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A Three-finger Robot Hand

Thanathorn Deeseentum, Dhamachart Chanprasartsuk, Thanisorn Sriudomporn and Viboon Sangveraphunsiri*

Department of Mechanical Engineering, Chulalongkorn University, Bangkok, Thailand 10330.
*Corresponding Author: viboon.s@chula.ac.th, Tel: 022186437 Fax: 022522889

Abstract

The objective of this project is to develop a cost effective 3-fingers adaptive robotic hand for flexible usage of grasping object. The native control system of the mechanism is an under-actuated control system. The mechanism consists of two actuators. The first actuator is used for controlling the grasping motion through 2 separated mechanisms while the second actuator is used for controlling the rotation of the hand base. This project aims to survey, in term of analysis and design, hand mechanism, power transmission as well as control system based on the existing hands investigated by many researchers. Then the prototype of the robotic hand is designed and constructed to verify the concept. Various aspects, such as analysis of mechanism and manufacturing with reasonable cost, will be studied to gain more practical purposes. So that the project can be extended to real application in the future and it is possible to extend to be used as an artificial hand.

Keywords: Three-finger Robot Hand, under-actuated, finger mechanism, artificial hand

1) Introduction

Human working abilities have many more limitations when compared that of the machines. Robotic hand is one of the important devices using in robotic arm system. There are many designs of robotic hand which are appropriate for different types of work. However, robotic hand still needs an improvement for better capability in grasping and holding objects with various shapes in order to be capable of performing like a human hand.

Currently, many research about robotic hands not only for manufacturing industry but also other applications such as medical, surveying, rescuing, etc. Our study can also be targeted to be used as an artificial hand. Therefore, the design of the mechanism used should consider efficiency, feedback response, grasping force, grasping position, stability, accuracy and flexibility are inevitably required.

Nevertheless, existing models of robotic hand are still expensive and have some limitations which lead to difficulty in working with general tasks. Thus, this project aims to design and manufacture a three-finger robotic hand which is made from general materials with reasonable cost. Moreover, this project will be able to fulfill user's requirements and understanding of the 3-finger robot hand.

2) Objective

The objectives of this project are to design, manufacture, develop and test a reasonable cost of 3-finger robotic hand and also it could be grasped various shapes object.

3) Principle

The 3-finger robotic hand uses 2 actuators (DC motor) to drive the mechanism. The first actuator is used to control the grasping movement of three fingers by transmitting power through the gear system. The gearing system is composed of 2 planetary gear sets. The finger mechanism is driven by the power from the driving system that is evenly divided amongst the 3 fingers. Practically, when one of the fingers makes a contact with the object, it will stop and allow the other 2 fingers to continue moving according to the grasping moment. Power from the gear system will transmit to 3 transmitting cranks which are connected to finger mechanisms in order to drive grasping movement.

The second actuator is used to drive finger steering system which can rotate the finger base for various pattern of grasping.

The control system is implemented on microcontroller (Arduino) using the C-language. The diagram shown in Fig.1 illustrates how the

control system is developed. The motors are driven by the L298N Dual H-Bridge. The commands to drive the motor controller is from the developed application program. The switches, attached at the mechanism, are to maintain the motion within the pre-defined working space.

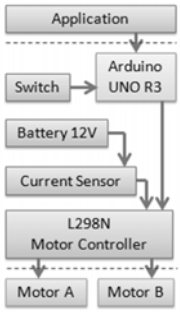

Fig.1 Control system diagram

4) Mechanism Design

The software CAD/CAM (in this case is CATIA) is used as the development tool to reduce development time. The designed mechanism can be simulated to check the correctness of the design. This reduces a lot of rework time. The design of this project can be divided into 6 parts as follows.

4.1 Finger mechanism

The finger mechanism has 3 joints similar to human finger for high grasping movement efficiency. Fig. 2 shows how to form the finger mechanism. The mechanism is designed based on a well known four-bar linkage.

The finger can be divided in to two side. Mechanism on the left side (No.1) is used to drive the grasping movement and mechanism on the right side (No.2) is used to keep the finger straight by using 3 springs before contacting the object.

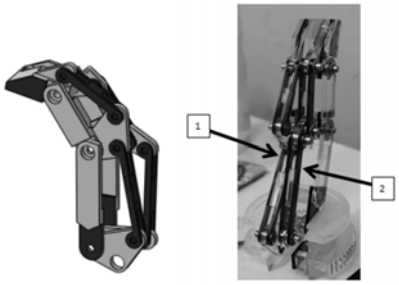

Fig.2 Finger mechanism 3D CAD model

4.2 Main Structure

This part is composed of 4 layers. The upper 2 layers are used as the base of the 3-finger mechanism whereas the lower 2 layers are used for carrying the weight of whole system and installing the control system . Between the upper and lower layers, there are 6 legs for tranfering weight from upper layers to the base of this structure.

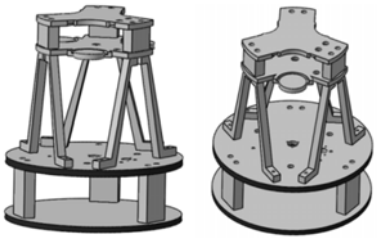

Fig. 3 Main structure 3D CAD model

4.3 Gear transmission system

This part has 2 planetary gear systems inside for dividing power to each finger mechanism. The output power from this system is transferred to power transmitting crank by the 3 upper gears.

Section 1 which is attached to the motor rotates after user command the grasping application on smart phone. Three planet gears No.6 in section 1 rotate and transmit power to sun gear No.9 and ring gear which is attached to section 2. The sun gear is attached to the middle shaft which is an axle for upper gear No.5.

Inside section 2 is the another planetary gear system which is composed of 2 layers. After section 2 rotates, three planet gears No.10 transmit power to sun gear No.8 which is attached to upper gear No.4.Whereas three planet gears No.7 transmit power to ring gear which is attached to section 3. Finally, the three upper gears transmit the power to three power transmitting cranks equally.

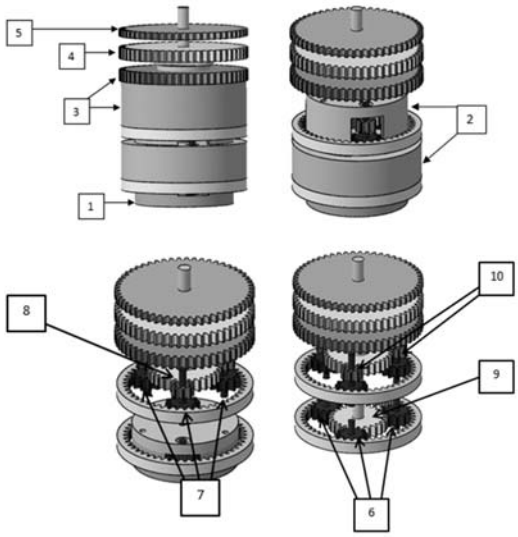

Fig. 4 Gear transmission system 3D CAD model

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4.4 Power Transmitting Crank

Power transmitting crank receives the power from each gear transmission system and transmit the power to the grasping movement of the 3-finger mechanisms . It is composed of 3 main components which consists of stud and gear, nuts which is packaged inside the specifically designed structural support and transmitting crank.

The power transmitted from gear transmission system transfers to 3 studs through gear No.1 for each finger. Then, the specifically designed structural support No.2 which has nut inside translate in vertical axis. To avoid the rotation of structural support , three shafts which are attached to the main structure guide structural support through slide bearing . Finally, the 3 transmitting cranks which are attached pivotally to structural support transmit power to the each finger mechanism.

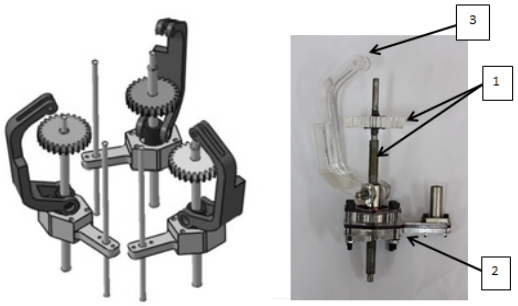

Fig.5 Power transmitting crank 3D CAD model

4.5 Steering system

The steering system uses 1 actuator to rotate 2 finger mechanisms for changing grasping patterns.

The motor transmits the power to gear No.1 through shaft after user commands the appliction on smart phone. Gear No.1 transmits the power to Gear No. 2, 3 and 4 in order to rotate finger base in opposite directions.

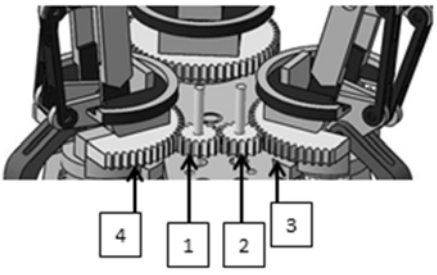

Fig. 6 Steering system 3D CAD Model

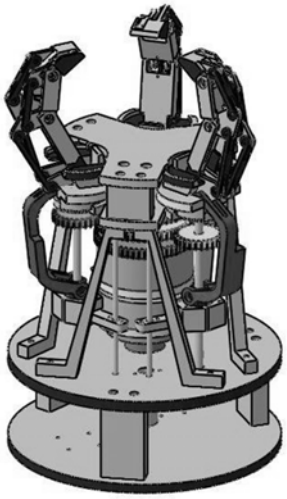

Fig. 7 Assembly Model

5) Manufacturing Process

"CATIA" program is used in this project to design 3D CAD model due to its convenience in working with laser cutting machine which would improve the design efficiency. Laser cutting machine is capable of cutting flat acrylic plate according to the 2D design in which those cut parts will later on be constructed together to obtain 3D parts. Then, the 3D parts are assembled with metal shaft,spring,bearing or other mechanical parts in order to make them become the finger mechanism , structure ,cyufpo, gear transmission system . After all of the mechanisms are done, they are combined as a the 3-finger robotic hand. The control system will be designed afterwards.

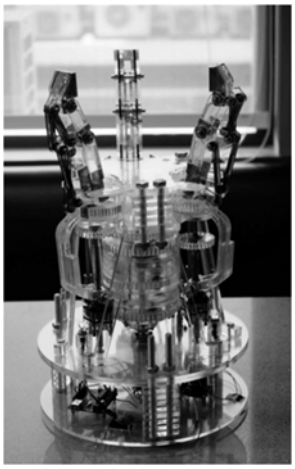

Fig.8 Three-finger robot hand after manufacturing process

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6) Control system design

The control system consists of 3 equipments which are controller board Arduino Uno R3, motor controller board L298N and 12V DC motor. Firstly, the code from the computer is uploaded to the circuit board. Then, The speed and direction of the motors are controlled by H-bridge Motor controller. After that, an application in Android-based devices, MIT app inventer is utilized to create the user interface that would allow the user to send the command to Arduino Uno R3 instead of computer using Bluetooth module HC-05.

After install the switches in the system, the system will stop when three switches are pressed to prevent the damage from moving beyond the starting point. The current sensor is the last equipment that is put into the systhem to stop the finger when it grasp the object tight enough by setting the maximum current passing through the motor controller. Current sensor will prevent the motor controller from over-current damage. The wiring diagram is designed using program called Fritzing before manufacturing to decrease an error in manufacturing.

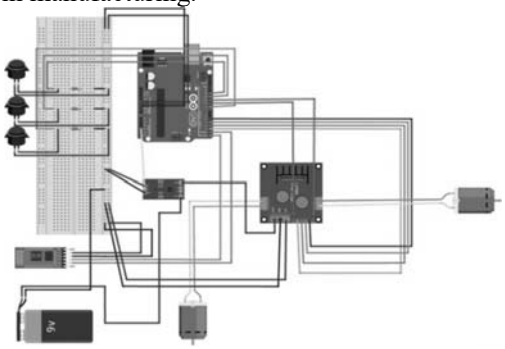

Fig.9 Wiring diagram

7) Result

The result of this project showed that the robotic hand can grasp objects with various shape such as cylindrical, spherical, ellipsiscal, non symmetrical ,cubic and as well as flat plate as shown in figures as follows.

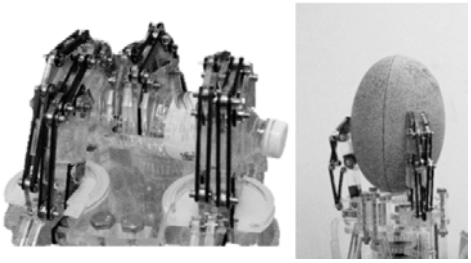

Fig.10 The result of grasping ellipsiscal and cylindrical object

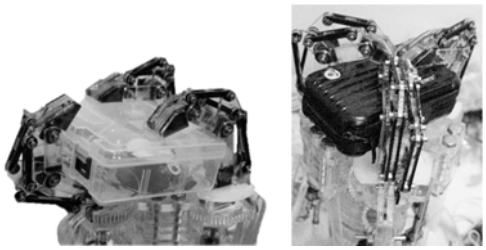

Fig.11 The result of grasping rectangular object

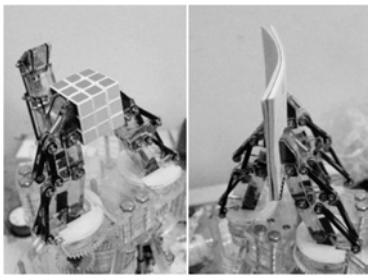

Fig.12 The result of grasping cubic and flat plate object

Fig.13 The result of grasping non symmetrical object

8) Discussion

After testing the robotic hand, there are some errors although it can grasp many shape of object. When all of the three fingers make contact the object, the motor will improve torque and current. With the more current fed into the circuit board, the current reaches its maximum allowed current which is 2 mA. Therefore, the current sensor is essential in the system in order to measure the current.

Most parts of this robotic hand are acrylic because it is easy to buy and manufacture. Due to the brittleness of acrylic and an inaccuracy of laser cutting machine, many parts of this project have to be designed to be large. Hence, sizes and material choices for all the parts could be scaled down as a suggestion for the future work.

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The application for control robotic hand mechanism uses Bluetooth to connect between controller board and smart phone. In some specific case, the application can't transmit the signal to controller board because the application is created from readymade application which has a few errors.

9) Conclusion

This project can achieve the objectives which are to design, manufacture, develop and test the 3-finger robotic hand which could grasp objects with various shapes under the certain budget. This project can be useful in the future although there are some errors. Errors can be reduced according to the list below

1. The size of robotic hand can be reduced by changing its material to metal which has higher yield strength and can provide reasonable ductility. The metal can be manufactured by CNC machine in order to improve the precision, in term of size and dimension, of metal parts.
2. The robotic hand can be improved in term of the maximum grasping force by changing motor controller board which can handle more current.
3. Application-and-user communication stability could be enhanced by developing the source code with computer programming language according to the designer's thought instead of readymade application.

10) References

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