Evolution in Electrical and Electronic Engineering Vol. 3 No. 2 (2022) 1039-1043
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EEEE

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN: 2756-8458

Hybrid Soft Robot Hand

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DOI: https://doi.org/10.30880/eeee. 2022.03.02.122
Received 18 July 2021; Accepted 15 September 2022; Available online 30 October 2022

Abstract: Developing a hybrid soft robot hand from soft and hard materials is one of the new innovations in robot hand technology. Most of the common robot hand nowadays is rigid that influenced less dexterity and compliance. In this research, the Hybrid soft robot hand prototype is designed to focus on mechanical actuation. The model is based on Asian size and designed using SolidWorks. The prototype is fabricated using Thermoplastic polyurethane (TPU) for hard material and Polylactic Acid (PLA) for soft material before being installed with the electrical part. The complete prototype was tested and underwent dexterity experiments like gripping objects and bending each finger. The results show the thumb finger achieved a maximum bending angle of 158.35 degrees, and the middle finger achieved a minimum bending angle of 122.957 degrees.

Keywords: Robot Hand, Soft Robot, Hard Robot, Hybrid Robot, Rigid Hand

1. Introduction

A robot hand is an end-effector attached to a robot arm or a human limb as a prosthetic hand to perform any desired task such as gripping, spinning, or even pinching, depending on the application. Manufacturers have improved the robot hand ragging from industrial application to rehabilitation. Mechanical complexity determines the degree of freedom in design; however, there are usually exchanges as increased complexity can increase device size and reduce strength and durability [1]. The model-like Shadow Hand has 24 joints and 20 degrees of freedom, greater than the human hand [2].

Delta Bionic is another example of Malaysia's manufacturer under a Non-Governmental Organization (NGO) that has developed 3D-printed robotic prosthetic hands for distribution to the disabled. A hard robot hand manufactures each part using hard material such as aluminum, metal, and hard plastic—the hard robot hand-worn on the robotic arm, or prosthetic hand depending on the application [3].

The robot hand can use strength to grasp and move heavy objects and place them back in other's positions [4]. This hard robot hand application is commonly found in robot arms, prosthetic hands, and space applications such as NASA robots. The soft robot hand manufactures soft and flexible materials like silicone, elastic, and rubber. Soft robotic robustly grasping and identifying objects using internal strain [5]. Often for grippers at the end of a prosthetic arm for more delicate and accurate grasping of

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objects. Applications using soft robot hands are available in the medical field, such as Cable-driven soft robot surgical systems, robot arms for food packaging, and laboratory applications for experiment purposes [6]. The study in this research consists of the eccentric application of ABFPA -capable bending in the manufacture of robotic fingers [7].

Combining the hard robot with a soft robot hand called hybrid soft robotic is hypothesized to improve the robot hand in compliance and dexterity. The hybrid soft robot hand is expected to reduce the soft robot's drawback by combining the hard robot in manufacturing, like the human hand's construction, since the rigid robot has several issues and inability to match the human hand. Nevertheless, the mechanical parts, an actuation mechanism, compliance, and dexterity are the problem of ensuring the hybrid soft robot hand matches the human hand.

2. Materials and Methods

2.1 Material

The filament used is Thermoplastic polyurethane (TPU) for hard material and Polylactic Acid (PLA) for soft material. This material is very suitable to fabricate the prototype because it is cheap and high quality.

2.2 Method

From this part, the study focuses on the robot hand's mechanical action to find the smooth movement to achieve dexterously and compliance like a human hand. This research aims to design a robot hand model with compatibility combined with a soft robot hand and electrical parts. Each measurement used in the model design is based on the real Asian human hand range. First, the parameters focused on the size of the palm. Second, the size of the joint to connect the palm to the fingers. Third, the size of the hole for tendon assembly. This part will involve SolidWorks software to design the robot hand model and print using a 3D printer. The servo motor will be installed in the 3D printing model as the main movement of fingers.

2.3 Block diagram of the system

Figure 1 shows the system architecture of the Hybrid Soft Robot Hand.

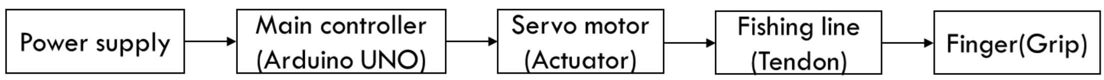

Figure 1: System architecture of the Hybrid Soft Robot Hand

The hybrid soft robot hand operates starts with the power supply to the Arduino Uno. The Arduino is the main controller to actuate the servo motor to give the movement to the fishing line as a tendon of the robot finger. The fishing line is the medium to pull the robot finger to make a gripping work.

3. Results and Discussion

This part is containing two important elements in producing robot hands hybrid soft robot hand. The first focus is to examine the rigid hand whose design follows the specifications required, especially on the mechanical properties to produce a robotic hand that works precisely like the human hand. After the successful design of the hand, the fabrication process is obtained. Next is to discuss soft robot hands. The soft robot hand is the most important part specially designed to get a precise and robust grip surface. Finally, discuss the combination of a rigid hand and a soft robot hand to produce a hybrid that is expected to mimic the human hand. The final prototype is tested in two categories which are the grip and finger bending experiment.

3.1 Results

i. Rigid hand

After studying the rigid hand's mechanical properties, the beginning of the model was designed based on the palm's surface characteristics. The space region inside the palm part is an innovation designed for soft material. The part of the palm is very important when holding an object. A soft material surface with a high grip force and the object did not easily slip during lifting and placed back. Figure 2 shows the final design of the rigid part of the robot hand.

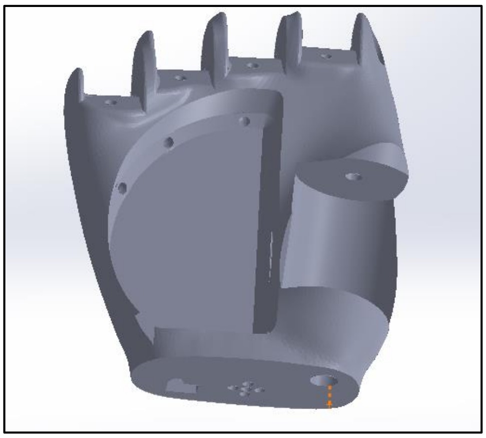

Figure 2: Rigid hand design.

ii. Soft finger

Among them is taking into account the size of the object that can be lifted or held perfectly[2]. The soft finger in this research is designed using soft material. This is intended to focus on the production of strong grips as well as prioritizing flexible features. With this soft material, the object slips' risk while holding the object can be reduced because the fingers will grip at 90º and its high surface force[2]. Figure 3 shows the soft finger design.

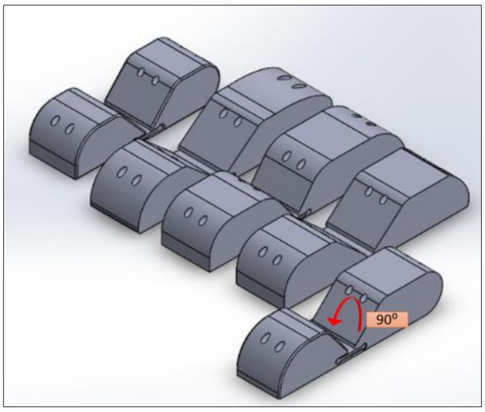

Figure 3: Soft finger design.

3.2 Grip experiment

The grip test has measured the extent to which the hybrid hand-design mechanism works. Therefore, each of these finger grips has a force driven by a servo motor operating with a maximum of 5V. The result is obtained as in Table 1 and presented in the graph shown in Figure 4.

Table 1: Finger grip with the weight of material result.

Material	Weight (Gram)	Voltage Output (V)
Credit card	5	2.48
Tennis ball	59.4	2.58
Badminton racket	78	2.53
Bottle (200ml)	200	2.54

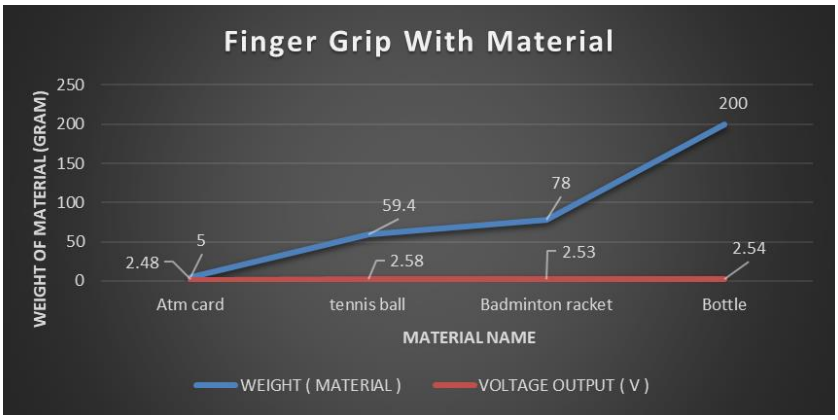

Figure 4: The finger grip with the weight of the material.

3.3 Finger experiment

This bending experiment is a test to determine how this robot finger can perform bending based on the actuation driven by the servo motor. This experiment determined the extent to which this finger for bending approached like a human hand. This experiment is performed by moving each finger at a time. The result is obtained as in Table 2 and presented in the graph shown in Figure 5.

Table 2: Finger Maximum Bending and voltage output

Finger name	Max Bending Angle (°)	Voltage output (V)
Thumb	158.35	4.69
Index	127.382	4.61
Middle	122.957	4.7
Ring	135.952	4.6
Pinky	131.61	4.7

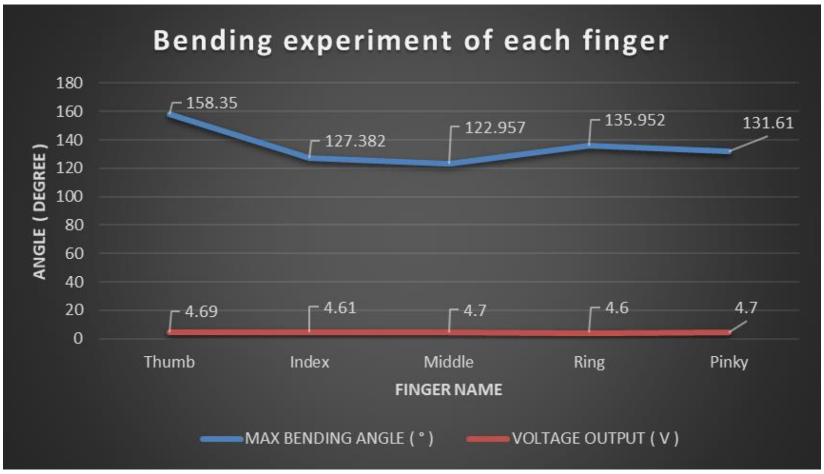

Figure 5: Finger maximum bending.

4. Conclusion

In this research, hybrid soft robot hand is among those still said to have not many researchers who have done the work and still need detailed investigation. However, this research has achieved the objective to design a hybrid soft robot hand model with the mechanical characteristics to achieve dexterity and compliance. Although the function does not reach 100 percent, the measurement result has proven the basis of manufacturing using this hybrid soft and hard material. Next, successfully fabricate and assemble all the hybrid soft robot hand parts in a prototype form. The ability of the results of this assembly has been successfully tested, although only a basic experiment but is very important for future studies. For the next research, this should put a force sensor on the hand. Next, improve the design from the mechanical aspect to provide a smoother and delicate movement. Finally, it is recommended to use the DC external power supply to stabilize the electrical system for the experiment.

Acknowledgment

The authors would also like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, for the facilities, especially the Mechatronic Laboratory, for completing this project and its support.

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