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Odessa National Academy of Food Technologies

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BLACK SEA SCIENCE 2021

Information Technology, Automation and Robotics

Proceedings

Odessa, ONAFT 2021

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Odessa National Academy of Food Technologies, 2021

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The Phoenix Contact Axiocontrol AXC 1050 controller was selected for the Office and software was developed to perform the task.

The paper deals with the task of Automating the positioning of pneumatic actuators behind the help of the Phoenix Contact controller

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KINEMATIC ANALYSIS OF THE HINGE-LEVER MECHANISM OF THE GRIPPING DEVICE ANTHROPOMORPHIC ROBOT

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Abstract. *The analysis of forearm prostheses presented on the modern market has been carried out. Their features, advantages and disadvantages are characterized.*

The relevance of this research work is shown.

A prototype of the prosthesis was selected. Selected drive type with justification of the choice. A method for controlling the prosthesis has been developed. The kinematic diagram of the brush has been compiled. The analysis of the functionality of the modular hand prosthesis was carried out. Calculated brush drive. Corresponding drive selected Hand force factors calculated.

Keywords: *PROSTHESIS OF FOREAR, Four-bar Linkage, Kinematic diagram of fingers, Hand Mechanism Design, 3D Printing, DC motor.*

INTRODUCTION

Prosthetics is the restoration of lost forms and functions of individual organs or parts of the body. Prosthetic construction is engaged in development and production of artificial technical means of restoration.

Currently, 42,000 people with disabilities in the Odessa region are in need of prosthetic and orthopedic care.

The largest number of amputations on the upper extremity - amputation at the level of the forearm (50.5%). Disabled people who have undergone such an amputation are primarily deprived of the opportunity for self-care, and in most cases even lose their profession. Therefore, the purpose of prosthetics of the upper extremities: the return of the disabled to the possibility of self-care and employment.

The main task of prosthetic construction is to create a technical device that can maximally fill the lost functions, ie return the disabled person the opportunity to perform basic household movements. Such movements are: grasping and manipulating the object. At amputation at the level of a forearm the full-fledged movement in shoulder and elbow joints remains that is sufficient for very exact positioning of an artificial hand in space without need of compensation of mobility of a radial wrist joint.

To implement the same grip requires a special technical device, a very simple design solution which is now widely used and is a mechanical prosthesis. The most common control methods are: traction mechanical, cosmetic and bioelectrical methods.

The purpose of my work is to develop a domestic prototype of a bionic prosthesis, which in modernization will not yield to European counterparts

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 (Fig.1).

Fig.1 Cosmetic prostheses

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. (Fig.2)

Fig.2 Bioelectric prosthesis

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

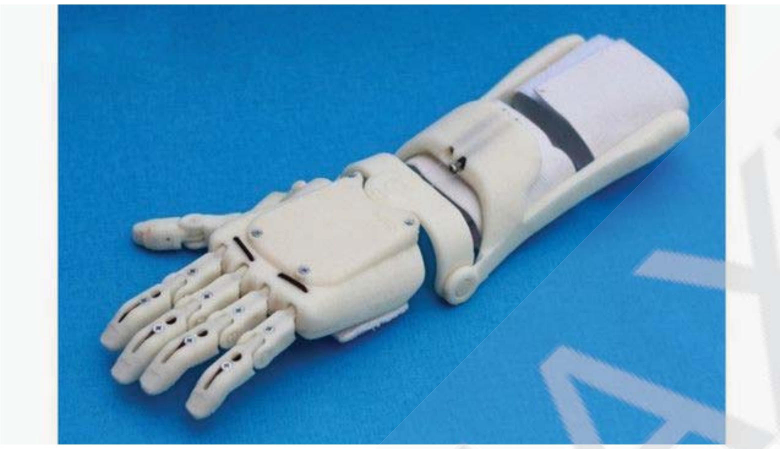


Fig.3 Active traction prosthesis

III. PROTOTYPE DEVELOPMENT

3.1.Drive types

For full recovery of the functions of the lost hand, it is necessary that the created prosthesis could repeat all kinds of grips. So the management of the prosthesis should be a simple, intuitive control system, which the patient can be taught in a short time. It is also important that the prosthesis has sufficient grip strength to hold the objects, as well as a sufficient reaction rate so that the objects can be manipulated. And on top of that, the battery life of the prosthesis should be enough for the whole day.

Currently, there are a huge number of different actuators: electric motors (Fig 4),

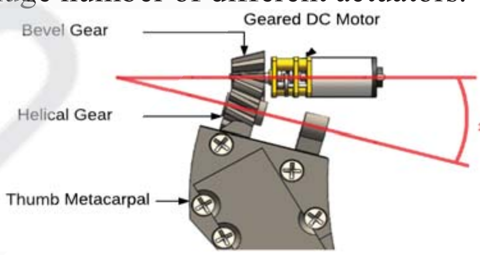


Fig.4. DC motor

hydraulic drive (Figure 6), pneumatic muscles (Figure 7), silicone muscles, materials with shape memory and others.

Fig.5 Hydraulic drive   Fig.6 Pneumomuscle

The actuator installed in the prosthesis must be compact, powerful enough, with great stroke and speed. Generally speaking, the closest to the muscle in terms of mass and dimensions. From all variety of actuators existing at present the most suitable on the listed parameters are electric motors. In this work, a DC motor with a built-in reducer is selected. It is more compact compared to stepper and collectorless motors and much cheaper. But, it is worth noting, it creates more noise at work and has a finite number of duty cycles.

Among the main advantages of this engine are its size, power, metal gears of the gearbox, can withstand heavy loads, and ease of mounting, both the engine and the pulley on the shaft, due to the presence of coffin.

A helical transmission is used as a transmission. (Screw nut)

The kinematic scheme shown in Fig 7 (c) was used to transmit the force from the motor to the finger. In this scheme, the finger consists of two movable joints and one fixed (the last 2 phalanges are a single part). This scheme allows you to move all 3 phalanges on a unique trajectory, using only one engine. Also at such design of a finger there is a possibility of creation of a modular brush that gives a number of the following useful properties: fast and easy replacement of fingers at breakage; quick adjustment of the prosthesis to the degree amputation of the arm.

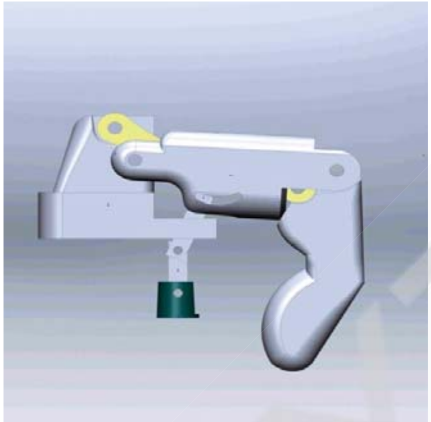
Fig.7. The kinematic scheme

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.8 Position 1 Pic.9 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)).

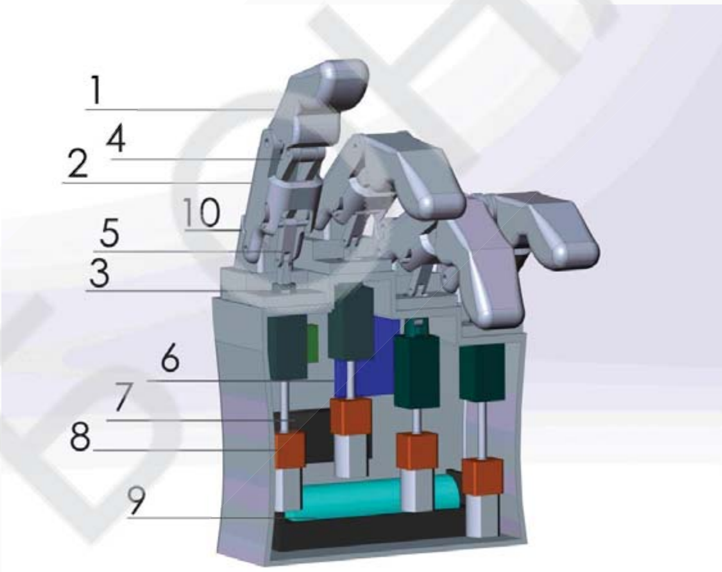
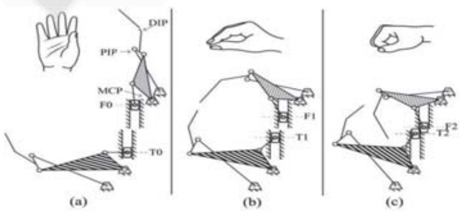


Fig. 10 General assembly

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.

The main controller will be the Arduino Nano 328 controller 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.

IVAnalysis of the functionality of a modular arm prosthesis

4.1 Kinematics of modular hand prosthesis

For the correct repetition of all kinds of hobbies, it is necessary to correctly set the kinematics of the fingers and hands. It is necessary to determine on what trajectories each phalanx of a finger moves. To this end, this section calculates the kinematics of the fingers and hands.

Figure 11 schematically shows the kinematic diagram of the finger. Also in Figure 11 presents the introduced notation: lengths and angles. To determine the kinematics, it is necessary to calculate the dependence of the angles a and y on the position of the nut. It is believed that the finger is first unbent and the nut is in the extreme right position

Using the theorems of cosines and sines, we obtain:

$$\gamma = arccos\left(\frac{b_1^2 + {B_1C_1}^2 - b_3^2}{2b_1B_1C_1}\right) - arcsin\left(\frac{b_4 sin\beta}{B_1C_1}\right)$$

$$\alpha = arctg\left(\frac{a_4}{a_1 + \Delta l}\right) + \arccos\left(\frac{a_2^2 + (a_1 + \Delta l)^2 + a_4^2 - a_3^2}{2a_2\sqrt{((a_1 + \Delta l)^2 + a_4^2)}}\right).$$

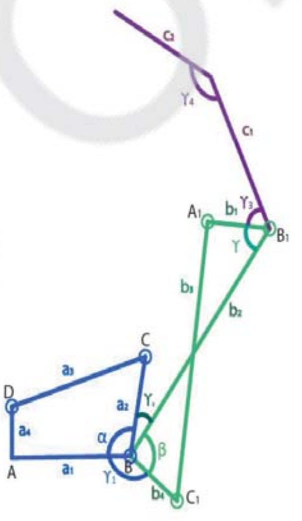


Fig.11 Kinematics of modular hand prosthesis

4.2 Knowing the dependence of the angles α and γ on the position of the nut is not difficult to restore the trajectory of each joint and each of the points of the phalanges

$$\begin{cases} x_3 = x_2 + \cos(3\pi - \alpha - \gamma - \gamma_2 - \gamma_3 - \gamma_4)c_2 \\ y_3 = y_2 + \cos(3\pi - \alpha - \gamma - \gamma_2 - \gamma_3 - \gamma_4)c_2 \end{cases}$$

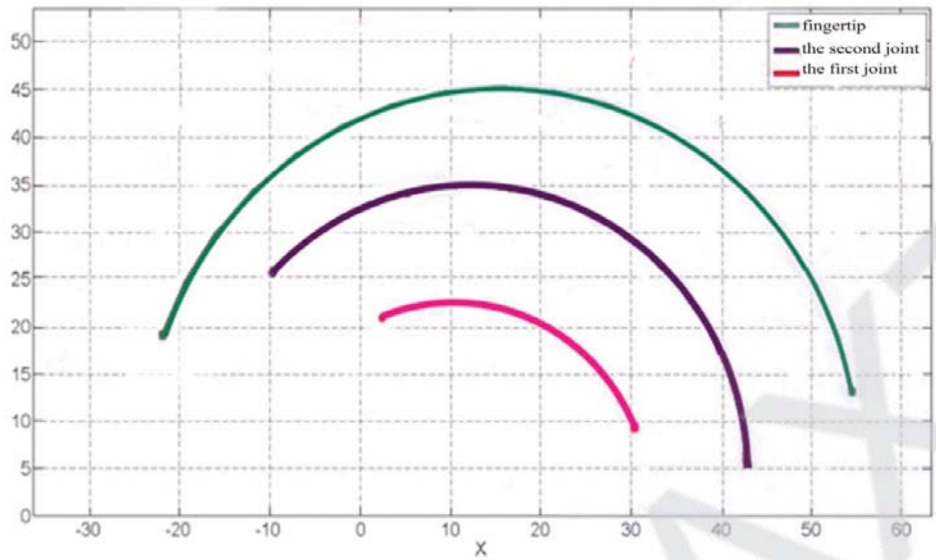


Fig. 12 The trajectory of the joints and fingertips

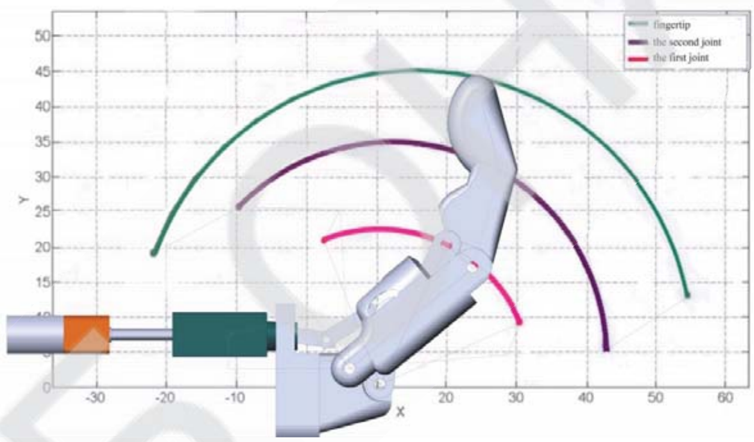


Fig.13 The trajectories of the joints and the fingertip are combined with the movement of the finger

a_1 мм	a_2 мм	a_3 мм	a_4 мм	b_1 мм	b_2 мм	b_3 мм	b_4 мм	c_1 мм	c_2 мм	γ_1 рад	γ_2 рад	γ_3 рад	γ_4 рад
11,3	16,7	24,6	8,95	9,1	42	40,7	9,7	26,7	25,7	2,67	0,52	1,12	2,61

V Dynamics of modular hand prosthesis.

5.1 One of the most important characteristics of the prosthesis is the strength of its shawl. In this section, the calculation of the dynamics of the finger of the prosthesis. Determines the forces created by different types of grip.

Suppose that the moment created on the motor shaft is equal to M_motor (in this work, motors with Mmotor = 2.4 kg · cm = 0.24 N · m were used). Determine the force that will develop the nut when it moves along the screw. The moment created at point B is equal to:

$$M_{B=}F_{mot}a_1 \sin\left(\alpha + < ACD - \frac{\pi}{2}\right) \cos\left(< ACD - \frac{\pi}{2}\right)$$

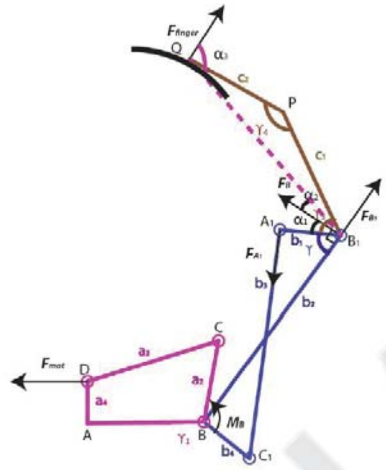


Fig.14 Notation of lengths and angles.

Introduced notation of moments and forces 5.2 Using the theorem of cosines and moment balances with respect to points A1 and B1, we obtain

$$F_{finger} = \frac{F_B b_1 sin < C_1 A_1 B_1}{c_1 \cos(< C_1 A_1 B_1 - \alpha_1)\, sin\alpha_3 + \cos(\alpha_3 - \alpha_2) b_1 \sin(< C_1 A_1 B_1)}$$

Figure 18 shows a graph of the dependence of forces F_B (red) and F_{finger} (blue) depending on the position of the nut (for the case when F_{finger} is directed normally to QP).

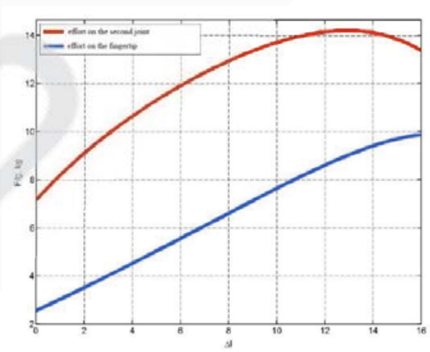


Fig.15 The graph of the dependence of the forces on the fingertip on the position of the nut is combined with the movement of the finger

The graph shows that as the finger bends, the forces increase. Approaching the extreme position there is a slight decrease F_B

CONCLUSIONS

- The analysis of anatomy and principles of work of a human hand is carried out. Determine the main parameters that must meet the prosthesis. The main types of gestures that the prosthesis should reproduce are determined.

- A model of a functional prosthesis of the arm on the Thread rod was developed and assembled. 3D prototyping technology is used for manufacturing.
- A model of a modular hand prosthesis has been developed and assembled.
- The analysis of kinematics of a modular prosthesis of a hand is carried out. The equations of trajectories of phalanges and beams are received. The analysis of the basic types of captures which the prosthesis can carry out is carried out.
- The analysis of dynamics of a modular prosthesis of a hand is carried out. The expression for the forces developing on a fingertip is received. These efforts are enough to make the prosthesis can take and hold most of the items used in the home.

The obtained results are aimed at creating a functional prosthesis, and will further create a device as similar as possible to the human hand in appearance and functionality (taking into account the achievements of modern science and technology).

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