FAKULTI KEJURUTERAAN ELEKTRIK

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FINAL YEAR PROJECT

DEVELOPMENT OF TELE-OPERATED ANIMATRONIC HAND

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Bachelor of Mechatronics Engineering

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Supervisor's Endorsement

"I hereby declare that I have read through this report entitle "Development of Tele-Operated Animatronic Hand" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature : .....

Supervisor's Name : .....

Date : .....

DEVELOPMENT OF TELE-OPERATED ANIMATRONIC HAND

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A report submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF MECHATRONICS ENGINEERING

Faculty of Electrical Engineering

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Student Declaration

I declare that this report entitle “Development of Tele-Operated Animatronic Hand” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

Specially dedicated to my beloved mother and father

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ABSTRACT

Robotic hands create safe working environment especially in industries and eventually help to avoid injuries in handling hazardous items or objects. The importance of doing this project is to come out a hand that able to handle object better for industry. The early design of this gripper has only 2 fingers where the tendency of slippage might occurs in which accident or unwanted things may happen. The significant of doing this project is to create an animatronic hand via glove that can substitute real human hand and reduce the tendency of slippage where it eventually reduce accidents. Thus, the ideas of highly accurate tele-operated 14 DOF animatronic hand that able to handle items or objects well and the ability to imitate human hand is proposed. The experiment will be analysed in terms of tele-operation accuracy and repeatability which will be carried out in lab. In this project, this tele-operated animatronic hand will have 5 fingers and have the ability to copy human hand movement. Plastic is used to fabricate this hand and flex sensor will be used to sense the movement of human hand. The expected result of this project is that the design hand is able to imitate the real human hand with a high accuracy value of 85.32% for pinky finger, 89.25% for ring finger, 89.83% middle finger, 91.03% index finger and 90.34% thumb. In conclusion, the tele-operated animatronic hand accuracy can be achieved by increasing the length of the crank and is verified in the accuracy test. Thus, the objectives are achieved.

ABSTRAK

Tangan robotik mewujudkan persekitaran kerja yang selamat terutamanya dalam industri dan akhirnya membantu untuk mengelakkan kecederaan dalam mengendalikan perkara berbahaya atau objek. Kepentingan melakukan projek ini adalah untuk menghasilkan tangan robot yang mampu untuk mengendalikan objek yang lebih baik bagi industri. Reka bentuk awal penggenggam hanya mempunyai 2 jari di mana kecenderungan kekuatan untuk tergelincir boleh berlaku di mana kemalangan yang tidak diingini atau perkara boleh berlaku. Projek ini adalah untuk mewujudkan satu tangan animatronic melalui sarung tangan yang boleh menggantikan tangan manusia sebenar dan mengurangkan kecenderungan gelinciran di mana ia akhirnya dapat mengurangkan kemalangan. Oleh itu, idea-idea yang dicadangkan untuk projeck ini ialah 14 DOF tangan animatronik yang tele dengan tangan manusia yang mampu menangani perkara atau benda-benda yang baik dan mempunyai keupayaan untuk meniru tangan manusia. Sistem keseluruhan akan dianalisis dari segi ketepatan tele-operasi dan kebolehulangan. Eksperimen akan dianalisis dari segi ketepatan tele-operasi dan kebolehulangan yang akan dijalankan di dalam makmal. Dalam projek ini, ini tangan animatronik tele yang beroperasi mempunyai 5 jari dan mempunyai keupayaan untuk meniru pergerakan tangan manusia. Plastik biasa digunakan untuk membuat tangan ini dan flex sensor akan digunakan untuk mengesan pergerakan tangan manusia. Keputusan yang dijangka dari projek ini adalah bahawa tangan reka bentuk mampu meniru tangan manusia sebenar dengan nilai ketepatan yang tinggi 85.32% untuk jari pinky, 89.25% untuk jari manis, 89.83% jari tengah, 91.03% jari telunjuk dan ibu jari 90.34%. Kesimpulannya, ketepatan tangan animatronik yang tele dengan tangan manusia yang beroperasi boleh dicapai dengan menambah kepanjangan engkol dan dibuktikan dalam ujian ketepatan. Oleh itu, objektif tercapai.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In today's world, robots have become part and parcel of human life. The population of robots have tremendously increasing year by year which can be clearly seen when Arturo Baroncelli, the President of the International Federation of Robotics (IFR) [1] stated that Year 2013 has shown another record in the sales of robot with 168,000 of units. This quantities of robots sales has a high magnificent demand in the Asian market which can be referred to Metra Martech's report "Positive Impact of Industrial Robots on Employment Updated in January 2013". The growth of industrial robots will continue to accelerate.

Robotic hands are widely used because of its abilities to perform and do more tasks in many aspects like medical, research, industries and many more than human can do. It is widely used especially in industrial processes and has replaced numerous operators or workers due to its speed, product quality, more accurate, more productivity and low tendency of making mistakes compare to humans.

1.2 Motivation and Significant of the Research

Robots have the ability to imitate or copy human movement like hands, legs, body and other parts of body. According to Peter Gorle, "Positive Impact of Industrial Robots on Employment Updated in January 2013" [2], human unable to make products with precision or consistency like robots, working conditions of robots are more ideal than human and the labour cost imbalanced can be well-balanced when robots are used.

Robots have the abilities to perform and do more tasks in many aspects like industries, chemical, medical and many more than human can do. According to Mathias Wiklund, COO Comau, Robotics, Italy [3], robots are widely used due to its abilities which resulted in lots of new applications needed to be explored. He added that in automotive business especially will likely be the biggest in worldwide that use robots for a long period of time in terms of quality, productivity and many more.

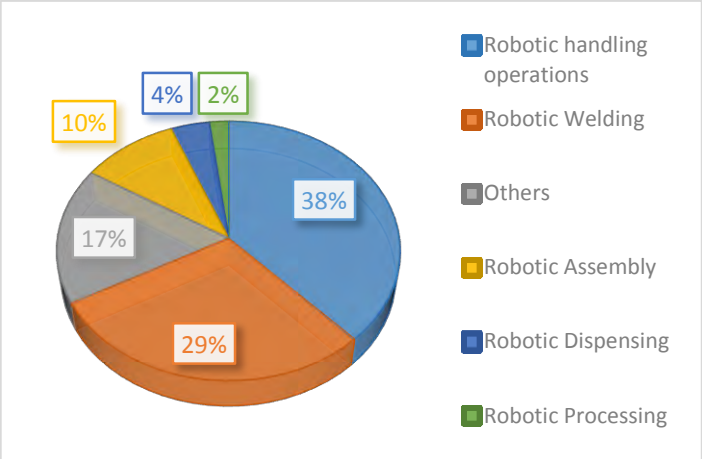

Figure 1.1: Applications of Industrial Robots [4]

According to a survey made by the IFR Statistical Department, World Robotics, 2010 [4] shown in Figure 1.1, Robotic handling operations (38%), Robotic Welding (29%), Robotic Assembly (10%), Robotic Dispensing (4%) and Robotic Processing (2%) are 5 top applications used in industry.

In robotic hand handling section, there are many problems that occurs while handling items, products or objects. Sometimes, it can affect the product, objects, tools or human itself (workers) especially in Industries. For example like slippage of a hazardous chemical products or any objects which sometimes may lead to death. To overcome this problem, many technology has been used to developed robotic hand which focus more on the end effectors (grippers). Different robots used different types of grippers. The grippers or end effectors plays an important role to hold or place an items, thus, the grippers must be designed in the best design.

The importance of doing this project is to create an animatronic hand via glove that can substitute real human hand and reduce the tendency of slippage where it eventually reduce accidents. Thus, this project is going to propose the ideas of animatronic hand for industries which can handle the object, tools or products better.

1.3 Problem Statement

Robots have helped many industries especially in the areas of safety. This statement can be supported when Marlin Steel, Baltimore, MD, USA [2], stated the advantages of using robots makes the working environment safe. He added that, robot not only helps to create a safe working environment, but also benefit the company and workers. Robot hands helps to avoid injuries especially in handling hazardous things. This can be seen in Figure 1.2 where the injury is cause by hydrofluoric acid (used for metal cleaning, glass etching and many more) [5]. Many injuries like back pain (ergonomic issues) and many more types of injuries can lead to fatal error or maybe worse, death if it is not well treated. Thus, the ideas of animatronic hand is proposed.

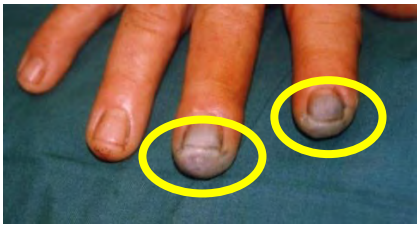

Figure 1.2: The injury of hands cause by hydrofluoric acid [5]

Robot hands especially the end effectors is the most crucial parts of robots hands in handling process. The Design of a Robotic Arm with Gripper & End Effector for Spot Welding developed by Puran Singh, Anil Kumar, Mahesh Vashisth from the Department of Mechanical and Automation Engineering, Amity School of Engineering and Technology Delhi, India, 2013 [6], designed a gripper with 2 DOF with 2 fingers to pick, hold and grasped various types of objects (shapes).

The disadvantages of using gripper is that the handling is not as secured as normal hand (five fingers) due to its number of fingers (two). Thus, this project is going to propose the ideas of animatronic hand for industries which can handle the object, tools or products better. This animatronic hand imitates the movement of human hand so that the work done is better.

In order to make the animatronic hand better in handling the product, the challenges faced in designing this hand is to make every designed fingers movement to be accurate and no delay. In order to make the designed animatronic hand more accurate in movement and no delay, the idea is proposed by increasing the length of the crank. By increasing the length of the crank, the movement will be more precise as it will pull the string farther which will make the fingers to bend more compared to shorter crank. However, by increasing the length of the crank, the force required for the shaft to move is greater when it pulls further due to the weight of the added load. In order to find balance solution between accuracy and force, I assume by using a lighter object to extend the length of crank. When lighter object is used to extend the crank, the accuracy can be achieved, thus the force due to the weight of added load can be lessen.

1.4 Objective

The objective of this research are:-

1. To design highly accurate tele-operated 14 DOF animatronic hand (prototype)
2. To analyse overall system performance in terms of tele-operation accuracy and repeatability

1.5 Scope

This project involves two parts which are hardware and software. The scopes of this project are:-

i. To fabricate the tele-operated animatronic hand for grasp purposes that has 14 DOF
ii. Each finger used only one actuator with limited movement and it do not have any ball joint
iii. The glove only able to control one movement of each finger
iv. To produce animatronic hand by using piping tube with the size of 5.5cm - 7.5cm which will be used as fingers thus it does not have the ability to carry a heavy object
v. Size of the palm is from the range of 8cm – 9.5cm
vi. The experiment will be analysed in terms of tele-operation accuracy and repeatability which will be carried out in lab

1.6 Report Outline

The first chapter is about a brief explanation on the research background of animatronic hand on the reason why robot hands are required in industries. Motivation is the main idea of making this project and problem statement is included to identify and solved the problem in making of animatronic hand. The objective is included to see whether it is achieved at the end of the animatronic hand project and the scope is also included in this report to limit certain criteria that is unable to achieve due to some reason.

The second chapter is about the literature review of animatronic hand. It is mainly about the theory and basic principles of animatronic hand, anatomy of human hands, review of previous works or journal and the summary and the discussion of the review.

The third chapter is about methodology and is divided into four which are the introduction, the design highly accurate tele-operated 14 DOF animatronic hand and the analysis of overall performance in terms of accuracy and repeatability. Introduction in this section is mainly about the method used to achieve all objectives. Next is the design highly accurate tele-operated 14

DOF animatronic hand which consists of the design parameter, the components selection of the animatronic hand and tele-operated hand, electronic circuit for animatronic hand and tele-operated and component selection for the design circuit. Finally, the analysis which is about the complete procedure of the experiment and safety precautions.

The fourth chapter is about the result and discussion. In this chapter, the result of the test in terms of accuracy and repeatability is shown and discussed.

Finally, the last chapter is about conclusion and recommendation. This chapter will conclude all the tele-operated animatronic hand project whether it achieved the objective or not. Recommendation will be made to proposed other advanced idea or materials that can be added in the tele-operated animatronic hand.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory and Basic Principles

This section covers about the theory and the basic principles of animatronic hand that are related to the development of animatronic hand. It covers with three subsection which are animatronic hand, anatomy of human hand and basic principles. Animatronic hand covers the theory of animatronic hand and how it works. Anatomy of human hand covers about the basic theory of human hand and basic principles is mainly about the principle on how the material like sensor works.

2.1.1 Animatronic Hand

According to Macmillan Dictionary, 2009-2014 [7], animatronic means a technology that use an electronic system to operate a puppets like models of an animals or people or can be simplified as the combination of animation and electronic.

Animatronic hand has many different types of design and various ways to control the hand not to mention, the types of sensors and actuator used. There are many types of Animatronic hand like shadow dexterous hand, dexterous robotic hand and many more. Animatronic hand [8] shown in Figure 2.1 is one of the types of animatronic hand that uses a glove to move a design hand where the design hand imitates the

movement of real human hand. The glove uses flex sensors as the sensors and servo motors as an actuator. When the glove (flex sensors are attached on the glove) moves, the servo motors will pull the wires that attached to each fingers of the design hand.

Figure 2.1: Animatronic Hand [8]

2.1.2 Anatomy of Human Hand

According to Oxford Dictionary, 2014 [9] states that hand is defined as the end part of an individual arm beyond the wrist including the thumb, fingers and palm.

According to Aristotle, Di partibus animalium: 687a 7, ca. 340 BC [10], hand is the key of human intelligence which only humans are gifted with the hands that capable of doing different tasks such as handling and sensing. Our hands are one of the most complex part of our bodies that consist of fifty four bones in different variation of sizes and able to accomplish a wide range of tasks. When it comes to robotic hand, it cannot compete with actual hands due to its structure, materials used and many more. Brand and Hollister 1999; Kry et al. 2002 [11] states that human hand consist of bones, muscles, skin, tendon and complicated relationships between them. According to Orthogate and the Internet Society of Orthopaedic Surgery and Traumatology (I.S.O.S.T), 1999-2014 [12], Human hand consists of twenty seven bones and twenty seven joints shown in Figure 2.2, thirty four muscles, countless blood vessels, nerves and soft tissue with a hundred over ligaments and tendons shown in Figure 2.3. Human hand can be classified into three groups which are wrist, carpal and digital bones shown in Figure 2.4.

Figure 2.2: A picture of hand with twenty seven bones and twenty seven joints [12]

Figure 2.3: A picture of hand with thirty four muscles, countless blood vessels, nerves and soft tissue with a hundred over ligaments and tendons [12]

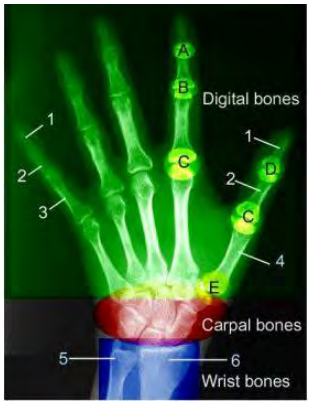

Figure 2.4: Human hand is classified into three groups which are wrist, carpal and digital bones [13]

According to Mufa T. Ghadiali, M.D., F.A.C.S ,Diplomate of American Board of Surgery [13], Carpal bones is situated at wrist that consist of eight bones that connected to five metacarpal bones where each metacarpal bone linked to finger. Each of our fingers has three phalanges and two joints except thumb which has two phalanges