interaction of the virtual and physical possible, i.e. creates cyberphysical space [14].

Society sees digitalization as a completely new paradigm of state development, based on the day-to-day and ubiquitous use of digital technologies with digital competencies being necessarily available, which will bring about revolutionary changes and formation of the digital society.

The analysis of the scientific literature suggests that the specificity of the interpretation of the definition "digitalization" is conditioned by the subject providing the definition, which causes ambiguity in the understanding of the concept under study and emphasizes the controversy of certain provisions and statements.

Economy digitalization provides effective bilateral interaction between the state, society, business and person by means of digital technologies, if all the participants of communication have the appropriate digital competencies.

The digital economy is inextricably linked to the existence of the information society. The term "information society" is based on the statement that quantitative changes in the sphere of information have led to the emergence of a qualitatively new type of social order – the information society.

According to D. Lyon, the main characteristics of the information society are as follows:

- in the technical sphere – implementation of information technologies into all spheres of production, economic and business life, into the system of education and everyday life;
- in the social sphere – under the influence of information a new, information consciousness is formed, the quality of life is changing;

• in the economic sphere – information turns into a major resource, becomes a source of added value and employment;

• in the political sphere – freedom of access to information is the basis of the political process, of the principles of pluralism and democracy;

• in the cultural sphere – formation of appropriate norms and values that meet the requirements of an individual and democracy [11].

Digitalization should be seen as a tool, not a goal in itself. Under a systematic state approach, "digital" technologies will stimulate the development of an open information society as one of the essential factors for increasing productivity, economic growth, job creation, and improving the quality of life of Ukrainian citizens [18].

“Digital” technologies are necessary to increase the efficiency of Ukrainian industry, and in some sectors they are becoming the basis of product and production strategies. Their transformative power changes traditional business models, manufacturing chains and leads to the emergence of new products and innovations. Digitalization has a positive social character for Ukraine, as it focuses on improving of the quality of social security infrastructure, quality of social services, organizing of transparency and targeting of social assistance, and reducing costs [18].

Digitalization is rapidly penetrating into the daily lives of people as well as providing new opportunities for all sectors of the economy of Ukraine in terms of modernization of working and management methods, changing manufacturing cycles and logistics.

A significant problem that appeared with the onset of digital transformation and will intensify over time is cybercrime. Scientists conditionally divide computer crimes into two main groups according to the classification attribute of the category of access to computer equipment: 1) internal users; 2) external users, where the user is the subject that accesses the information system or the intermediary to obtain the information he needs to use [6].

Simultaneously with the spreading use of Internet technologies, the threat of violations aimed at hacking, theft of personal information, blocking of information

services, blackmail, fraud etc. is proportionally increasing. This is due to a number of reasons, including increased trust in electronic data processing tools, expansion of the range of subjects involved in information relations in the global network, increased number of various services, transition to servicing of banking institutions. Various schemes are being spread on the Internet today, aimed at obtaining money from inexperienced and trusting users of online stores, virtual auctions, dating sites and more. Usually, this type of fraud is used by websites that resemble well-known international resources visually and by name. However, unlike well-reputed brands, you can hardly expect to get a product ordered or a refund from them. The reason for using such resources is the desire to get an order at an extremely low price. Sometimes, violators also use the opposite qualities of a person, creating a dummy site for a charitable foundation or boarding school [6].

With the spread of technologies, the nature of crimes has changed. Previously, most of them were plastic card frauds, but now there is a real boom in the field of online payments. The most professional hackers have already turned to thievery through client-banks (remote banking systems). Card fraud takes second place, whereas the number of thefts from company accounts or e-wallets is increasing [18].

Determining the current state of cybercrime in Ukraine, we can note that it, like any other social phenomenon, is subject to the prediction with the help of certain indicators that reflect its quantitative and qualitative characteristics. Such assessment and modelling can be done through the analysis of such indicators of cybercrime prevalence in Ukraine as: its level, geography, structure, dynamics, etc.

Concerning the level of cybercrime and its dynamics it should be noted that in 2009 there were 217 crimes registered in Ukraine in the field of use of electronic computing machines (computers), systems and computer networks, and telecommunication networks, in 2010 – 190, in 2011 – 131, in 2012 – 138, in 2013 – 595, in 2014 – 443, in 2015 – 598, in 2016 – 865, in 2017 – 2573, in January-August of 2018 – 1885 crime cases (Fig.1).

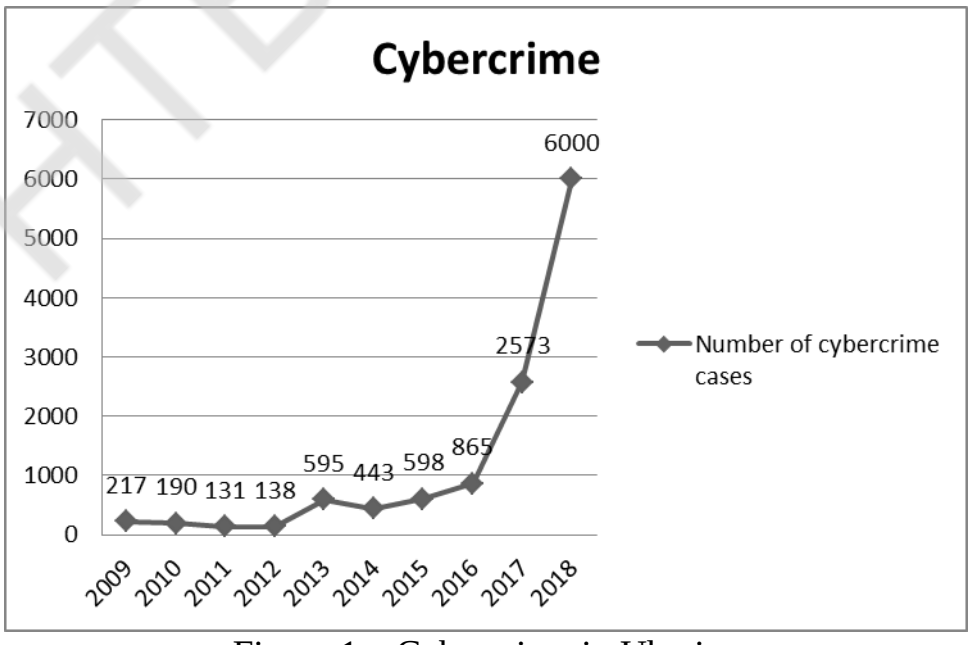

Figure 1 – Cybercrime in Ukraine

The proportion of cybercrime in the total number of registered crimes is 0.05% of the total number of registered crime cases in 2009, 0.04% – in 2010, 0.03% – in 2011, 0.03% – in 2012, 0.11 % – in 2013, 0.08% – in 2014, 0.11% – in 2015, 0.15% – in 2016, 0.49% – in 2017 and 0.51% of crimes reported in January-August of 2018 (Fig.2) [9].

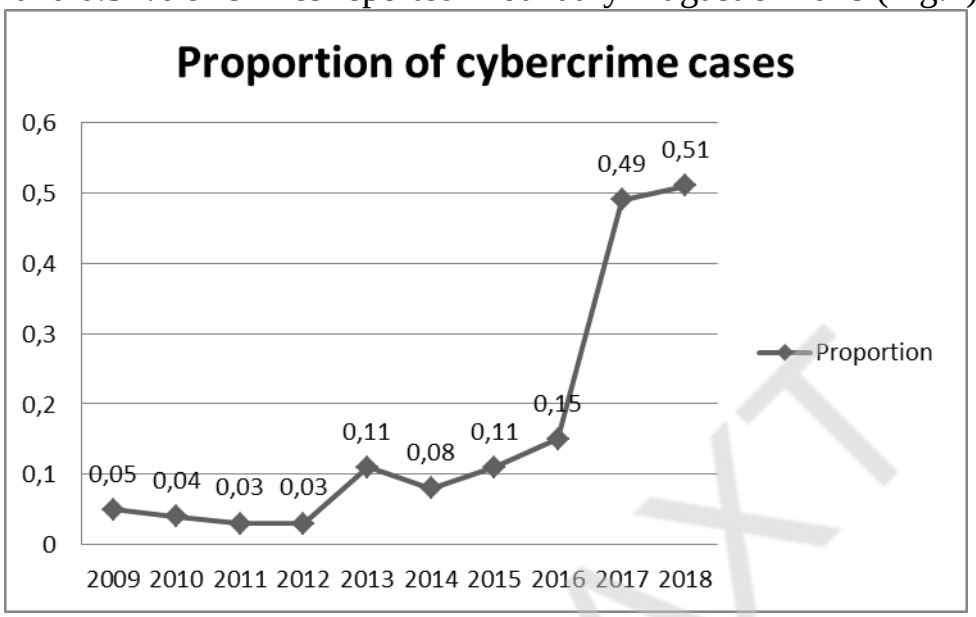

Figure 2 – Proportion of cybercrime cases

A significant increase in the number of cybercrimes registered in 2013 is attributed to the fact that "the increase of this type of crime is caused by the annual growth of the number of Internet resource users in Ukraine" [7].

As we can see from the obtained statistics on crime, theres is a significant positive increase in cybercrime (Fig.3).

Taking into account the determination coefficient (R^2), we can come to the conclusion that this prediction may be considered reliable.

Another equally important step is to identify the types of cybercrime that will carry the greatest danger. For this the method of ABC analysis is used in the research.

To solve this problem an ABC analysis is conducted by the sum method on the basis of the report of Cyber Police of Ukraine concerning cybercrime cases during 2018.

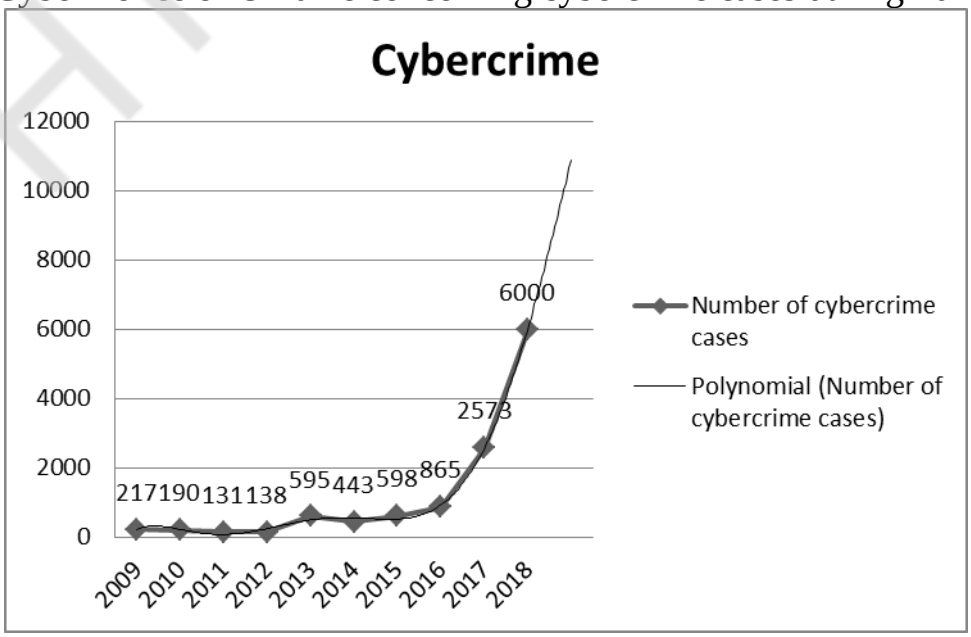

Figure 3 – Cybercrime forecasting in Ukraine

The results are summarized in the table (Fig. 4).

Cybercrime	Number	Factor share in the sum of factor values according to the data [8]	Increasing value of OS*, %	Increasing value of OC*, %	Sum of OS and OC, %	Group
in the field of payment systems	2398	39,96000667	39,9600067	25	64,9600067	A
in the field of e-commerce	1598	26,62889518	66,5889018	50	116,588902	B
in the field of cybersecurity	1325	22,07965339	88,6685552	75	163,668555	B
in the field of illegal content	680	11,33144476	100	100	200	C

Figure 4 – ABC analysis of cybercrime cases

OS* – share of the object from the total number
OC* – contribution of the object to the total result

Figure 5 presents the ABC curve that graphically interprets the division of cybercrimes into groups.

Summarizing the obtained results, we can note that the most vulnerable is the field of payment systems. The implementation of countermeasures in it can reduce the number of cybercrimes by almost 40% of all possible.

We believe that digitalization of economy will increase cybercrime growth. After all, most of the population, institutions, companies and organizations will start to switch to full digital support, that is, they will store basic information in the digital space and on servers.

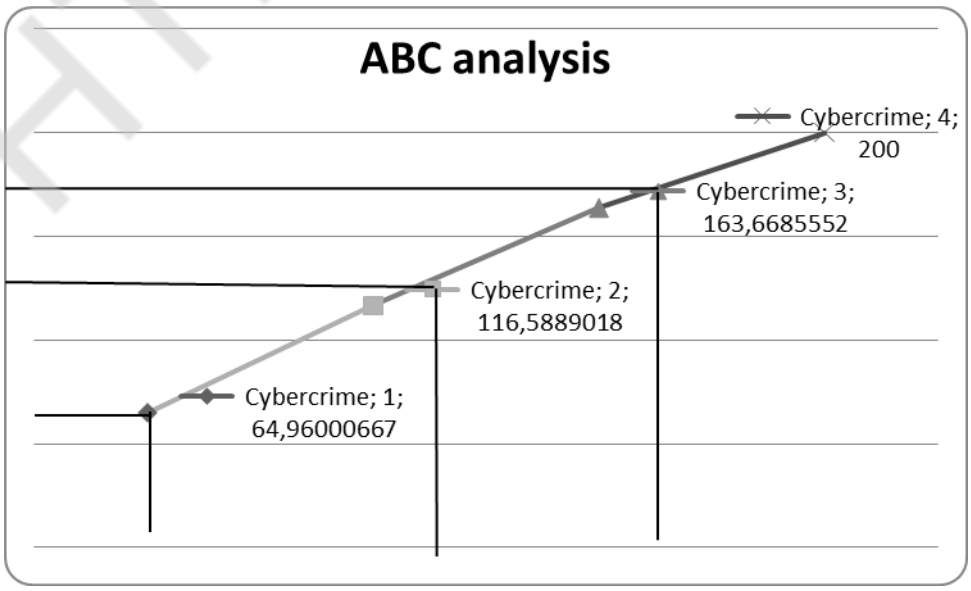

Figure 5 – Graphic result of ABC analysis

Nowadays Ukraine is actively fighting this problem, an authorized body – the Cyber Police of Ukraine – has been created. At present, it performs such functions as: implementation of state policy in the sphere of countering cybercrime; early informing of the population about the emergence of the latest cybercrimes; implementation of software for systematization and analysis of information concerning cyber incidents, cyber threats and cybercrimes; responding to requests from foreign partners coming through the channels of the national round-the-clock network of contact points; participation in further training of police officers on the use of computer technologies in countering crime; participation in international operations and cooperation in real time; support of the activities of the network of contact points between 90 countries of the world; countering cybercrimes.

For the future we propose to improve Ukraine's national system of cybersecurity, so that it could:

- provide a front line of defence against cyber threats by increasing general situational awareness of incidents, vulnerabilities and threats in public institutions, at critical infrastructure objects and in the public segment;
- prevent intrusion by sharing information and implementing countermeasures that can reduce current vulnerabilities;
- protect against the full range of threats by enhancing counterintelligence and intelligence capabilities;
- strengthen cybersecurity through educational, media civic initiatives;
- encourage and provide cybersecurity trainings, research and development in the field of cybersecurity.

So, having modelled the implementation of digitalization into the economy, we can conclude that Ukraine will suffer from an increase in cybercrime.

With the total economy digitalization, the growth of cybercrime will accelerate, so, according to our forecasts, in 2019 the number of cybercrime cases can reach the mark of 9000. The main violations among them are crimes in the field of payment systems (about 40%). Therefore, security measures have to be improved in this sphere to reduce cybercrime.

Improving of e-commerce security and cybersecurity (countering sellers, coders, stealing databases, etc.) also remains urgent.

V. Conclusions

The analysis of the scientific literature suggests that the specificity of the interpretation of the definition "digitalization" is conditioned by the subject providing the definition, which causes ambiguity in the understanding of the concept under study and emphasizes the controversy of certain provisions and statements.

Digitalization makes it possible to accelerate innovation, support start-ups, teach the basics of programming to everyone interested, implement digital technology into the branches of economy. The implementation of all conditions mentioned above will increase the productivity of the entire economic system of the state and gain additional competitive advantages in the globalized digital world.

Digitalization of the economy provides effective bilateral interaction between the state, society, business and person by means of digital technologies, if all the participants of communication have the appropriate digital competencies.

In our research we substantiated that the implementation of digitalization into economy causes a number of problems and risks, the main of which, in our opinion, is an increase in the level of cybercrime.

The implementation of digital and information technologies into everyday life and economy causes a gradual increase in cybercrime, as evidenced by the results of our research.

With the total economy digitalization, the growth of cybercrime will accelerate, so, according to our forecasts, in 2019 cybercrime can reach the mark of 9000.

The main violations among cybercrimes are crimes in the field of payment systems (about 40%). Therefore, security measures have to be improved in this sphere to reduce cybercrime.

Improving of e-commerce security and cybersecurity (countering sellers, coders, stealing databases, etc.) also remains urgent.

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ROBOTIC PLATFORM FOR SMART SURVEILLANCE AND MANAGEMENT

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Abstract. *Goal of this project is the research and development of an agent for a distributed Smart Surveillance and Building Management system. It consists of a set of modules that are providing a base platform for a variety of on-ground robotic designs specialized in different fields of Intelligent Surveillance. This system is designed to apply best practices of robotic hardware design in connection with agile software to the system as well as stay as cheap and secure as possible in order to offer enthusiasts an ability to design and build their concepts in a faster and cheaper way.*

Keywords: *distributed systems, multiagent systems, Smart Surveillance, robotics*

Introduction

Nowadays a strong tendency is noticed in replacing human on dangerous, trivial, and repeating job, with robots that are designed to be able to survive the environment and accomplish the task successfully. Right now, almost all heavy industrial giants are using robots with or instead humans as it results in higher speed, better quality, lower cost and as a result an increased efficiency and bigger income.

This note describes the problem in applying heavy industrial experience to the industry of security and surveillance, in order to minimize human activity and, as a result, human error and risk.

Modern surveillance and management systems are consisting of set of sensors and actuators that can control all the systems in the building only under human maintenance. There are still risky jobs that are occupied by people such as security guard and cleaner. The idea of applying agent-based intelligent system is to cover all the needs of the building in such trivial and repetitive actions and in addition move people out of risk zones. For example, it is common practice to supply risky jobs with an insurance, however with such system applied, company will decrease insurance budget and worker will occupy a safer job.

Different jobs in maintenance are easily decomposed on basic scenarios such as patrol, localization, navigation, report etc. While some of them such as mentioned reporting duty require just a PC and a reporting software, most of the duties are based on continuous movement to the places that require attention, as patrolling, or on searching for things of interest which include localization and patrol. This is where mobile robotics are to be used.

To be a full replacement of a person as a surveillance worker, robot must apply such conditions:

1. Robot is to have same or bigger movement velocity and human-comparable velocity controller
2. Robot is to have a stable connection to the operator in order to support override in case of trouble

3. It should be designed in accordance to the environmental challenges it is to meet on duty

4. Robot is to have basic sensors that are replacing human perception at a level required for this duty.

As for the system which is to maintain the location and perform surveillance there are such tenets:

1. System should be agile to new devices, such as sensors, robots, cameras, and operator consoles

2. It is to provide a secured communication of all nodes that are involved into process

3. It is to be supplied with a standardized API for different subsystems in order to freely integrate with other systems such as Access Control System or Customer Relationship Management system.

4. It should be based on a standard architecture both for the hardware and the software and have minimal changes from it.

As it is aimed for enthusiasts too, its platform is to have a reliable community of professionals that are interested in supporting it.

Literature analysis

Smart Surveillance

As it is stated in the literature, Smart surveillance, is the use of automatic video analysis technologies in video surveillance applications.[1]

There are various applications for it such as [1]:

1. Real time alerts.
a. User defined alerts.
b. Class specific alerts.
c. Behaviour alerts.
2. High value video capture.
a. Automatic Unusual Activity Alerts.
3. Automatic Forensic Video Retrieval.
a. Spatio-Temporal Video Retrieval.
b. Surveillance Video Mining.
4. Situation Awareness.

The architectures implemented are usually divided as [1]:

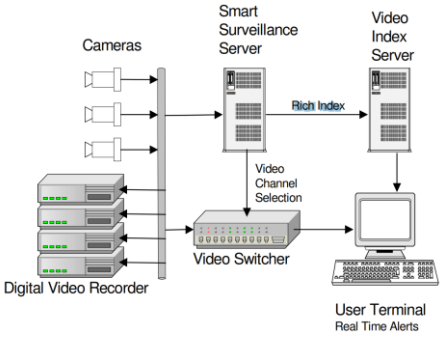
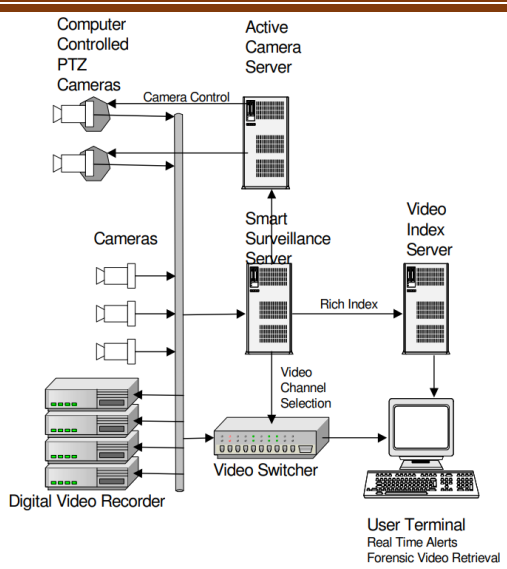


Fig.2 Structure of ASSA system.



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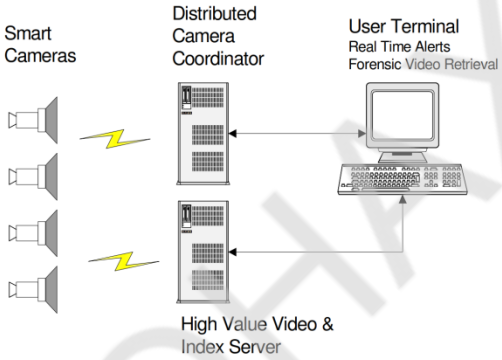


Fig.3 Structure of DSSA system.

Smart Maintenance

Smart maintenance is about leveraging new technology such as mobile solutions, big data applications and IoT, to ensure that all the equipment required for production always operates at 100% efficiency. In today's highly competitive market, you must deliver high-quality products quickly and cost-effectively.[2-4]

In addition to maximizing uptime, smart maintenance helps to[2-4]:

- Increase productivity

The productivity at your company soars, as machines are always up and running. Thanks to insights on how to maintain or repair equipment, service technicians work more efficiently too.

- Reduce maintenance costs

Poorly scheduled maintenance and the resulting downtime are costly. By smartly balancing preventive and predictive maintenance, you'll reduce costs for components and labor.

- Extend equipment lifetime

Clear insights into the condition of your machinery/equipment and well-scheduled maintenance and repairs are sure to lengthen the lifetime of your equipment.

- Ensure compliance

The reporting features and procedures enabled by smart maintenance solutions help you easily comply with all maintenance-related standards, such as the ISO55000 standard.

- Enhance safety and cut energy consumption and CO2 emissions

By timely monitoring and fixing potential problems, your employees work under safer conditions. Moreover, advanced tools can help cut energy consumption while reducing CO2 emissions.

Multi agent systems

An agent is a computer system located in the environment and can function autonomously in this environment to achieve their design goals [8].

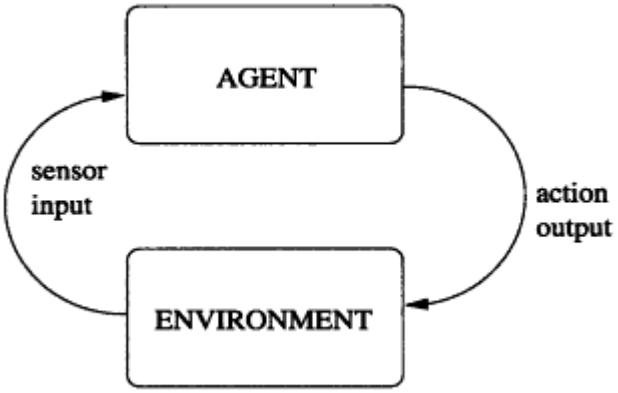


Fig.4 An agent in its environment.

The agent takes sensory input from the environment and produces as output actions that affect it. The interaction, as a rule, lasts, does not stop.

Figure 4 gives an abstract view of the agent. In this chart we can see the result of an action generated by an agent to influence it environment. In most areas of reasonable complexity, the agent will not have complete control over his environment. It will have a partial at best control because it can affect it. In terms of the agent, this is means that the same action was performed twice in the outwardly identical circumstances may have quite different consequences, and this may not have the desired effect. Therefore, agents must be prepared in environments other than the most natural ones for failure. We can formally summarize the situation by saying this environments are generally considered non-deterministic [6]. Typically, the agent performs various actions available to him. This set is possible actions represent his ability to change his environment. Please note that not all actions can be performed in any situation. For example, the "lifting the table" action is only applicable when the weight of the table is small enough for the agent to lift it. Similarly, the "buy Ferrari" action will be unsuccessful if no amount of money is available. Therefore, operations have the preconditions that determine the possible situations in which they can be applied. The main problem an agent faces is deciding what actions he needs to take to best meet his design goals. Agent architectures are really software architectures for decision-making systems that are built into the environment [7].

Control system can be viewed as an agent. A simple example of such a system is a thermostat. Thermostats have a sensor for detecting room temperature. This sensor is embedded directly in the environment (i.e. the room), and it produces as output one of two signals: one that indicates that the temperature is too low, another which indicates that the temperature is OK. The actions available to the thermostat are “heating on” or “heating off”.

The action “heating on” will generally have the effect of raising the room temperature, but this cannot be a guaranteed effect - if the door to the room is open, for

example, switching on the heater may have no effect. The (very simple) decision making component of the thermostat implements (usually in electro-mechanical hardware) the following rules [6,7,9]:

- too cold - heating on,
- temperature OK - heating off.

More complex environment control systems, of course, have considerably richer decision structures. Examples include autonomous space probes, fly-by-wire aircraft, nuclear reactor control systems, and so

on [6].

Main conditions of agent's intelligence [8]:

- Reactivity. Intelligent agents can perceive their environment, and respond in a timely fashion to changes that occur in it in order to satisfy their design objectives.
- Proactiveness. Intelligent agents can exhibit goal-directed behavior by taking the initiative in order to satisfy their design objectives.
- Social ability. Intelligent agents can interact with other agents (and possibly humans) in order to satisfy their design objectives.

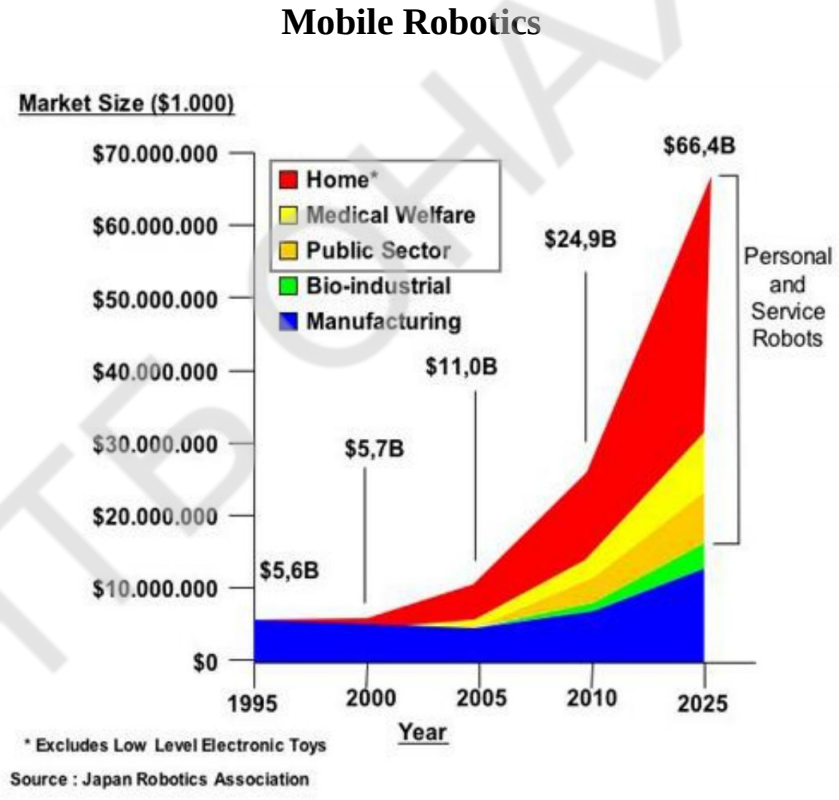


Fig. 5 Market Size of the Personal and Service Robots

A mobile robot is a vehicle which is capable of an autonomous motion. The autonomous mobile robots are very interesting subject both in scientific research andpractical applications. Figure 5. show the recent situation and the future of the marketsize of the personal and service robots (source: Japan Robotics Association).[10]

Indoor/Structured Environments
Cleaning large buildings
Transportation industry and service
Research entertainment
Surveillance buildings
Customer support museums, shops

Table 1. Indoor applications of mobile robots

Outdoor/Unstructured Environments
Agriculture
Forest
Space
Underwater
Military
Fire fighting
Sewage tubes
Mining

Table 2. Outdoor applications of mobile robots

The structure of the general indoor/outdoor applications of autonomous mobile robots are presented in Table 1 and Table 2:[10]

Object, subject and methods of research

Mobile Robotic Platform

Kinematics

Kinematics is the a branch of classical mechanics that deals with points , bodies and a system comprising of different bodies without considering the forces acting on each .

There are two main methods used :

Forward kinematics : Measuring or finding the current position of the robot.

Inverse kinematics : Using the goal position coordinates , find actions needed to reach goal position.

What is kinematics used here for?

To localize the rigid body (being our robot here) in 3D space , while having a reference coordinate associated to it .

The reference here being is the coordinates of the robot itself.

The reference coordinate system is defined by three coordinate values, position in the x axis , position in the y axis and its angle from the centerline of the robot.

To find our position in the Cartesian plane, we use a concept called Odometry .

Odometry

Usually uses encoders to measure wheel or angle of rotation, as well as wheel orientation .

Here two equations are used to find left wheel and right wheels displacements:

DL=2r/C*NL

DR=2r/C*NR

In this case to find the linear displacement of the robot it is enough to find to use the average of both wheels displacements i.e.

D=(DR+DL)/2

Control

A Control Systems Engineer is responsible for designing, developing, and implementing solutions that control dynamic systems. Dynamic systems are systems that constantly change. The aim of a Control Systems Engineer is to bring stability to these constantly changing systems to produce the desired outcome.

Two main types of control systems are used :

Open loop systems : Where the controller controls the actuator using the input value given , without having any feedback fed into the input. An example would be a washing machine or light switches.

Closed loop systems : The controller controls the actuator using a constantly changing input value because of the feedback which takes into account the error. An example is an air conditioner.

This system is controlled in a closed loop using data from motors' encoders and apply force calculated by PID controller counting in Proportional, Integral, and Derivative errors.

PID controller

A PID controller is an instrument used in industrial control applications to regulate temperature, flow, pressure, speed and other process variables. PID (proportional integral derivative) controllers use a control loop feedback mechanism to control process variables and in cooperation with fuzzy logic provides a stable and easy way of control.

Proportional (P) Control: It increases the speed of the response of the system and add stability to a certain point. Furthermore, it decreases steady state error.

Integral (I) Control: It destabilizes the transient region and eliminates the steady state error. Furthermore, it introduces robustness to external disturbances.

Derivative (D) control: It increases stability by decreasing oscillations in the system which is basically damping action. The downside of Derivative control is that it does not affect the steady state error.

In this system, we have used Ziegler-Nichols rule for tuning the PID control. This method allows to find proportional, Integral, and Derivative gain based on the transient response of the plant which in this case is our Robot. After several experiments we were able to get PID controller values which gave us the desired result.

The disadvantages of this Ziegler-Nichols method was that its very time consuming and introducing oscillations in the system was putting motors of the Robot at risk.

Usage in Smart Surveillance and Maintenance

There are lots of successful of implementing robotics in surveillance and maintenance system such as Project "STOP". It was implemented by a company INGENIARIUS LTD in

Portugal for Auchan corporation as a complex solution of robots, servers and sensor networks connected in one system[5].

Figure 6 INGENIARIUS team with the Project "STOP"

Results

As project is still in progress there is much things to do but for now there are already completed tests and simulations of the designed model:

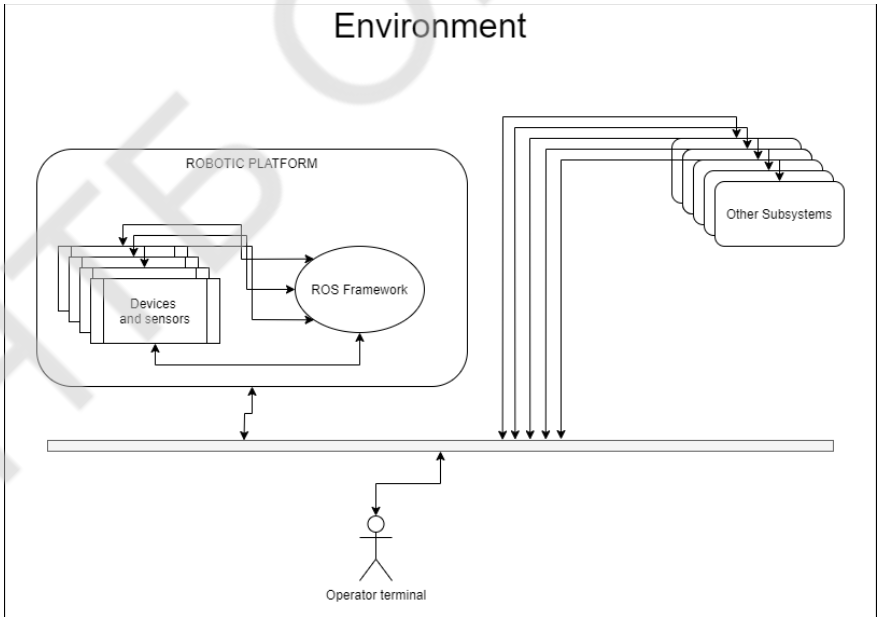
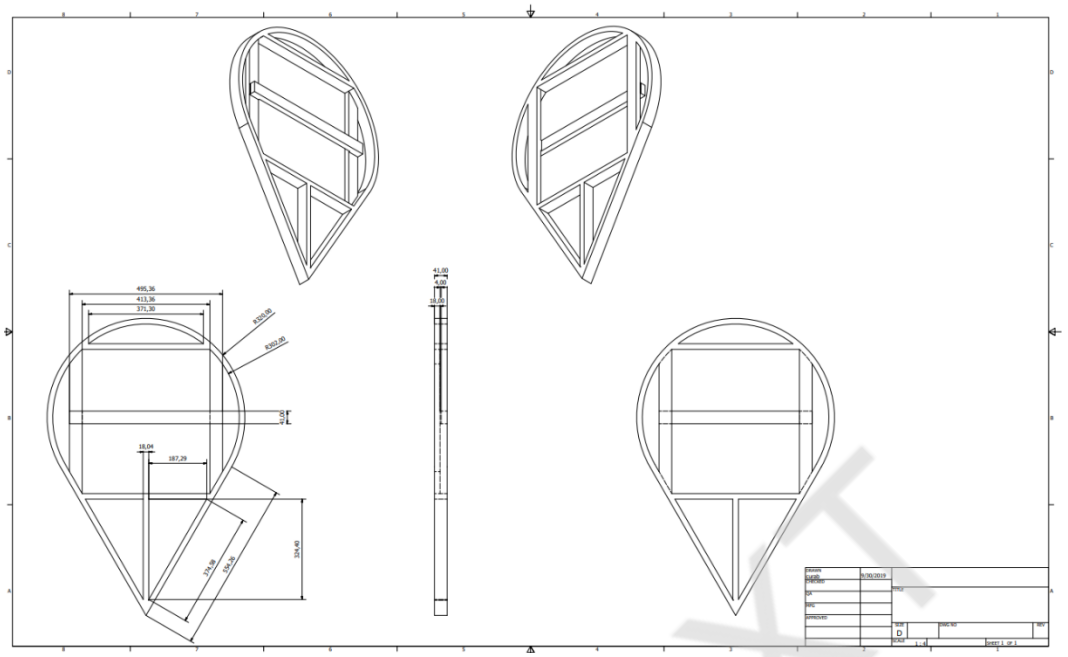


Figure 7 The Environmental diagram

There is an ongoing assembly of first platform which aim is to clarify for us the existing problems in design and architecture. Figure 8 shows a basement of the robotic platform which is made of steel to survive different tests but can be replaced with the appropriate material as well.



Pictures 1 also shows it in real world:

Conclusion

The result of this research is creation of a new open and cheap mobile robotic platform that can be used for designing robots that are to replace people at their jobs in surveillance and maintenance industry.

As this platform is mobile it allows to provide patrolling, localization and navigation services as well as assist in escort.

Its interior architecture and design provide an ability to connect mostly all the needed sensors and actuators used in indoors and outdoors environment.

As for the community, it consists of numerous universities and colleges all around the world. It is easy to find help during design and maintenance of the robots.

This development is highly demanded in facilities with big amount of repetitive routines that demand no intellectual work. After a short description a big IT company that supplies systems to corporations became interested in it.

As it was said this system main goal is to increase savings and quality of surveillance and maintenance of the companies, as well as remove people from doing repetitive unintellectual jobs.

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