# NEWEST DEVELOPMENT IN INTERCONNECTING THE DATA CYBER GLOVE 2 AND THE ROBOTIC HAND MECHATEROBOT

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The article deals with the development of mechatronic interface for a robotic wrist Mecha Robot as well as with software interface that is compatible with the mechanical and sensory part of the Cyber Glove 2 – Mechaterobot device under development. Three variants of the designed wrist were subjected to scrutiny, of which, after careful analysis by the so-called scoring method implementing critical weight differences, the most appropriate variant was selected. The proposed variant was prototypically produced by an additive method. After manufacture, the functionality was tested experimentally not only for mechanical properties, but also for Cyber Glove 2 sensors through data linking. To this end, it was necessary to develop our own software, called "Cyberglove 2 Robotic Hand", which was created in the programming language C ++.

**KEYWORDS**

*Robotic hand, humanoid effector, wrist, interface, 3D print*

## INTRODUCTION

Implementation of robotic hands in different applications brings new innovative solutions to replacing human labor. Research and development of their application in healthcare, engineering, food, automotive, chemical industries, as well as in other research-related applications is currently well underway. Humanoid effectors [Rumíšek 2003, Bozek 2014, Mecha 2019, Kinova 2003] will be deployed in all of those fields. Humanoid robots, who will work alongside men or duplicate human movements, will make expansion of automation possible into every branch of industry [Korba 2014, Dobránsky 2016]. In mass or large-scale production, movement duplication of one operator by multiple robots with anthropomorphic tentacles will find its application where nowadays multiple workers carry out one and the same job multiple times [ Robotiq 2015, Drotár 2015].

## ROBOTIC HAND MECHATEROBOT

Mechate is a type of robotic effector also called a robotic hand. It was developed by Entertainment Solutions with the aim of providing a mechanical manual platform to any number of applications. The robotic hand has 5 degrees of freedom and it is designed for animation purposes. It is controlled by five servomotors. It is very important feature is the option of setting the sensitivity of every finger by the user [Smrček 2013].
A mechanical interface is formed by an opening 12.7 mm in diameter on the back of the hand. This opening allows for its mechanical joining with either the robot's arm or wrist.

**Figure 1.** Robotic hand Machate Robot

## ROBOTIC HAND'S WRIST VARIANT PROPOSALS

3 wrist variants were manufactured for the MechateRobot robotic hand [Mecha 2015]. All three variants meet the condition of three degrees of freedom of movement. All variants were created and then rendered in the PTC Creo 2.0. The selected optimum variant was made of plastic on a 3D printer.

## ROBOTIC WRIST VARIANT NUMBER 1

The first variant was executed as an elementary kinematic chain pictured on the Fig. 2.

**Figure 2.** Robotic wrist variant no. 1

This design of a kinematic chain is made up of four main parts. The variant's structure is simple and its advantage is non-complexity of production and its cost. Its disadvantage is its overall size, which is also one of the main reasons why we did not proceed with manufacturing the prototype.

## ROBOTIC WRIST VARIANT NUMBER 2

The second variant design was a cylinder-shaped wrist consisting of four parts. Rotation of the central rotating part is ensured by a simple cog and transmission. A disadvantage of this variant and the main reason why it was not selected for the final solution is its more complicated structure and incompatibility of the 3D printer's technical parameters therewith, so that it would not be possible to proceed with its manufacturing using the printer.

**Figure 3.** Robotic wrist variant no. 2

## ROBOTIC WRIST VARIANT NUMBER 3

This variant is a combination of the preceding variants and it features all of their advantages such as simple structure and a relatively low height.

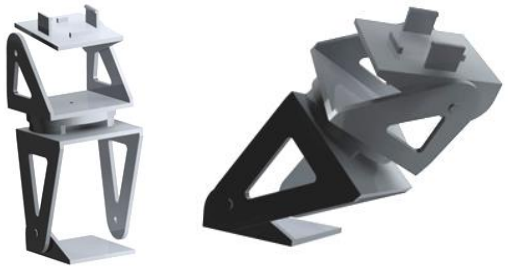

**Figure 4.** Detail of the robotic wrist variant no. 3

## SELECTION OF A SUITABLE SERVOMOTOR

A Monza SSA120M servomotor was selected to control the robotic hand's wrist. This servomotor features metal cogs and has sufficient strength to control the whole wrist. A clear list of technical parameters of the selected servomotor is given in Tab. 1 and the servomotor itself is shown in Figure no. 5


**Figure 5.** Selected servomotor Monza SSA120M

**Table 1. Servomotor's technical parameters**

| | |
|---|---|
| Power: | 4.8 – 6V |
| Dimensions: | 40.7 x 20 x 42.9 mm |
| Weight: | 55g |
| Torque at 4.8V: | 0.95 N/m |
| Torque at 6V: | 1.20 N/m |
| Ball bearings | 1xBB |
| Transmissions: | Metal |
| Servomotor type: | Analogous |

## CALCULATIONS VERIFYING SELECTION CORRECTNESS OF THE CHOSEN SERVOMOTOR

The servomotor's suitability check was done via calculation of forces necessary to control the robotic hand.

Selected servomotor's torque at the first (most impacted) servomotor:

$M_k = F\ x\ l,$

$M_k = (\ m\ x\ g\ )\ x\ l,$

where:

F – force affecting the end segment of the arm

l – effector arm 's length

m – total structure and effector weight

g – gravitational acceleration

The effector structure's total weight was calculated according to the formula

$$m = m_1 + m_2 + m_3$$

where:

m1 – weight of the interface structure

m2 – weight of all servomotors

m3 – weight of supporting parts of the robotic hand

m = 70 + (3 x 60) + 600

m = 70 + 180 + 600 = 850

Upon fitting the above to the formula $M_k = (\ m\ x\ h\ )\ x\ l$

Mk = (0.85 x 9.1 ) x 0.143

Mk = 1.1 Nm

Maximum torque of this servomotor is 1.2 Nm. Therefore, the torque at the 1st servomotor that operates the hand and arm meets the requirements.

P – total number of points

i – criterion number

j – number of the alternative

p – criterial number of points

n – number of rating criteria

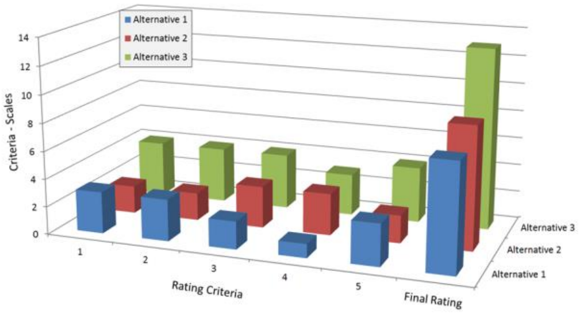


**Figure 6.** Selecting an optimum alternative of the wrist's structural design.

The alternative no. 3 scored the highest (13 points) and according to the ranking by the selected scoring method, this alternative is an optimum one. The alternative no. 3, Fig. 7, has been selected as another solution.

**Figure 7.** Selected variant fitted with servomotors

The selected variant and the model's design in the CAD system are adjusted to the given servomotors. To maximize the required firmness of the structure, the relief holes were filled.

## PARTS OF THE SELECTED VARIANT'S STRUCTURE

Figure 8, part "a" shows the first segment of a kinematic chain, that can be bolted to any platform. This segment was specifically designed and dimensioned for the parameters of the selected and used servomotor.

Figure 8, part "b" captures the second segment of the kinematic chain. A servomotor will be positioned onto its lower part to ensure the rotating movement of the third segment.

Figure 8, part "c" represents the third segment of the chain. The bottom has a circular groove in which the third segment rotates on a tooth. A greater stability is thus achieved.

The last, end segment, on Figure 8, part "d" has a storage space (a clip) for fastening of the robotic hand.

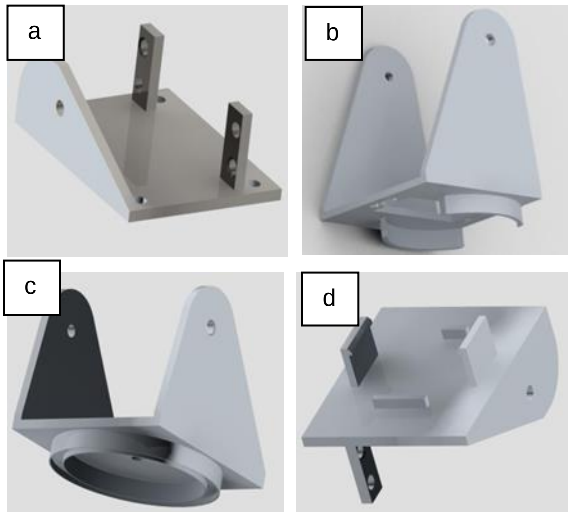


**Figure 8.** Parts of the wrist structure

## MANUFACTURING OF THE SELECTED WRIST VARIANT ON A 3D PRINTER

The printing process started with conversion of the CAD models into a required format (*.stl) and its subsequent uploading into the printer-compatible program. The program enables the user to watch the process and the estimated time of printing completion, Fig. 9. Figure no. 10 shows the program's interface

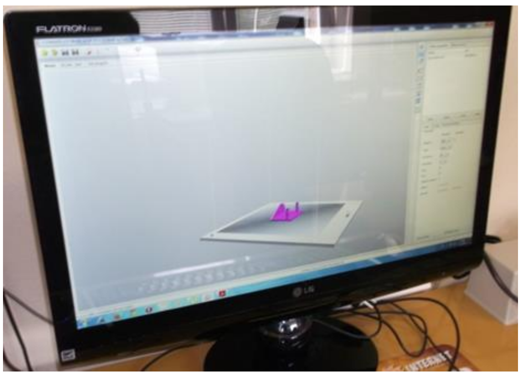

**Figure 9.** 3D printer with a working station

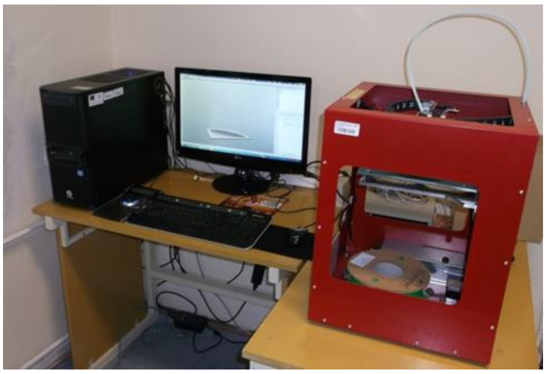

**Figure 10.** Software's printing interface

## VERIFYING THE WRIST AND THE ROBOTIC HAND FUNCTIONALITY

After the wrist was printed on a 3D printer, it was fitted with the Mechate Robot robotic hand and its functionality and overall firmness were tested, Fig. 11. The wrist showed sufficient firmness when loaded with controlling forces aimed at achieving the required movement of the robotic hand. The servomotor that was used handled the load without any problems. However, since this was the first wrist prototype, it is important to note there surely exists room for further structural improvements [Kováč 2003].

**Figure 11.** Mechate Robot push-up wrist and robotic hand

To control the robotic hand and wrist, a wireless glove CyberGlove 2 was used.

**Figure 12.** Data glove CyberGlove II

After calibration and fine-tuning, the simulated movements were transmitted to the manufactured wrist and robotic hand almost precisely. CyberGlove 2 makes use of the wireless bluetooth technology and it has its own supply source. The glove features 18 inbuilt sensors monitoring elemental movements of a human hand and through the signal they read, the information is transmitted to the respective servomotors as power impulses to control the robotic hand. The data glove is connected directly to the Cyberglove 2 Robotic Hand program. The glove is made of a woven fabric to facilitate easy hand dressing and it is interconnected with the power source as shown on Figure 12.

## CYBERGLOVE 2 ROBOTIC HAND SOFTWARE

A proprietary software Cyberglove 2 Robotic Hand was developed in the programming language C++ for connecting and synchronizing the data glove and the robotic system. Below is the extract from the Robotic Hand program's code, through which the data glove's sensor sensitivity is set up:

```
sensor_R_thumb2 = glove->getData((GHM::Fingers) 0, (GHM::Joints) 2);
//
sensor_R_index1 = glove->getData((GHM::Fingers) 1, (GHM::Joints) 1);
sensor_R_index2 = glove->getData((GHM::Fingers) 1, (GHM::Joints) 2);
//
sensor_R_middle1 = glove->getData((GHM::Fingers) 2, (GHM::Joints) 1);
sensor_R_middle2 = glove->getData((GHM::Fingers) 2, (GHM::Joints) 2);
//
sensor_R_ring1 = glove->getData((GHM::Fingers) 3, (GHM::Joints) 1);
sensor_R_ring2 = glove->getData((GHM::Fingers) 3, (GHM::Joints) 2);

sensor_R_pinky1 = glove->getData((GHM::Fingers) 4, (GHM::Joints) 1);
sensor_R_pinky2 = glove->getData((GHM::Fingers) 4, (GHM::Joints) 2);

glove_time = glove->getLastUpdateTime()-glove_base_time;
glove_time = System::Math::Round(glove_time,0);
```

The software enables calibration of the data glove's movement sensors for each finger separately to achieve the greatest possible response precision of the controlled robotic hand. Two movement sensors are calibrated for each finger and three for the hand's wrist, Fig. 13

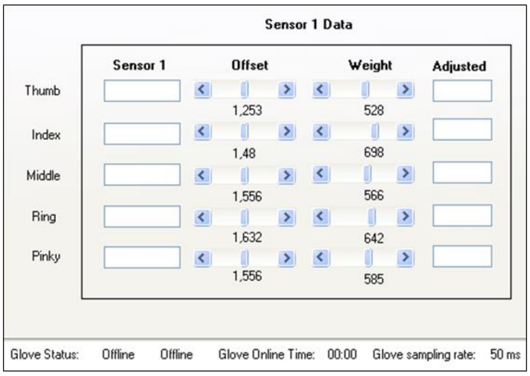


**Figure 13.** Setting up the sensitivity of the data gloves movement sensors

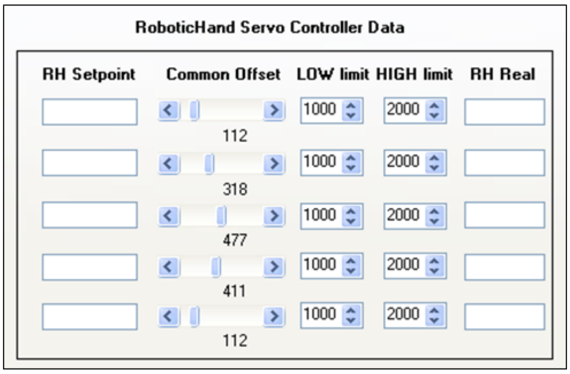


**Figure 14.** Setting up the servomotor sensitivity and their range of motion

With this software, it is possible to control the robotic system with a data glove. The software allows for calibration of individual servomotors to adjust the sensitivity of movement and the sensitivity of the control itself. Each servomotor can be calibrated separately with a different range of motion and a different sensitivity.

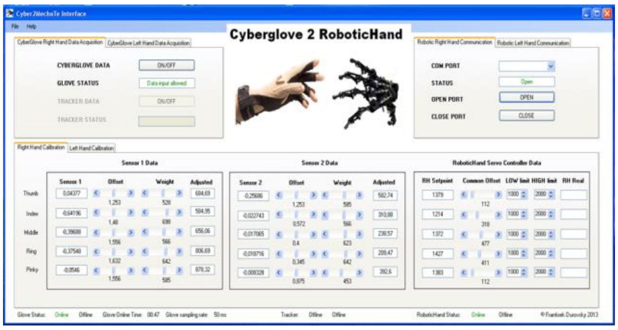


**Figure 15.** Cyberglove 2 Robotic Hand Program Environment

## CONCLUSIONS

The aim of the design was to create a functional wrist model with three degrees of freedom for the MechateRobot robotic hand. A 3D printing method has been chosen to produce the model. The wrist and the hand should serve the animation purpose of transferring the movements onto a robotic hand and that of movement duplication during teaching or research. A fully functional robotic wrist model with three degrees of freedom was created. Each of these degrees of freedom allows a robotic hand that is attached to the wrist to simulate its function identical to that of a human wrist. This enhances the MechateRobot robotic hand's importance in animation and potential use in engineering and educational practice.

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KEGA 030TUKE-4/2017 Implementation of innovative instruments for increasing the quality of higher education in the 5.2.52 Industrial engineering field of study

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