# Daniel Salyi, Döníz Borsos: Bionic Hand with Phalanx built-in servos

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*Abstract: Losing one or both hands is a devastating experience, as the human hand is used for numerous activities. As a result, restoring a lost limb is a rather important goal, to give back a lost functionality to a user. Currently, most academic papers use a muscle-like approach to achieve such an object, while commercially available solutions to restore one's limb are done by embedded motors and controllers.*

*In this paper, we focus on creating a prosthetic hand, as close to biomimicry as possible, by embedding a DC motor, a controller and a series of gears into each phalanx of the hand. This is achieved with inexpensive and readily available components and technologies such as 3D printing. The device could be used for telemanipulation and as a prosthetic.*

*Keywords: Bionic Hand, servo, Biomimicry*

## 1. Introduction

Admittedly, losing one or both hands is a devastating experience, as the human hand is used for numerous activities. As a result, restoring a lost limb is a rather important goal, to give back a lost functionality to a user. However, most academic papers use a muscle like system to achieve such an object, while commercially available solutions to restore one's limb are done by embedded motors and controllers.

The aim of this paper is to create a prosthetic hand, as close to biomimicry as possible, by embedding a DC motor, a controller and a series of gears into each phalanx of the hand. This device could be used for telemanipulation and as a prosthetic.

## 2. Development

First, let us consider some of the parameters of the human hand.

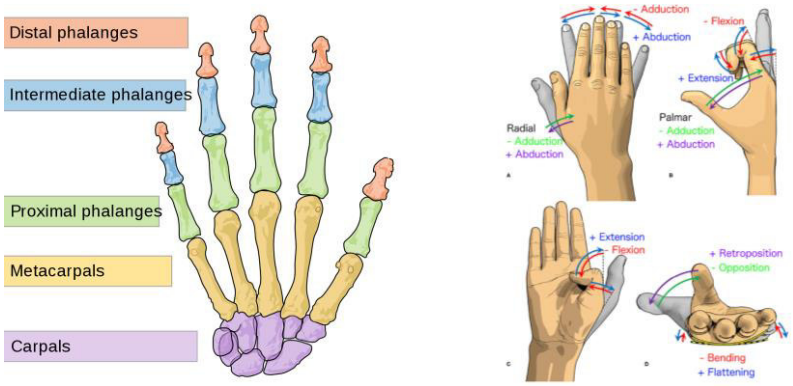


Figure 1. Skeleton and movements of the hand [1][2]

The skeleton of the hand consists of 27 bones, 14 of which are found in the fingers, as figure 1 depicts. Another terminology which is worth considering, is the movements of the fingers, illustrated on figure 1.


Figure 2. SG90 from TowerPro and Bourns potentiometer [3][4]

Taking a closer look at the components, there are two main items. The first one is the SG90 micro servo from TowerPro. However, it is too large for a phalanx, thus, the servo is disassembled and fitted into a plastic body, which was individually designed and 3D printed.

However, the potentiometer from the SG90 is too large to fit in any design and it is hard to interface. To solve this issue, it was replaced by another potentiometer which has a D-shape hole in the middle. This way, the potentiometer seamlessly blends in the design. The component used is named Bourns 3382G-2-502G and illustrated on figure 2.

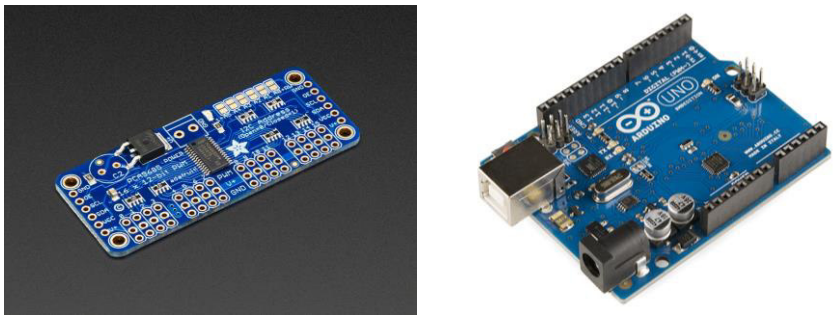

Figure 3. 16-channel PWM driver and Arduino UNO

Continuing with the control system of the device, there are 16 joints that we would like to actuate, as each joint corresponds to a servo, a 16-channel PWM driver is exploited to control all 16 servos.

Additionally, a microcontroller is employed with a popular Arduino Uno. To provide information to the microcontroller of the position of the joints, a laptop transmits the data. Figure 4 illustrates the relationship between the components.

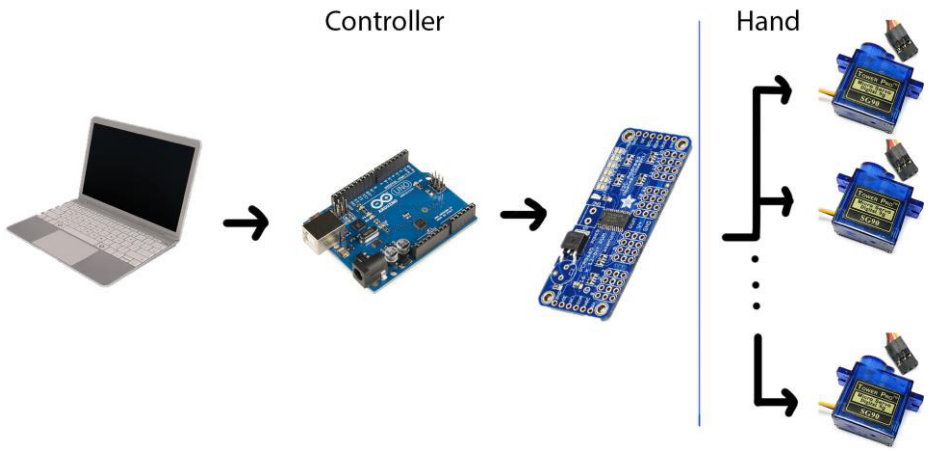


Figure 4. System Overview

In this paper, a 3D printer was used to print out the components which were designed in Fusion 360.

## 3. Results

Continuing with the bionic hand, figure 5 shows the device fully assembled.

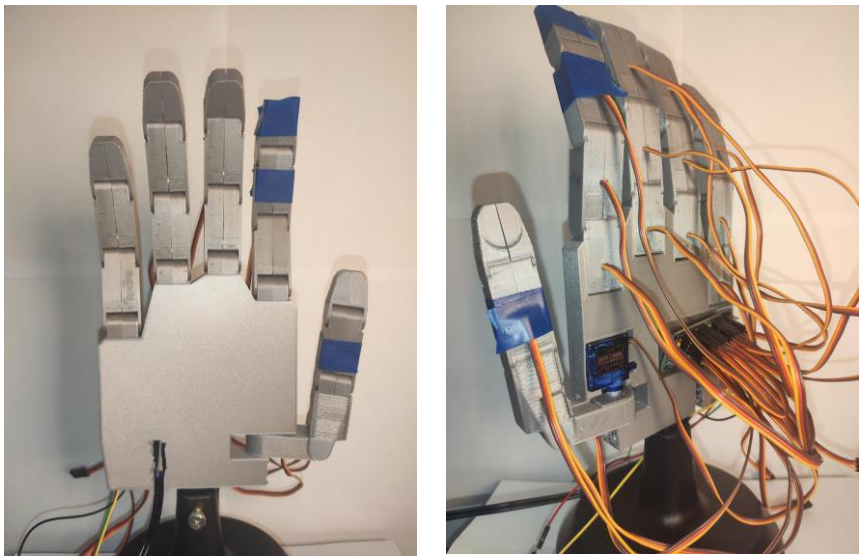

Figure 5. Fully assembled Bionic hand from the back and the front

The device mimics a right hand, with 5 fingers.

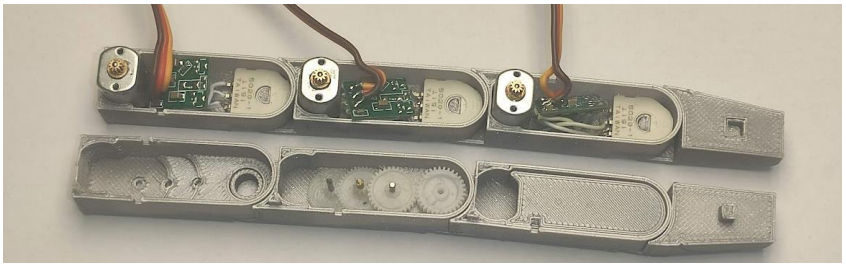

Figure 6. Fully assembled finger inside

Figure 6 depicts a finger of the bionic hand, where the motor, potentiometer and the control board of the phalanges is shown.

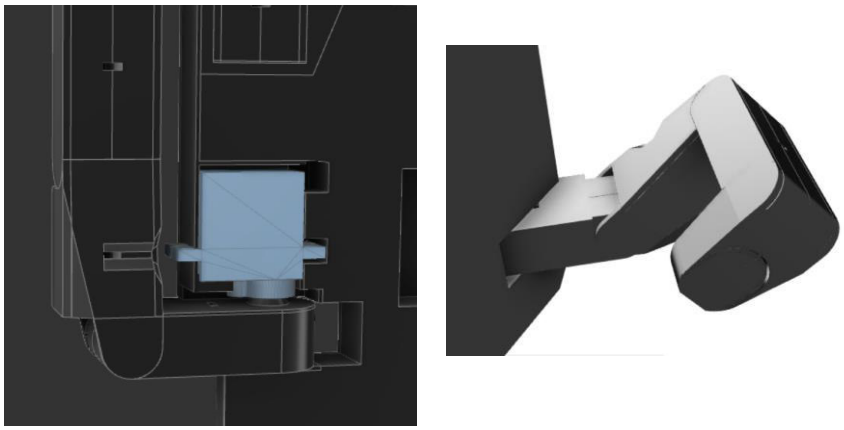

Figure 7. Thumb of the bionic hand

The bionic hand's thumb has 4 joints which provides 4 degrees of freedom to the device, whereas the human hand has 5.

To measure the capabilities of an upper limb prosthesis, a test was developed by Colin Light, Paul Chappell and Peter Kyberd in 2002 at the University of Southampton, which was named SHAP test (The Southampton Hand Assessment Procedure). It is a clinically validated hand function test that is made up of 6 abstract objects and 14 Activities of Daily living. The test is mainly focused on the user and his/her ability to manipulate objects, therefore the latter aspects of the test were omitted. We focused more on the 6 grip patterns of the hand, which are depicted on figure 8. [7]

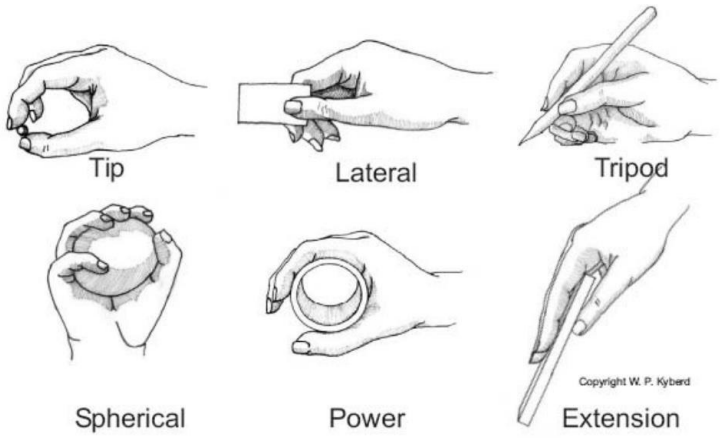


Figure 8. SHAP test [7]

The objects used in this paper are common household objects, such as a tennis ball, lipstick and PET bottles. Figure 9 illustrates the bionic hand performing the grip types specified by the SHAP test.

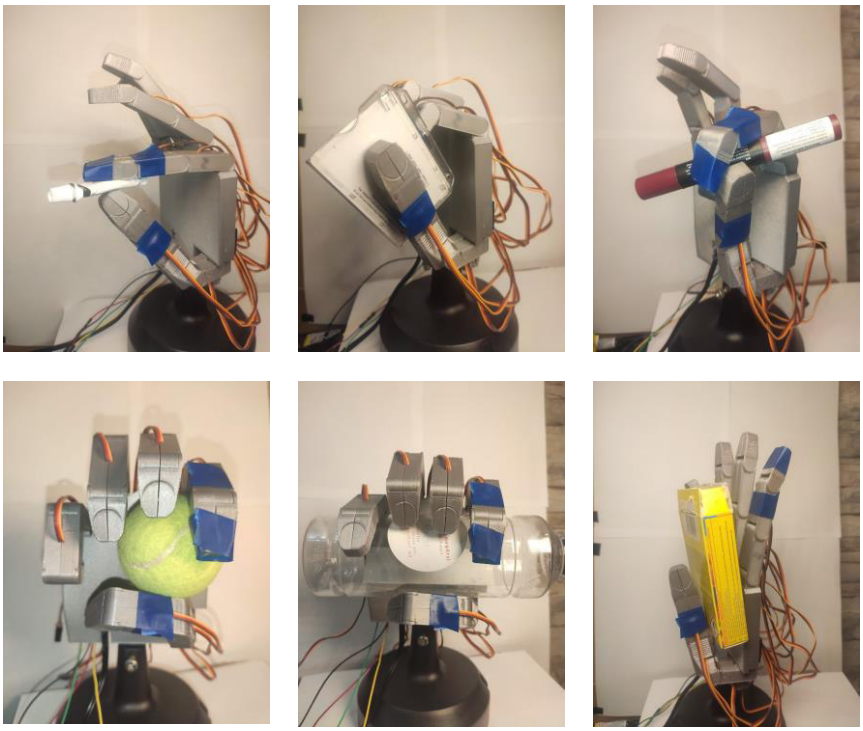

Figure 9. SHAP test results

The bionic hand can perform all the 6 grip types.

## 4. Conclusion

To conclude, this paper created a bionic hand with phalanx built-in servos, which was able to perform all 6 types of grips specified by the SHAP test. Therefore, it could be a functional prophetic hand.

## 5. Reference

[1] Contributors to Wikimedia projects, “Hand,” Wikipedia, Oct. 20, 2022. https://en.wikipedia.org/wiki/Hand (accessed Oct. 29, 2022).

[2] J.-J. Cabibihan, “FIGURE 5,” ResearchGate, Jan. 11, 2021. https://www.researchgate.net/figure/Various-movements-of-the-fingers-A-The-radial-abduction-adduction-of-the-thumb-and_fig5_348437896 (accessed Oct. 29, 2022).

[3] “Amazon.com: American Robotic Supply Tower Pro SG90 Digital Servo,” 2 Pack : Toys & Games. https://www.amazon.com/American-Robotic-Supply-Authentic-Digital/dp/B0783NS32R (accessed Oct. 30, 2022).

[4] “Bourns 5kΩ Potentiometer SMD, 3382G-1-502G,” RS. https://uk.rs-online.com/web/p/potentiometers/7703153 (accessed Oct. 30, 2022).

[5] Contributors to Wikimedia projects, “Arduino,” Wikipedia. https://hu.wikipedia.org/wiki/Arduino (accessed Oct. 30, 2022).

[6] A. Industries, “Adafruit 16-Channel 12-bit PWM/Servo Driver - I2C interface,” I2C interface [PCA9685] : ID 815 : $14.95 : Adafruit Industries, Unique & fun DIY electronics and kits. https://www.adafruit.com/product/815 (accessed Oct. 30, 2022).

[7] G. Merrett, “SHAP: Southampton Hand Assessment Procedure.” http://www.shap.ecs.soton.ac.uk/about-pubs.php (accessed Oct. 30, 2022).