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

UDC 004.01/08

Editorial board:

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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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

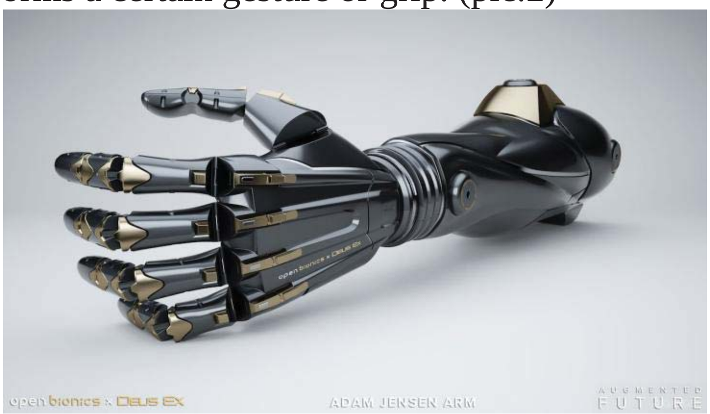
Pluses:	Minuses:
Aesthetic appearance Fingers can be put in the desired position due to the fact that they are made on metal fittings Possibility of use in a humid environment (unlike mechanical and electrical)	Almost complete lack of ability to perform any manipulations The fittings wear out quickly 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.

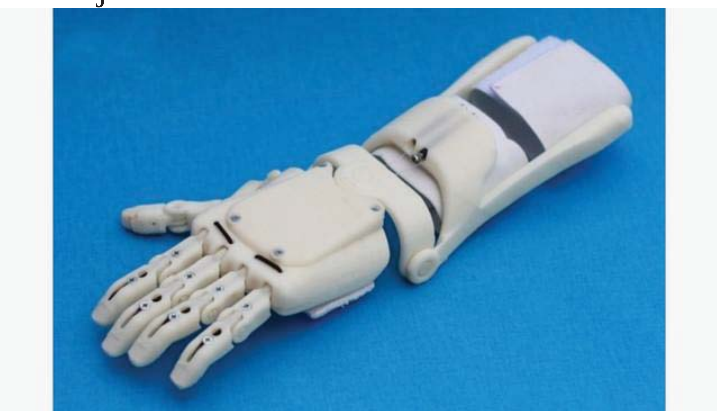
These are active manipulators controlled by the physical forces of their own body. The motor function of the prosthesis is carried out by means of a traction bandage. The advantages of this type are simple mechanics, the possibility of prolonged contact with water and low prices for prostheses of the 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

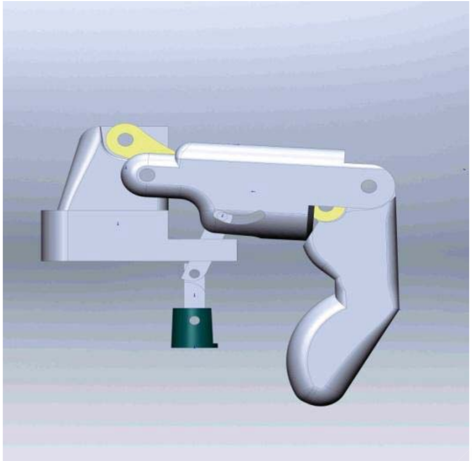
3.2. Drive Type Selection

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

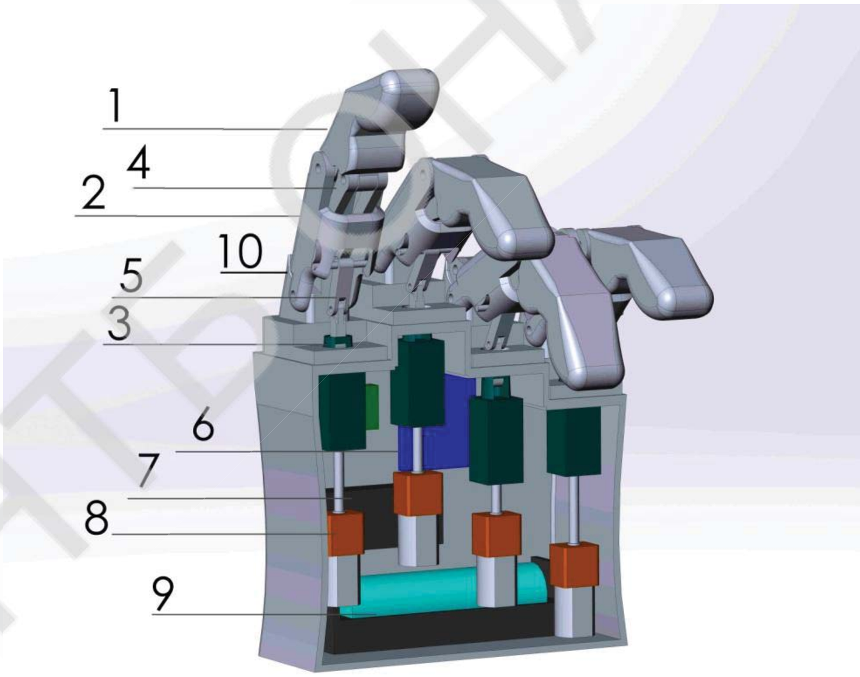
The selected device diagram is five-finger. Each finger consists of two phalanges that are interconnected on one axis, also a spring is fixed on this axis, which provides the finger with reverse movement (fixes it in the upper position 1).(Pic.5)

Pic.5 Position 1



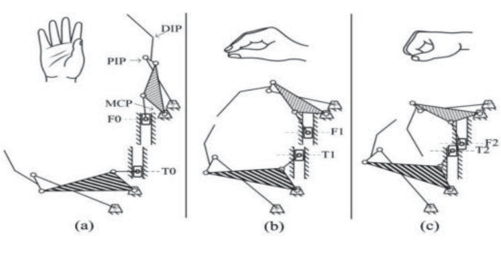
Puc.6 Position 2

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.

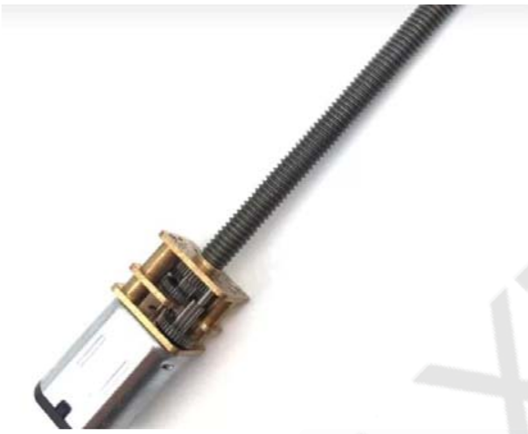


Kinematic diagram of fingers and thumb mechanism. (a) Open hand position, (b) Precision grip position, (c) Power grip position.

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.

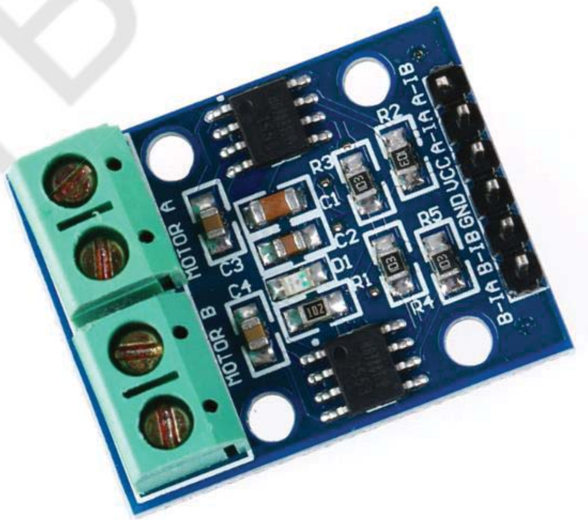
To drive the gripping device selected DC motors and gearboxes, in miniature format (pic 7). (Pic.6 (8))



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

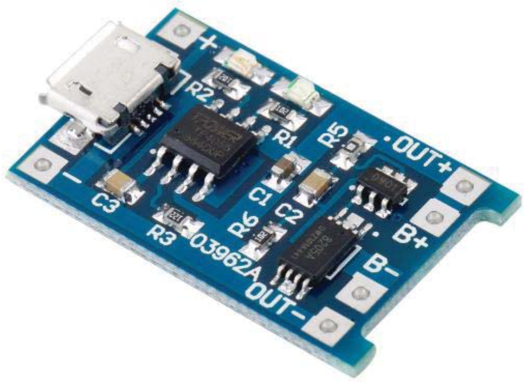
The device must have a power system. The designed model should be equipped with a battery, a voltage regulator, and a battery discharge controller.

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:

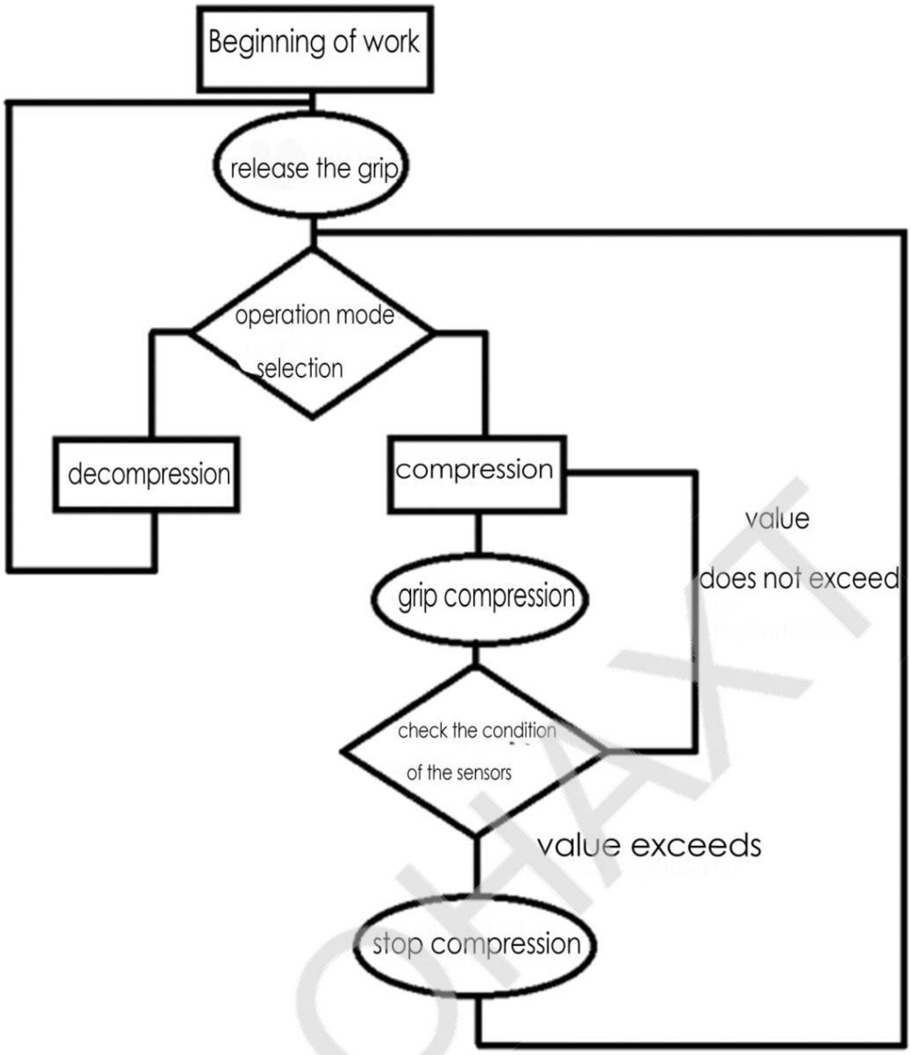
1. Block programming.
2. Programming elements of the scheme.
3. Code programming.

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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