

Ministry of Education and Science of Ukraine

*Odessa National Academy  
of Food Technologies*



International Competition of Student Scientific Works

**BLACK SEA SCIENCE 2020**

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2020

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**Black Sea Science 2020:** Proceedings of the International Competition of Student Scientific Works. Information Technology, Automation and Robotics. / Odessa National Academy of Food Technologies; B.Yegorov, M. Mardar, S.Kotlyk (editors-in-chief.) [*et al.*]. – Odessa: ONAFT, 2020. – 365 p.

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ROBOTIC PLATFORM FOR SMART SURVEILLANCE AND  
MANAGEMENT

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НАТБ ОНАХТ

## 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]:

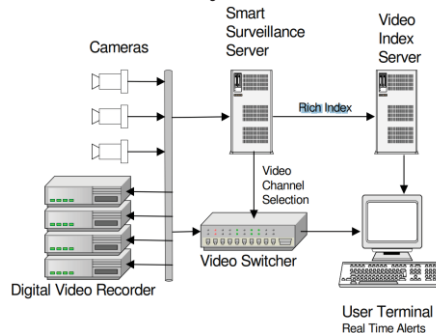


Fig.2 Structure of ASSA system.

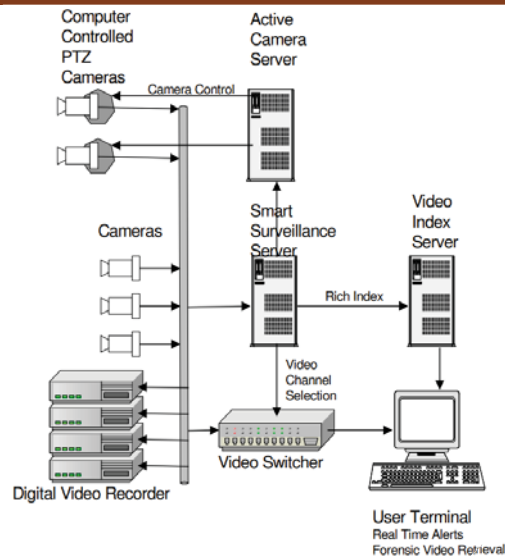


Fig.2 Structure of ASSA system.

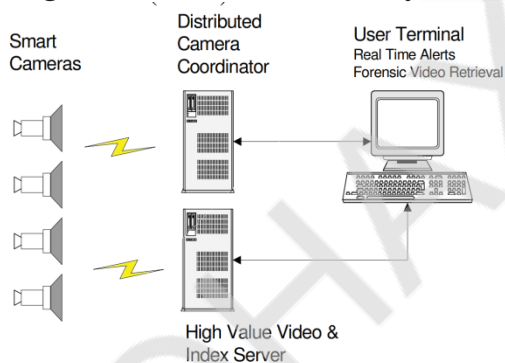


Fig.3 Structure of DSSA system.

### 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].

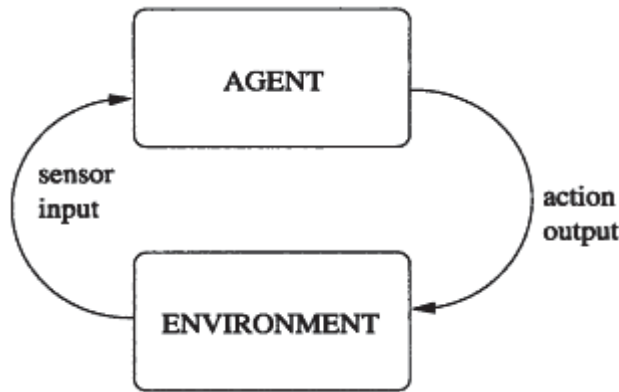


Fig.4 An agent in its environment.

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.

### Mobile Robotics

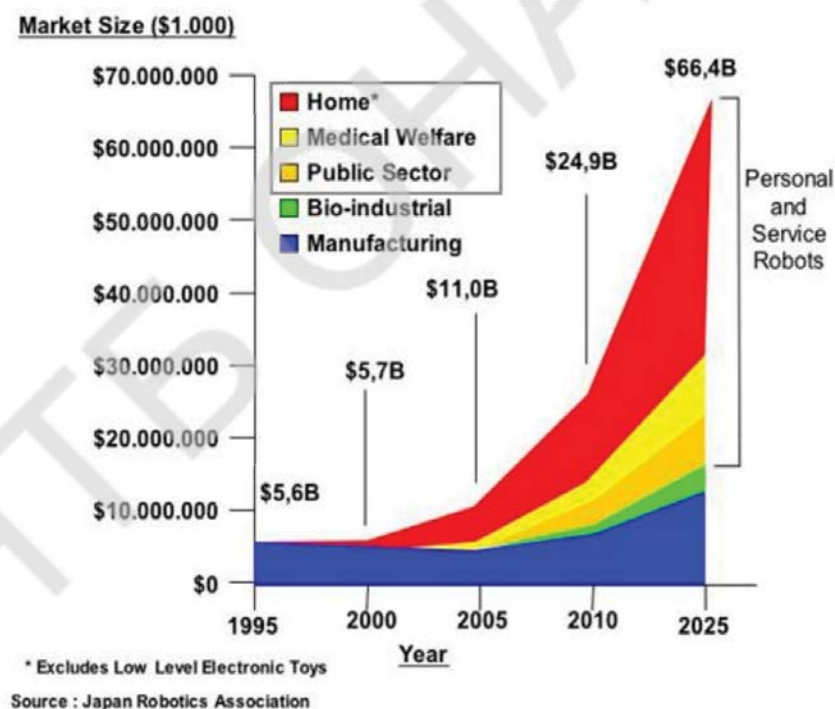


Fig. 5 Market Size of the Personal and Service Robots

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 and practical applications. Figure 5. show the recent situation and the future of the market size of the personal and service robots (source: Japan Robotics Association).[10]

<p><b>Indoor/Structured Environments</b>                  Cleaning large buildings                  Transportation industry and service                  Research entertainment                  Surveillance buildings                  Customer support museums, shops</p>
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Table 1. Indoor applications of mobile robots

<p><b>Outdoor/Unstructured Environments</b>                  Agriculture                  Forest                  Space                  Underwater                  Military                  Fire fighting                  Sewage tubes                  Mining</p>
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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:

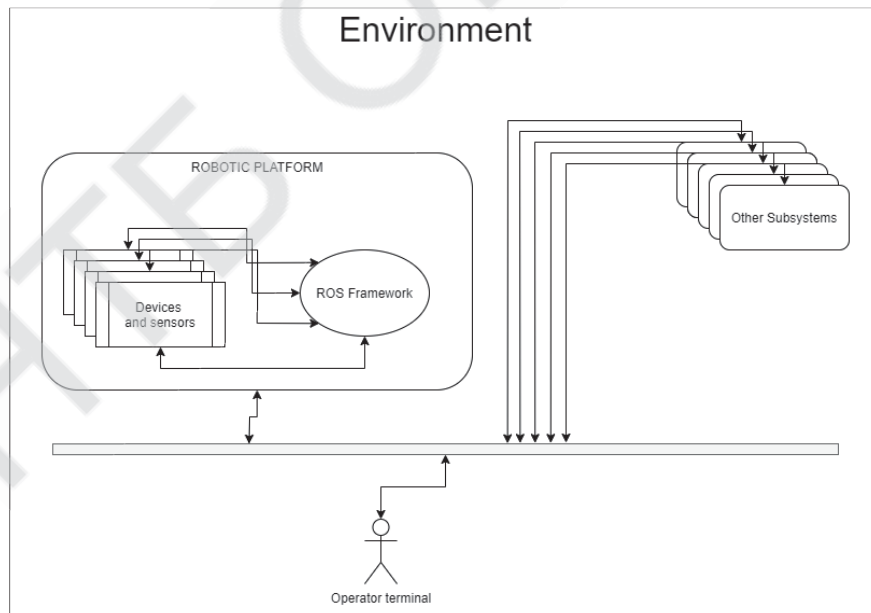
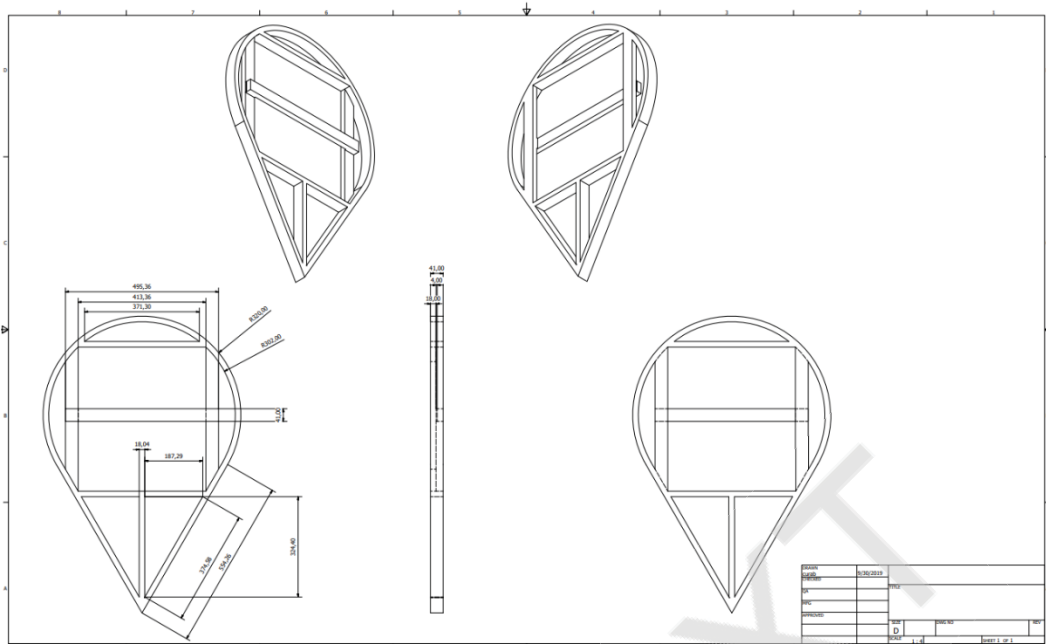


Figure 7 The Environmental diagram

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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