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Experimental Development and Additive Manufacturing Robotic Hands

Juraj Kováč*, Marek Mastilák

Department of robotic, Technical University of Košice, Slovakia
*Corresponding author: juraj.kovac@tuke.sk

Abstract The contribution has been producing robotic hand 3D printer together with its certified under laboratory conditions. The robotic arm is tested when gripping objects of various shapes. In each part of the work describes the design itself, followed by manufacturing, assembly and verification of the proposed robotic hand.

Keywords: *robotic hand effector, data gloves*

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1. Introduction

Currently, 3D printing method is the most used method for the production of prototype parts and components. 3D printer is presented as a simplification of the manufacturing of complex shaped objects and models without using traditional machining, where production is expensive and lengthy. When designing and manufacturing robotic hand is a method of 3D printing as a way to produce a robotic arm faster, cheaper and verify the model as a function remains in real terms. The term robotic arm end effector means, anthropomorphic gripper, consisting of several fingers, whose role is to grasp different objects. Currently such biomedical engineering hand part as those of the human limb prostheses, as well be understood as a universal gripper effector. The main advantage of the robot hand is capable of grasping the different objects regardless of the shape and surface. If they have to compare the different principles of operation of robotic hands and each version has its advantages and disadvantages.

2. Inspirational Solutions Robotic Arms for Self-development and Prototyping

A special category of gripping units in robotics is robotic hand. The aim of developing the solutions mimicking respectively replacing work of human hands. Given the high versatility, as well as the corresponding complexity globally is identifiable significant number of conceptual approaches to addressing the aforementioned issues. Affiliation within the framework of implemented research programs and focuses on the application of robotic arms in a precision assembly and disassembly of mechanical products. Parts of the development are also custom design and manufacturing verification and hand in laboratory conditions. Inspirational solutions robotic arms for self-development and prototyping are shown in Table 1.

2.1. Development of New Solutions Prototype Robotic Hand

Figure 1 shows one of the models proposed alternatives robotic hand. As the drive to address this variant were used micro servomotors stored in a straight line movement. The outputs shaft therefore your fingers facing forward. Such an arrangement of the actuator is gentler on the surface of the deposit. On the palm of the hand is in this case possible to place all servomotors. Servo motors are mounted on the back cover of the palm, making their installation easier. The transmissions of motion from the actuator to the individual fingers were used ball joints associated threaded rod, wherein the actuator changes the rotary motion to linear motion. It was therefore necessary to make the strength analysis, on the basis of which was the selection of servo motors to prevent damage to the individual components of the robotic arm.

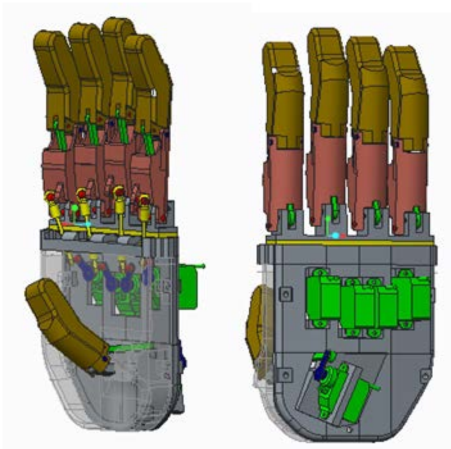
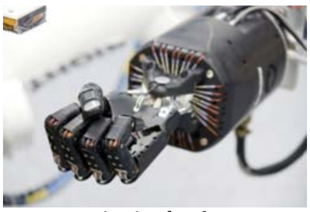


Figure 1. Variant prototype robotic hand right

Table 1. Examples of approaches to deal with robotic hand

Type of arms	Characteristic
 MechaTE Robot	**Robotic hand MechaTE Robot** from Custom Entertainment Solutions. The robotic arm is equipped with 5 servo motors and has 14 degrees of freedom. It is mainly intended only for animation purposes [14].
 ExoHand	**Robotic hand ExoHand** Festo concept is based on the duplication of the human hand. Developed bionic arm is highly flexible, using pneumatic actuators. The robotics is expected its use when handling free-form objects. Since the company is mainly engaged Festo tire as ExoHad hand drive using pneumatic pistons [15].
 BeBionic	**Robotic hand BeBionic** Bionic hands of serving as a replacement for human limbs (prosthesis). Also it has application in robotics. When developing the filmmakers inspired by human hands, and put at ease. BeBionic hand is fully automated and uses linear electric motors, which can be guided precisely to achieve specific locations. Fingers and thumb have only two articles. For use in practice, it is sufficient. The thumb can be tilted sideways. Solution increases its use in gripping and grip objects [16].
 An Artificial	**Robotic hand An Artificial** It uses a system of wires through which is controlled by the whole hand. Hand applies all the movements of the palm and fingers. It is a copy of a human hand in terms of movements. The construction form the fingers, which have the three elements and having a two inch cells. Only uses hand grip palm and fingers tilting sideways. To run on electricity and the electric wire wound, thereby pinching the fingers, thumb and palm. Backward movement is also achieved by an electric motor. The problem is the incorrect management of a high number of actuators [17].
 Shung	**Robotic hand Schung** Commercial right and left mechanical arm Schunk has a highly sophisticated concept solutions. Is a true copy of human hands. [18]

2.1.1. Stress Analysis of Selected Elements

Prior to the production of each of the robotic hand using 3D printing was conducted stress analysis of each of its elements. Stress Analysis was performed mainly on moving elements, namely the elements where there is a load change. Stress Analysis was performed on the first, second phalanges and save the finger as they represent a major part of the robotic hand. As the robotic arm is seen as a prototype, which is made of ABS plastic, and is intended solely to verify functionality in stress analysis was not considered a particular load by object manipulation, but was defined by the value of the maximum load that a particular component still withstand without damage. Example of the results of the FEM analysis is shown in Figure 2, Figure 3 and Figure 4. [11].

The analysis carried out follows:

- **Stress Analysis of the first article of your finger:** For stress analysis was an article in the first cantilevered eye, where you can see the color range, presenting the amount of strain and forces at that point. The load was simulated with the other eye. The load was simulated power 0N, with a maximum voltage is equivalent to 44.7422 MPa.
- **Stress Analysis second fingertip:** In the second item it was reduced to 20N load, which acts on the end of the article with the resulting tensions 9.2583 MPa.
- **Stress Analysis deposit Fingers:** When storing fingerprints were also 20N load operating in the axial direction X. Saving finger was on the bottom with BASE resulting tensions 1.44325 MPa.

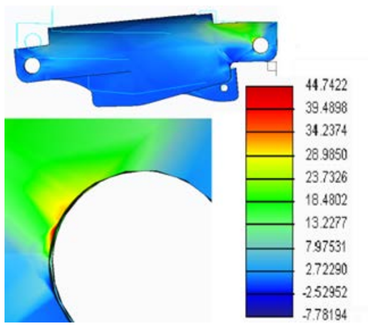


Figure 2. Stress Analysis First item

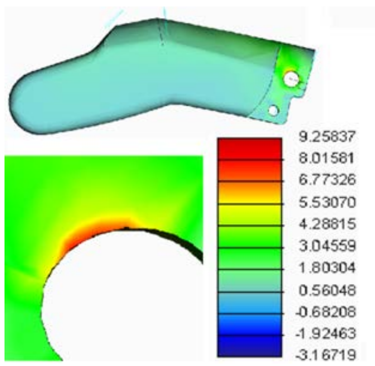


Figure 3. Stress Analysis of the second item

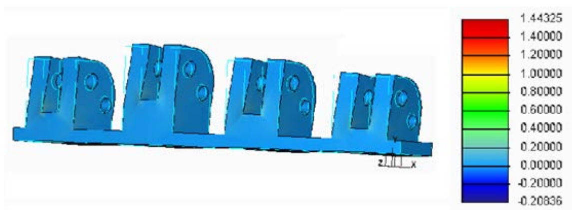


Figure 4. Stress Analysis deposit finger

Thus loaded elements can withstand sufficient load even if it is only a prototype made of ABS plastic and can therefore be printed on a 3D printer together with other components to create a functional whole. Based on the strength analysis was selected servomotor with the following technical parameters presented in Table 2 [11].

2.1.3. Process Modeling Robotic Hand

When designing a robotic hand with the most care was taken to its functionality and design that would be the most resemble a human hand. This has been especially adapted to contact fingers and the palm. Figure 5 shows the parts of the proposed robotic arms which are prepared.

Table 2. Specifications Micro servo Futaba S3114

Torque	1,51kg/1cm
Input voltage	6V
Rotation Speed	60°/s
Weight	7,8g
Gearbox	Ultra mini (plastic)
Engine Type	3 – pole
Sizes	22 x 11 x 22 mm (d, š, v)

Figure 5. servomotor futaba S3114

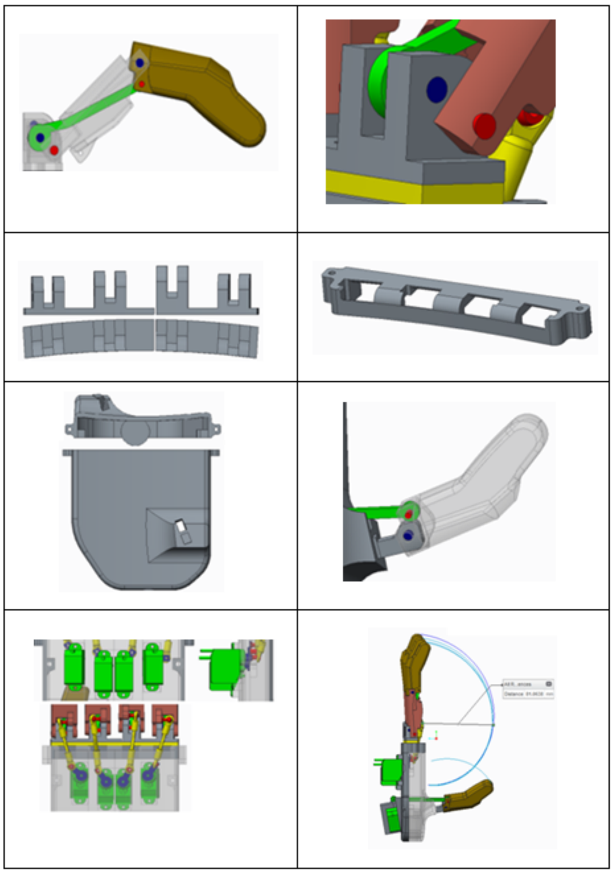


Figure 6. Creo 2.0 3D model of the robotic hnad

2.1.4. Verification of Production Processes Robotic Hand 3D Printing

For the experimental production of the structural elements of robotic arms are used by 3D printers Easy 3D macro (Figure 7). CAD models of components are created in the program Creo 2.0. Individual parts of the program are saved as STL files. which supports 3D printer. The STL files. it is also necessary to adjust the softness of the edges and the overall accuracy of parts produced according to the requirements and possibilities of the printer (Figure 8, Figure 9).

2.1.5. Assembly Robotic Hand

The robotic arm is made up of smaller sets than under the fingers, palms, and the engine mechanism. It was therefore necessary to establish a manual assembling the entire robotic hand for the case of the maintenance and repair operations. Art method of assembly of the parts of the robotic arms is shown in Figure 10.

2.1.6. Verify the operation of robotic hand

To control the robotic arm was used wireless data gloves CyberGlove 2, with which the simulated movements faithfully transmitted to a robotic arm made. CyberGlove glove 2, operates using Bluetooth wireless technology with its own resources. The glove is built 18 sensors to record the movements of a human hand, and transform them using the signal to the robotic hand that is connected directly to the program Cyberglove2 RoboticHand.

Figure 7. Easy 3D maker

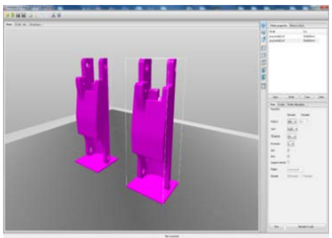


Figure 8. The first item STL format

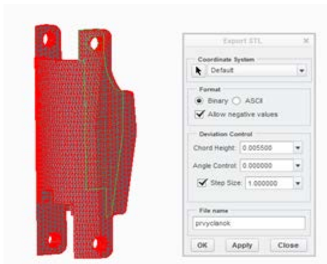


Figure 9. SW 3D Printers

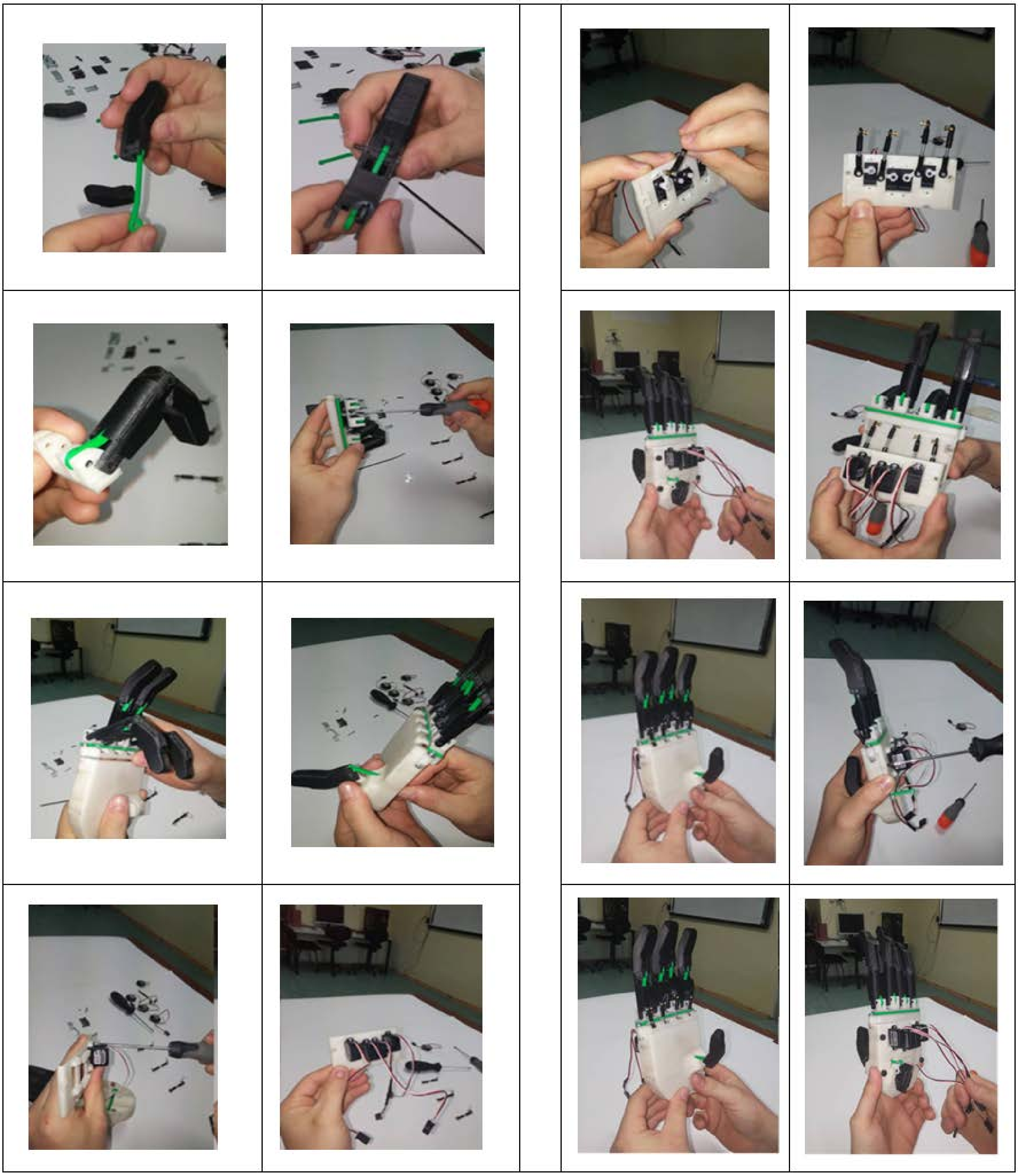


Figure 10. assembly robotic hand

Figure 11. Gloves CyberGlove 2

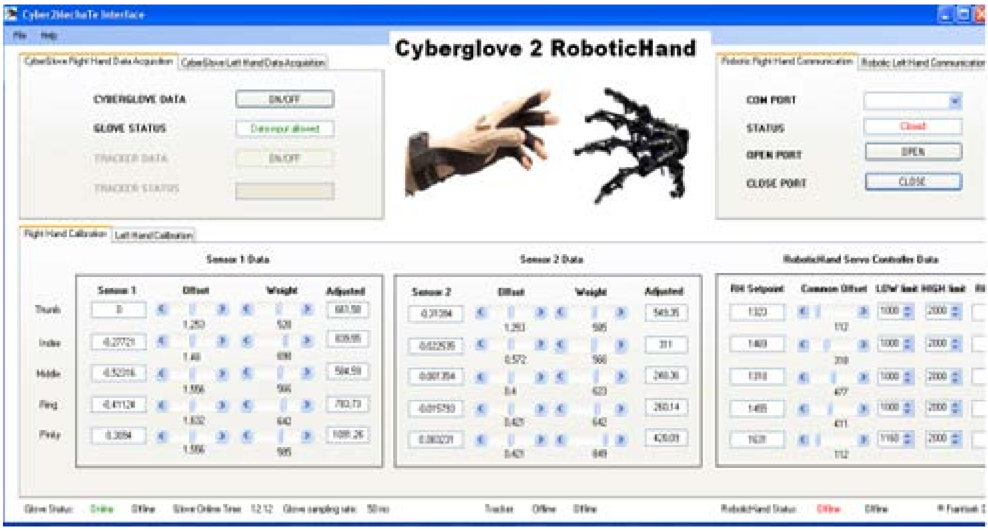


Figure 12. screen of CyberGlove 2 Robotic Hand

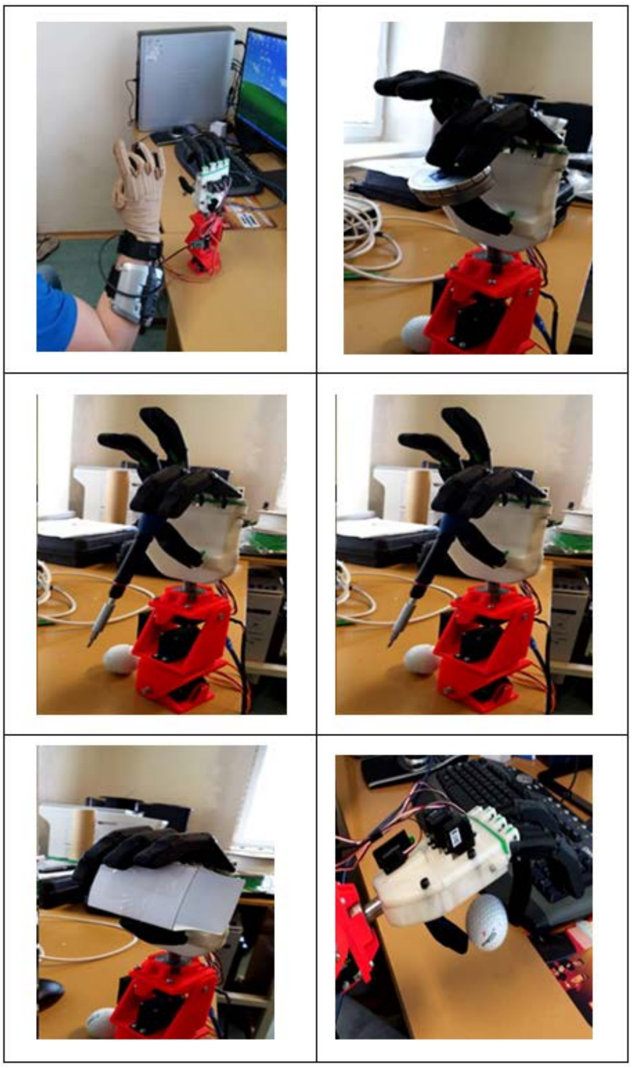


Figure 13. Examples of experimental laboratory verification activities Robotic hand

2.1.7. Examples of Testing the Functionality of the Hand and the Gripping Ability

The gripping robotic hand skills were tested on objects: bottles, cans, boxes, golf ball, technological pen, screwdriver, square profile. All subjects were given a robotic hand, in addition to a golf ball which robotic arm picked up from the table, the robot arm was controlled by a wireless glove CyberGlove 2. Examples of laboratory experimental verification are given in Figure 13.

3. Conclusion

3D printing is widely used for the production of prototypes, where the model has been tested, and debugged for detail starts to mass production. Significantly it reduces prototyping costs and simplifies production of various shapes and structures. This technology significantly reduces the cost of producing new components and also time because the operator sets the parameters chosen and the printer works alone. All 3D printers have a common printing process in which the component has been manufactured. When printing, the individual layers of material deposited on each other, thereby printing method differs from conventional machining processes.

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VEGA 1/0853/16 New project technologies for the creation and implementation of future factories.

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