„CONCURSULUI NAŢIONAL DE ŞTIINŢĂ ŞI INGINERIE „MOLD SEF”’

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Abstract: This paper describes the progress of work on the electronic prosthesis of the hand in detail ; how the prototype was created, how it is controlled, how the signals are sent and how they are received. Also, the electrical circuit and the program are described.

Index terms: Hand prosthesis, Arduino, servo, flex sensor.

I. INTRODUCTION

Today, mechanized systems have become indispensable assistants in many fields of human activity, in many ways surpassing the capabilities of ordinary people.

Relevance: The 21st century is a century of innovation, a century of rapidly developing new technologies that can not only improve the lives of people with disabilities, but also give a new meaning to their life. The creation of technical means to restore the ability of the hand to self-service these people and other activities is still an unresolved problem. There are opportunities to create a prosthesis from strong and simple materials with a high level of motor activity, but there remains a serious problem such as; the control of the prosthesis. “The task is to build control systems that could provide simultaneous control of several links while taking into account the dynamically changing biomechanical characteristics of the patient-prosthesis system: patient's motor activity, wide range differences of prosthesis as in prosthesis loaded with mass and during the transportation of the mass , and the nature of movements.” [1]

Purpose of the study: The purpose of this study is to develop a device which enables a person to control the movement of an artificial hand by putting a glove on a healthy hand.

The tasks:

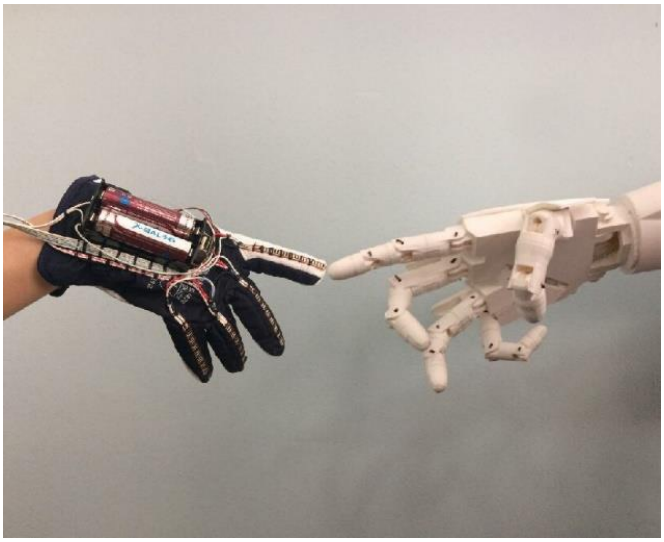
1. To study literature and Internet sources on modern materials and technologies for prosthetics hand.
2. Design in Paint 3D and print, using a 3D printer, details from white Verbatim PLA fiber.
3. To develop a device which enables a person to control the movement of an artificial hand by putting a glove on a healthy hand.
4. Write software for electronic hand operation.

Hypothesis: we suggested that this fundamental approach would increase the ability of people with disabilities to perform simple movements with an artificial hand.

In the research, **the used methods** were the analysis and synthesis of theoretical material of the following ; drawing of electrical circuits, 3D design, graphical methods, a Pascal program analysis of the results, comparison and generalization.

The novelty of the research lies in the fact that – this device would be the first sensitive glove that is used to imitate the palm movements of the healthy hand, the impulse is transmitted to the functional prosthesis from the healthy hand allows simple synchronous movements to be performed with both hands.

The practical significance of the work: research materials can be used in the work of educational schools and clubs of robotics, as well as becoming the basis for the development of research at the level of impulse transmission from brain neurons.



II. PROSTHESIS DESCRIPTION

This prototype of electronic prosthesis was developed in a month and finished on January 12, 2020. It is assembled from 56 parts that firstly were designed in Paint 3D (Fig. 4), then printed using a 3D printer in approximately 52 hours, and the total weight is 535 grams. The parts were made of white Verbatim PLA fiber (Fig. 5, 6).

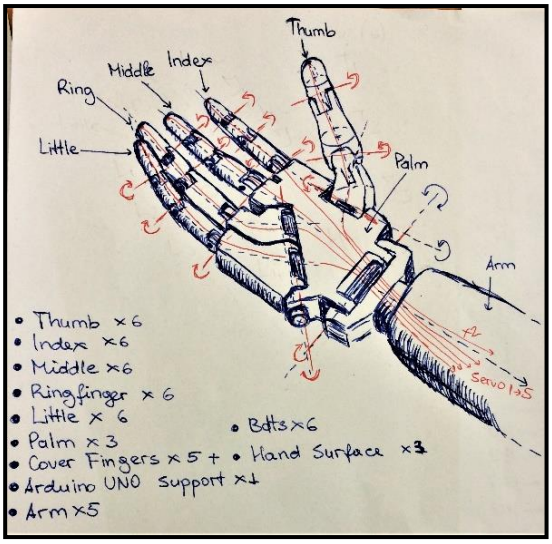


Figure 2: First drawing of hand

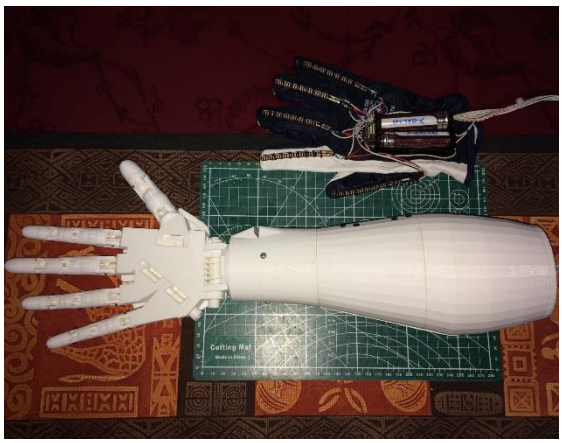


Figure 1: Hand and glove. Full project

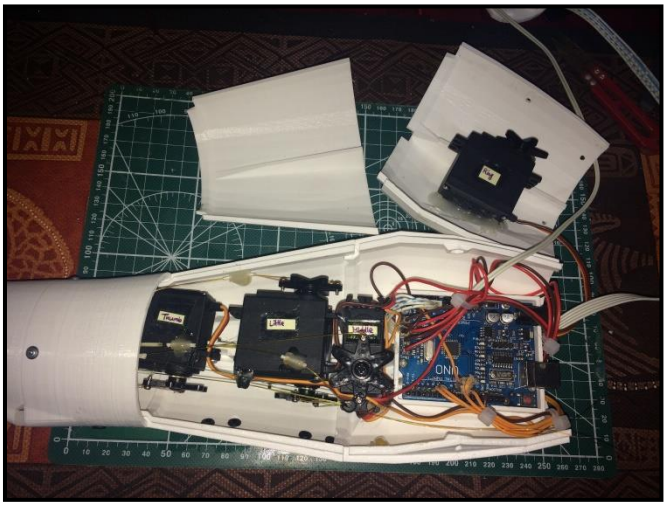
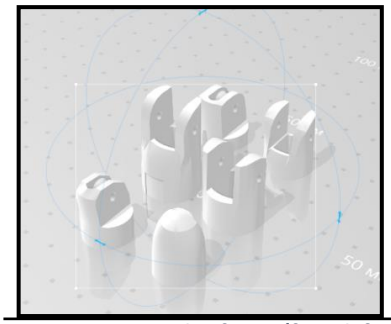


Figure 3: Inside of the hand

A person by putting the glove on a healthy hand, can control the fingers of an artificial hand with this device. It enables to bend and unbend each finger individually or several together. Inside there are five MG995 servos, the average speed of which is 0.16 sec / 60º (at 6 V), and the Arduino board, which is like the brain of the electronic prosthesis (fig. 3). Each finger has its own servo drive, which works as follows: a star is attached to the axis of the servo; two threads cling to its two vertexes, which are retracted to the end of the finger. The rotation angle of the MG995 servo is 120º. When the finger is 0º with the palm, the angle of the axis of the servo is also 0º, and when it reads the values from the board, which sets it in motion, the star rotates, pulls one thread and simultaneously releases the other, thereby causing the finger to bend, and vice versa.



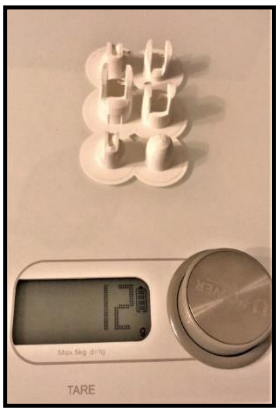


Figure 4, 5, 6: Index finger (from left to right: in 3D Paint, on the scale, comparing with a real hand)

III. ELECTRICAL CIRCUIT

Servo drives are powered by 7.2 V DC from two lithium batteries connected in series, which are on the glove (Fig. 7), because there are 5 and each of them uses a fairly much current, and the Arduino board may not cope with this. The signals are received from the digital pins of the board (D5, D6, D9, D10, D11), which is powered by a separate 5 V DC voltage source. These signals are obtained by changing the resistance of the flex sensors located on each finger of the glove (Fig. 9). These sensors works as variable resistors, having huge resistance in a steady state, which increases when they are bent. The sensors are powered by that 5 V DC source and are protected by 10 kΩ constant resistor on each. Each sensor is connected to an Arduino board with analog pin (A0, A1, A2, A3, A4). Shortly, the signals come from the sensors to the board through the analog inputs, the board reads the values, converts them and sends them through the digital outputs to each servo in the range from 0º to 180º. For example, the index finger bends, respectively, the sensor changes resistance, the data goes on the board through A1, goes through D6, the servo rotates, causing the index finger of the electronic hand to bend.

Figure 7: The glove

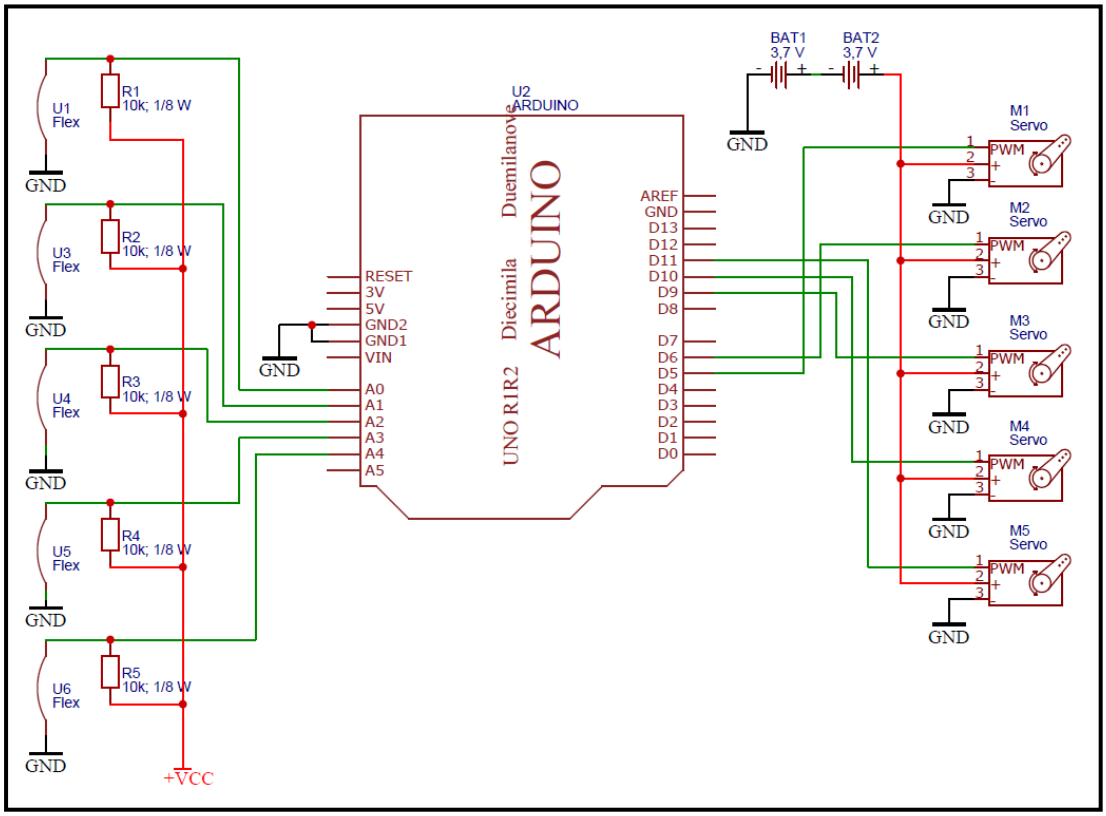


Figure 8: The project electrical circuit

IV. SOFTWARE PART. THE SKETCH

Despite the fact that the device has a complex structure, the sketch is quite simple. As in every program where there are used servos, the library (#include <Servo.h>) is first added to work with servos. This library already has certain parameters for programming servo drives, thereby simplifying the program. Next, create servo object to control a servo (thumb servo, index servo, middle servo, etc.). Then indicate to which analog pins flexible sensors were connected. At the same time give them names corresponding to their servos (int indexpin = 1, or "the index finger sensor is connected to the first analog pin"). Also, give variables to each sensor from which data will be read (int val1, val2, val3, val4, val5). Then also indicate which digital pins the servo drives are connected to, using the names we gave them earlier (indexservo.attach (6), or "the index finger servo is connected to the sixth digital pin"). Next is the part of the program that will run repeatedly. This is where the sensor data is read in one range, converted to another and sent on. For example, for the same index finger: (val2 = analogRead (indexpin);), it reads values from the index finger sensor in the range from 0 and 1023, but in this case, we use value between 768 and 853 for a high level of sensitivity. (val1 = map (val1, 768, 853, 0, 180);), the proportions between the two ranges are created here: when the sensor is in position 768 - the axis of the servo is at 0º, when 853 - the axis is at 180º. (thumbservo.write (val2);), data in degrees is sent to its servo.

At the end of each operation, it needs to wait 10 microseconds until the servo drive reaches its destination (delay (10);).

```
#include <Servo.h>

Servo thumbservo, indexservo,
middleservo, ingservo, littleservo;

int thumbpin = 0;
int indexpin = 1;
int middlepin = 2;
int ringpin = 3;
int littlepin = 4;
int val1, val2, val3, val4, val5;

void setup()
{
  thumbservo.attach(5);
  indexservo.attach(6);
  middleservo.attach(9);
  ringservo.attach(10);
  littleservo.attach(11);
}

void loop()
{
  val1 = analogRead(thumbpin);
  val1= map(val1, 768, 853, 0, 180);
  thumbservo.write(val1);

  val2 = analogRead(indexpin);
  val2= map(val2, 768, 853, 0, 180);
  indexservo.write(val2);

  val3 = analogRead(middlepin);
  val3= map(val3, 768, 853, 0, 180);
  middleservo.write(val3);

  val4 = analogRead(ringpin);
  val4= map(val4, 768, 853, 0, 180);
  ringservo.write(val4);

  val5 = analogRead(littlepin);
  val5= map(val5, 768, 853, 0, 180);
  littleservo.write(val5);
  delay(10);
}
```

The sketch

CONCLUSION

Having accomplished this research project, we were convinced that robotics is a field of science that uses certain knowledge in physics, mathematics, computer science, and material science in order to create, program and manage new devices, in our case, the management of the prosthetic arm.

Thus, we can confidently say that the main purpose was achieved, because, as a result of resolving many obstacles, which initially might have seemed unrealistic, we achieved our purpose. Repeated successful experiments with the invented device, gives reason to believe that we are able to make a prosthesis that a person can control. Tests have shown that by putting a glove on a healthy hand, one can control the fingers of an artificial hand.

This work can serve as inspiration, motivation for others, since there is nothing supernatural in this and everyone is able to understand, or even create such technologies by themselves, the key element to success is urge and determination for it. As Mike Tyson - one of our most purposeful contemporaries stated "If there is a wish - there will be opportunities, if there is an action, the result will there be."

REFERENCES

[1] G. N. Burov. “The current state of the problem of controlling prosthetic limbs and the achieved effect of prosthetics”. Text. - *Herald of the Prosthetic Orthopedic Guild*. №4 (10) 2002. pp. 37-43.

[2] A. E. Kobrinskii. “Here they are, robots”. Text. - M.: Science, 1972. p. 176.

[3] “Prostheses of the upper limbs”. Text. Catalog 2001-2002. RSC Energia, 2002. p. 21.