MULTIFINGERED ROBOT HAND ROBOT OPERATES USING TELEOPERATION

MOHD KHAIRUL IKHWAN BIN AHMAD

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Universiti Tun Hussein Onn Malaysia

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ABSTRACT

The purpose of research on anthropomorphic dextrous manipulation is to develop anthropomorphic dextrous robot hand which approximates the versatility and sensitivity of the human hand by teleoperation methods that will communicate in master– slave manners. Glove operates as master part and multi-fingered hand as slave. The communication medium between operator and multi-fingered hand is via KC-21 Bluetooth wireless modules. Multi-fingered hand developed using 5 volt, 298:1 gear ratio micro metal dc motors which controlled using L293D motor drivers and actuator controlled the movement of robot hand combined with dextrous human ability by PIC18F4520 microcontroller. The slave components of 5 fingers designed with 15 Degree of Freedom (DOF) by 3 DOF for each finger. Fingers design, by modified IGUS 07-16-038-0 enclosed zipper lead E-Chain® Cable Carrier System, used in order to shape mimic as human size. FLEX sensor, bend sensing resistance used for both master and slave part and attached as feedback to the system, in order to control position configuration. Finally, the intelligence, learning and experience aspects of the human can be combined with the strength, endurance and speed of the robot in order to generate proper output of this project.

ABSTRAK

Tujuan kajian terhadap manipulasi kelincahan perilaku adalah untuk membangunkan perilaku tangkas robot tangan yang mana menghampiri kebolehan dan pemahaman robot tangan dengan cara teleoperasi yang dapat berkomunikasi dalam urusan Master-Slave. Sarung tangan beroperasi sebagai bahagian Master manakala tangan robot pelbagai jari adalah sebagai Slave. Medium komunikasi antara operator dengan tangan robot pelbagai jari adalah melalui Modul Bluetooth SKKCA:KC-21. Modul Bluetooth tanpa wayar dibangunkan menggunakan motor arus terus logam mikro 5V dengan nisbah gear 298:1 yang dikawal menggunakan pemacu motor L293D dan aktuator mengawal pergerakan robot tangan digabungkan bersama kemampuan ketangkasan tangan manusia dengan mikropengawal PIC18F4520. Komponen bahagian Slave lima jari direka dengan 15 darjah kebebasan (DOF) dengan 3 darjah kebebasan (DOF) pada setiap jari. Rekaan jejari mengunakan *IGUS 07-16-038-0 enclosed zipper lead E-Chain® Cable Carrier System*, yang telah diubahsuai, digunakan untuk membentuk seakan saiz tangan manusia. Sensor FLEX, penderiaan kerintangan menekuk digunakan pada kedua-dua bahagian Master dan Slave serta dilampirkan sebagai suap balik kepada sistem untuk mengawal konfigurasi kedudukan. Akhirnya, kepintaran, pembelajaran dan aspek pengalaman manusia boleh digabung dengan kekuatan, daya tahan dan kelajuan robot dalam usaha untuk menghasilkan hasil keluaran yang sesuai untuk projek ini.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADC	Analog to Digital Converter
AN	Analog pin of PIC
AT	Attention Command
BD	Bluetooth Device
Bps	Bits Per Second
BT	Bluetooth
COM	Computer
DOF	Degree of Freedom
EM	Electromagnetic
I	Current
ISM	Integrated System for Mobile Communications
PC	Personal Computer
PIC	Programmable/Peripheral Integrated Circuit
PWM	Pulse Width Modulation
R	Resistance
Rx	Receive
SPP	Serial Port Profile
Tx	Transmit
UART	Universal Asynchronous Receiver and Transmiter
USART	Universal Synchronous-Asynchronous Receiver and Transmiter
V	Voltage

°	Degree
K	Kilo
Ω	Ohm

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CHAPTER I

INTRODUCTION

1.1 Project Background

A robot hand is defined as that can mimic the movements of a human hand in operation. Stable grasping and fine manipulation with the multi fingered robot hand are playing an increasingly important role in manufacturing and other applications that require precision and dexterity, see APPENDIX A. Nowadays, most of robotics hand with multi-fingered used as service robot, human friendly robot and personal robotics.

Teleoperation is the controlling of a robot or system over a distance where a human and a robot collaborate to perform tasks and to achieve common goal. The operator is the human controlling entity, whereas the teleoperator refers to the system or robot being controlled. Traditional literature divides tele-operation into two fields: direct teleoperation, with the operator closing all control loops and supervisory control, if the teleoperator (a robot) exhibits some degree of control itself [1].

Tele-presence means that the operator receives sufficient information about the tele-operator and the task environment, displayed in a sufficiently natural way, that the operator feels physically present at a remote site [1]. The feeling of presence plays a crucial role in teleoperation, the better he can accomplish a task.

Advanced research had been conducted to produce advantages to the robot industries by considering combination of telecommunication systems with another robot increasing group work robots in order to speed up the performance of the tasks and works. One method type of communication system that can embed into the robots peripheral is via using Bluetooth technology.

1.2 Problem Statements

The challenging thing is to develop anthropomorphic dexterous multi-finger robot, in order to get the precise and accurate grasp of the robotic hand. It is approximate the versatility and sensitivity of the human hand. Nowadays these are various types of robotics hand and its application. The most important aspects to be considered are their stability, reliability and economically. Main parts are a characteristic of robot hand is not the same as human. All of robot hand mechanism totally related to the cost. Simplifying the robot mechanism with less cost which is similar to human is most challenging task. Therefore, design and fabrication of human hand will be done in this research especially for master-slave with Bluetooth communication network.

1.3 Project Objectives

The main objective of this project is to investigate the characteristic and performance of the development of an artificial robot hands to mimic the human hand on manipulating the objects by introducing the teleoperation system.

1.4 Project Scopes

This project is primarily concerned with the artificial robots hands applied with sensors mimic to the human hands. The scope of this project involves two parts which is hardware and software implementation. In the hardware part, there are two other sub parts which is categories as hardware design and circuit design.The scopes of this project are:

a) To fabricate robot hands with 15 degree of freedom fingers capable of applying independent forces to a grasped object.

b) To produce a teleoperation artificial five fingers robotic hand which mimic the human hand on manipulating the objects as well as contribute to the solution of robot end effectors grasping problem and robot reprogramming difficulty

c) To control the movement by using glove to integrate with hand and teleoperate by Bluetooth wireless module.

d) To design control parts of the robot hand by PIC18F4520 18's family mid-range microcontroller as controller.

CHAPTER II

LITERATURE REVIEW

2.1 Robotic Hand Technology Developments

Robotics technology nowadays moves forward until now. The technology developments since 70's era until now are rapidly changing the robotic hand engineering history. Existing hand now can divided into four types where are; Robot hands of 80's, Commercial hands, Research hands and Prosthetics. Development of robot hands early 80's start with, Soft gripper in Figure 2.1- *Hirose Soft Gripper* by Shigeo Hirose from Tokyo Inst. Technology. This development began late 70's with 1 DOF when it graduated pulleys at joints and create evenly distributed forces [2].

Figure 2.1: Hirose Soft Gripper [2]

Then, in 80's, *Rajko Tomovic* and *George Bekey* pioneering effort in development of first prototypes *Belgrade / USC hand* in Figure 2.2 after World War II ,four DOF (1 for each pair of fingers and two for thumb).It's also have some adaptability such as one finger in a pair if other stalls can flex [2].

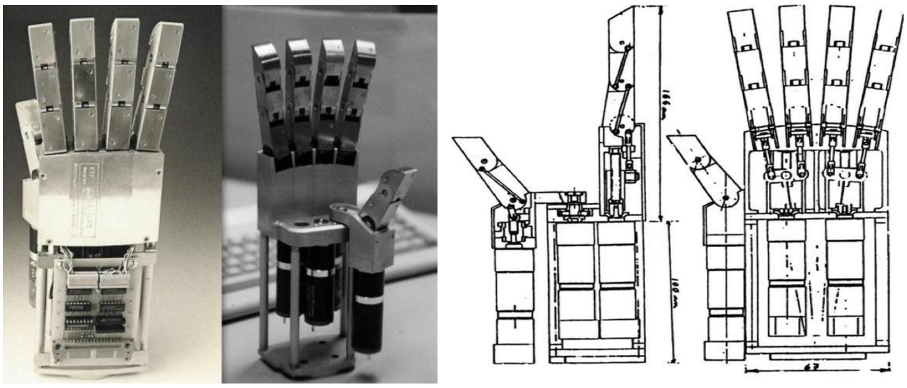

Figure 2.2: Belgrade / USC hand [2]

In the same era, more development and research done for this field to upgrade the prototypes and technologies. For example *Stanford/JPL hand* in Figure 2.3 prototype with nine DOF designed. Others feature such as four tendons or finger also designed for fingertip manipulation is combined with strain gauge fingertip sensors [2].

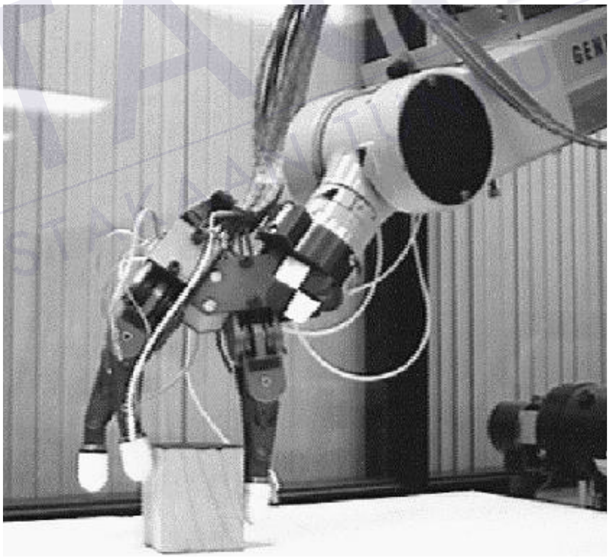

Figure 2.3: Stanford/JPL hand [2]

Then *Utah / MIT hand* in Figure 2.4 developed in 80’s upgrade with 16 DOF with 32 tendons. Sensor used for position and tendon tension sensing by Hall Effect. This hand strength durability about 7 lb. fingertip force same as human level with complex tendon mounting scheme [2].

Figure 2.4: Utah / MIT hand [2]

Hence the research and development in this disciplined increased and move towards, more of prototypes being commercialize being robotic hand products due to highly demand in industries or another platform also commercialize . *Barrett hand* from Barrett Technology in Figure 2.5, Incorporated used 4 motors, one motor per finger for three finger and plus another spread motor for palm. The breakaway technology allows fingers to adapt to object geometry. It's also including the optical encoder for position sensing. This hand capability to maintain up to 3.3 lb. fingertip force and the weight of this hands about 1.18 kg. Finally, this commercial hand sells about 30K US Dollar [2].

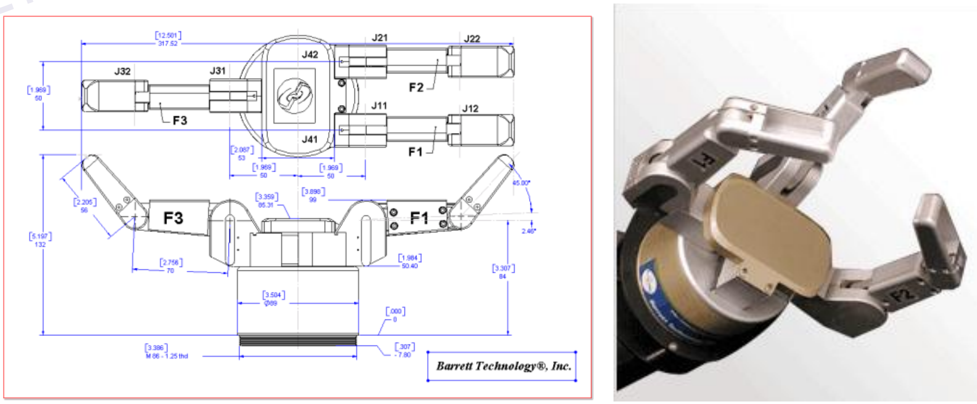

Figure 2.5: Barrett hand [2]

After that, *Gifu Hand* in Figure 2.6 developed by *Kawasaki* and *Mouri*, *Gifu University* which is sold by *Dainichi* Company. It i s about 50K US Dollar with 0.6

lb. fingertip force and this hand weight is 1.4 kg. *Gifu Hand* have 16 controlled DOF (last two joints coupled except thumb) combined with pressure sensing, but no accurate position sensing. One of this disadvantage is its size is larger than human size and its sensor not too sensitive [2].

Figure 2.6: Gifu hand [2]

Another commercial hand is *DLR / HIT hand* in Figure 2.7 developed by *Gerhard Hirzinger*, This hand sold by *Schunk* Company about USD 60K. This hand larger than human size which is capability to maintain up to 1.5 lb. fingertip force with Hall Effect sensors and the weight of this hand about 2.2 kg. It has 13 controlled DOF (last two joints of each finger are coupled) [2].

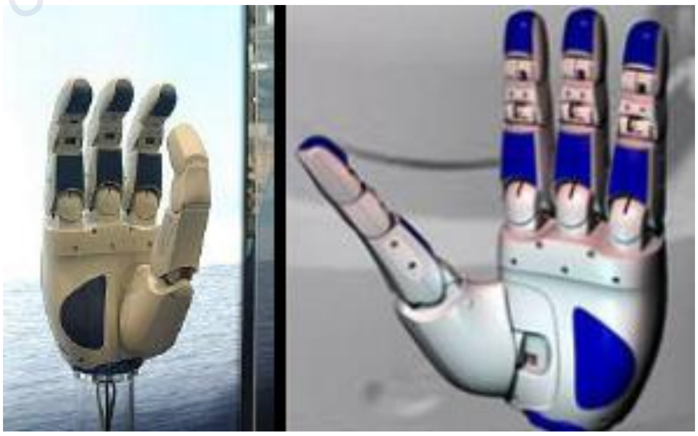

Figure 2. 7: DLR/HIT hand [2]

Finally, the latest product from Shadow Robot Company is *Shadow Hand* shown in Figure 2.8. It was have 20 controlled DOF (last two joints coupled except thumb) with Hall Effect position sensing, air pressure sensing and tactile array. It was about USD 100K for normal type and latest with motorized about USD 200K.

This hand being able brings about 1 lb. fingertip force mounted and its weight is 3.9kg. Best features in this hand is added with pneumatic actuators add compliance, wear and control issues. It system actuator drive by artificial muscle, it can work on highly back driveable embedded with low inertia electric motors. That's why; it used by British for research into bomb disposal for example cutting wires [2].

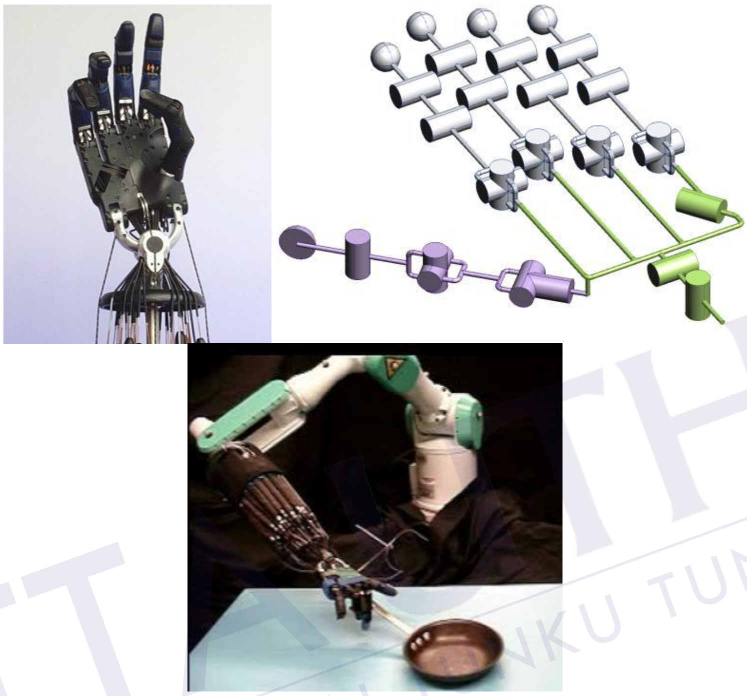

Figure 2.8: Shadow hand [2]

Robonaut hand in Figure 2.9 developed between Robert Ambrose and colleagues collaborates with NASA is research hands type. This research hand discussed about successful teleoperation of many complex manipulation tasks because used in Space operation. It has 14 controlled DOF including wrist and combined with motors in forearm. Then tactile sensing glove designs with FSR and QTC an element which is at the same time last two fingers mount at an angle and rotate at CMC joint [2].

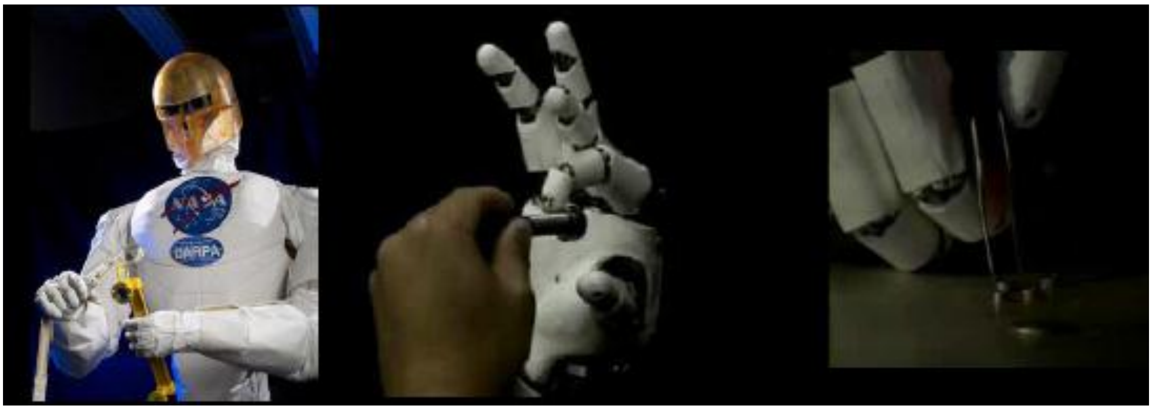

Figure 2.9: Robonaut hand [2]

Refer to figure 2.10, *Akio Namiki* and *Masatoshi Ishikawa* from University Tokyo produced *U.Tokyo hand*. This research hand has 14 DOF and mount with joint force sensors. Special features of this hand is accuracy about 1ms cycle time for vision based control of entire system [2].

Figure 2.10: U.Tokyo hand [2]

Then, *SBC hand* in Figure 2.11 developed *Kyu-Jin Cho* and *Harry Asada* from MIT. Its weight only 0.8kg and 16 controlled DOF with 32 shape memory alloy actuators. This hand segmented binary control to overcome actuator nonlinearities. It has unknown tip force, but force to weight ratio should be high [2].

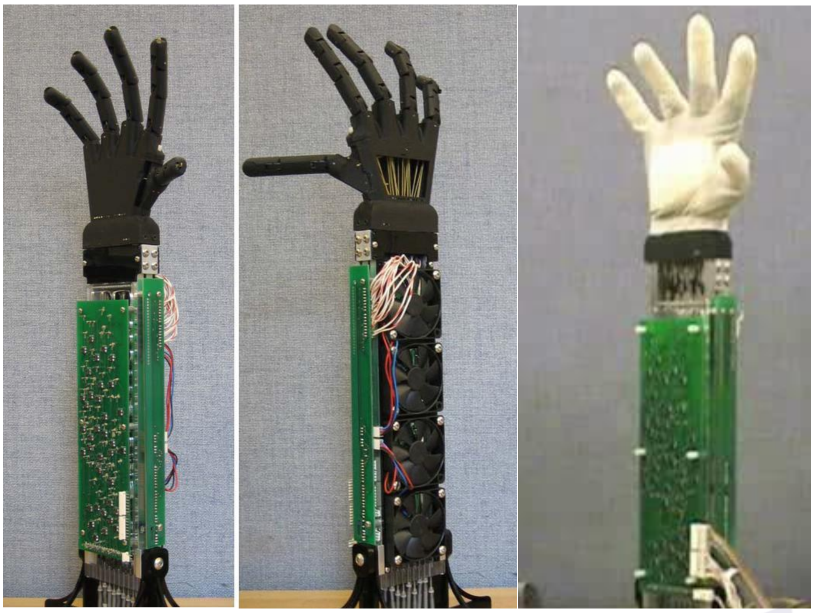

Figure 2.11: SBC hand [2]

Another research hand developed shown in Figure 2.12 is *SDM hand* by *Aaron Dollar* and *Robert Howe* from Harvard. This hand features is single controlled DOF for 8 joints which is have compliant joints and finger pads. Others is its shape deposition manufacturing, robust, light weight and inexpensive. Multi sensors which are embedded sensor such as Hall Effect position and optical contact force sensor [2].

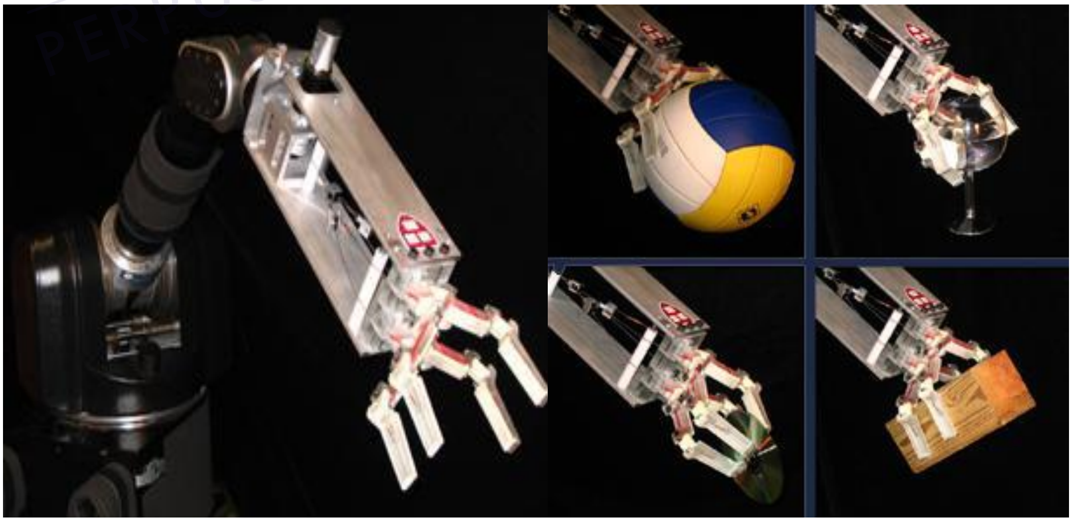

Figure 2.12: SDM hand [2]

Finally, *ACT hand* by *Yoky Matsuoka* from University of Washington developed shown in Figure 2.13 with three fully actuated fingers with human musculoskeletal structure (redundant actuation).This research hand goal is for study human control of hand movements because this hand passive and active dynamics consistent with human hand [2].

Figure 2.13: ACT hand [2]

Then, others type of hand is Prosthetic hands are *iLimb* (Touch Bionics) in Figure 2.14, *Cyber hand* in Figure 2.15 and *DEKA* (*Dean Kamen*) in Figure 2.16. All of that used in order to help people who need it and commercialized too. iLimbs is about USD 18K . There are more than 250 people uses this hand. There are 5 motors driven from single muscle signal and thumb preshape for power, precision and key grip. Motors stall individually for adaptive pose by option. Prosthetic hand by *Maria Carozza* called *Cyberhand* from *Scoula Superiore Sant'Anna*.Its has 6 motors controlled 16 joint with cable driven. Multisensors used such as position, cable force, fingertip force and tactile array sensor. It mounts with 3.3 lb. fingertip force, closes in 3 seconds and 0.45kg weight only which is not including forearm motors. Finally, DEKA –*Dean Kamen* are the prosthetic hand from the DARPA, Revolutionizing Prosthetics Program and others under development of (JHU/APL, RIC, Otto Bock) [2].

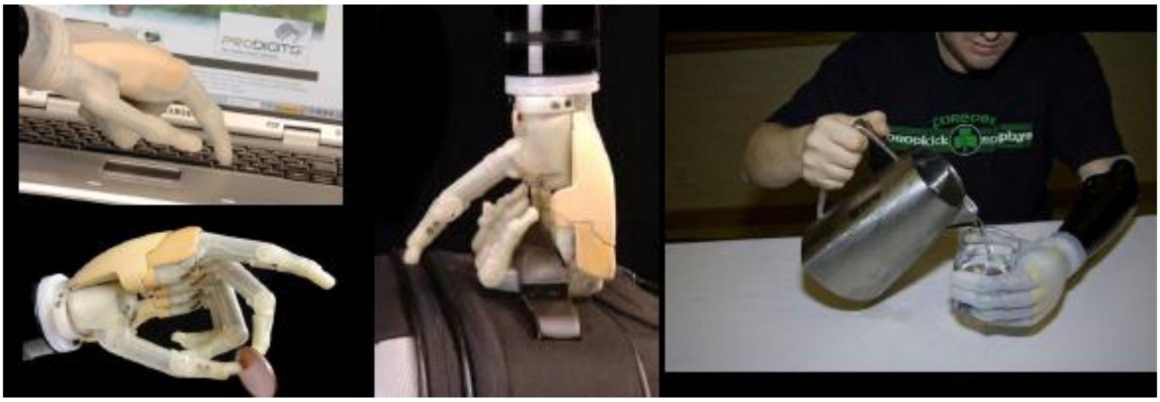

Figure 2.14: iLimb [2]

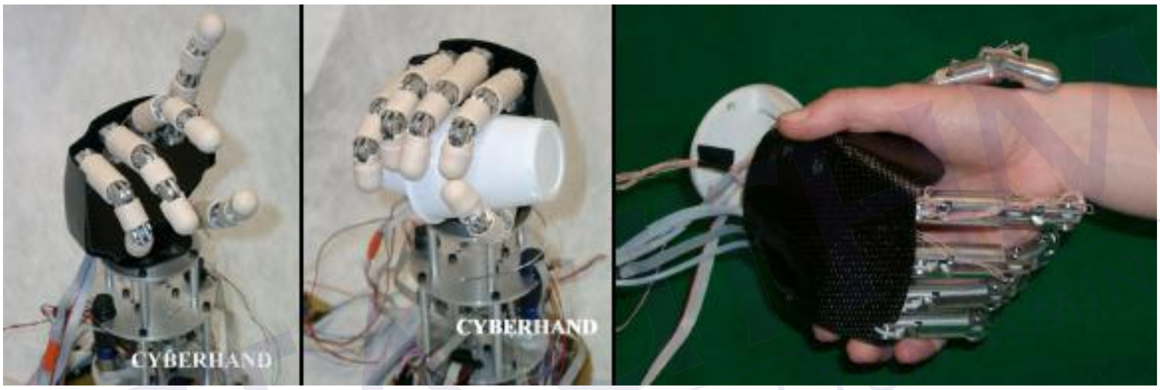

Figure 2.15: Cyber hand [2]

Figure 2.16: DEKA (*Dean Kamen*) [2]

2.2 Journals/Articles Review

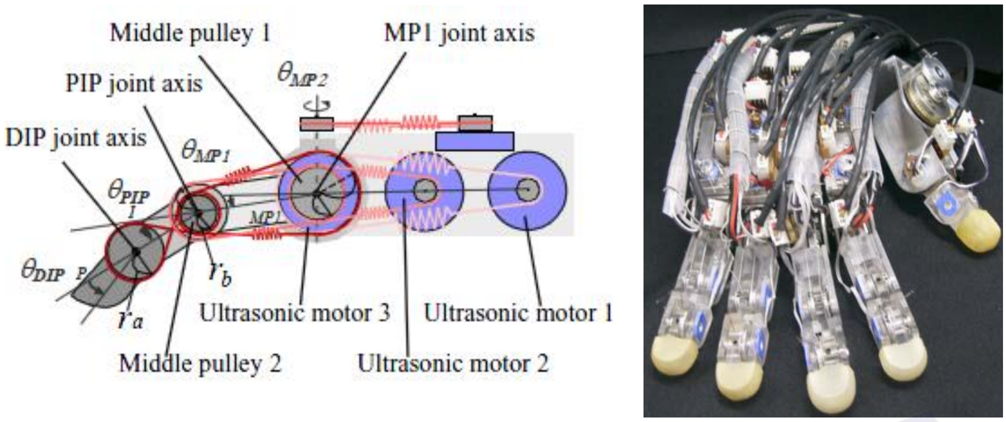

Figure 2.17: Developed five-fingered robot hand [3]

Many approaches for robotics hand have been proposed in the literature. Almost all of them discuss on previous literature is about robotics hand using tele-operation. *Ikuo Yamano* and *Takashi Maeno* developed tele-operation five-fingered robot illustrated in Figure 2.17 hand having almost an equal number of DOF to the human hand. The robot hand is driven by a unique method using ultrasonic motors and elastic elements. The method makes use of restoring force as driving power in grasping objects, which enables the hand to perform stable and compliant grasping motion without power supply [3]. Ultrasonic motor is high torque at low speed characteristics and driving method applied to a multi-DOF mechanism. Design limitation of finger part is alleviated by a wire-driven mechanism. As a result, the robot hand that has 20 DOF and almost same form as a human hand. *Jacobian* Matrix applied for force control application and Analog to Digital converter implemented as control system for this hand.

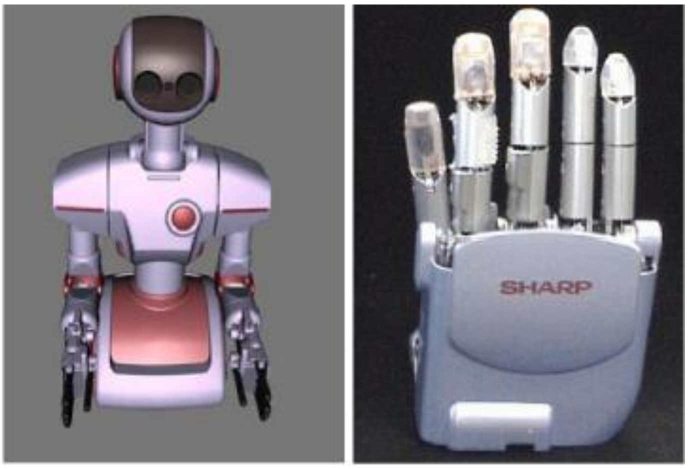

Figure 2.18: Dual-Arm Robots and its Multi-Fingered Hand [4]

Hiroyuki Nakai, Minori Yamataka, Toru Kuga, Sachiko Kuge, Hiroyuki Tadano,Hidenobu Nakanishi, Masanobu Furukawa and *Hideshi Ohtsuka*, presented the development of Dual-Arm Robot with Multi-Fingered Hands in Figure 2.18. Performances of the robot by demonstrating "Chadou" and"Cleaning up dishes" behaviors, which is includes object recognition and object manipulations. The head of the robot has three cameras, two of which are for stereovision system and the other is a zoom camera. With these two types of cameras the robot searches and recognizes objects. In addition, a small camera is equipped meanwhile the robot has only the upper half of the body on the robot hand and it is used to detect the position of and has no transportation device such as legs or wheels objects more accurately in grasping them [4]. This robot applied with five fingers with a total of eleven degrees of freedom. The hand is designed considering the dexterity and the size suited for human tools and has tactile sensors equipped on the fingertips of thumb, index finger and middle finger. Finally, the processors embedded in the hand deal with the data of the sensors and transfer it by serial communication. The control algorithm and data algorithm apply by using FPGA and real time Pc target as viewer.

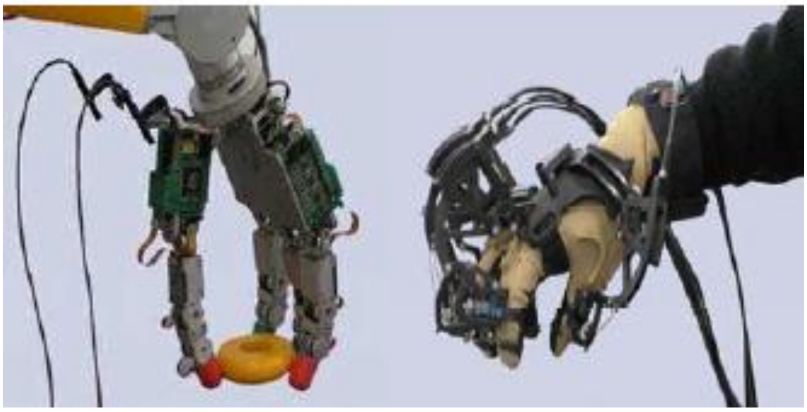

Figure 2.19: HIT/DLR hand with Dataglove and CyberGrasp [5]

Refer to figure 2.19, *Haiying Hu, Jiawei Li, Zongwu Xie, Bin Wang, Hong Liu* and *Gerd Hirzinger*, describes a master-slave tele-operation system which is developed to evaluate the effectiveness of tele-presence in tele-robotics applications. The operator wears a data glove augmented with an arm-grounded force feedback device to control the dexterous hand and utilizes a Spaceball to control robot arm. Contact forces measured by the finger sensors can be feedback to the operator and visual tele-presence systems collect the remote operation scenes and display to the operator by a stereo helmet [5]. This robot arm set up a teleoperation system with high robot dexterity and deep human immersive control. Interface input devices like Space Mouse, Dataglove and the tele-presence devices like the force feedback device: CyberGrasp, vision feedback device: helmet. In the tele-robot system, there are an arm/hand robot system, table, parallel hand-eye cameras system and world cameras system. The robot arm used is a Staubli RX60 robot and the hand is HIT/DLR dexterous hand. Finally, the local network communication system is based on the TCP/IP protocol and the Sever/Client mode which connects the human operation interface system and the tele-robot system.DSP based control system is implemented in PCI bus architecture and the high speed serial communication between the hand and PID position control systems will follow the commanded position trajectory and impedance joint torque control is introduced for the motion control in the constrained environment by tracking a dynamic relation between the active force and impedance torque control.

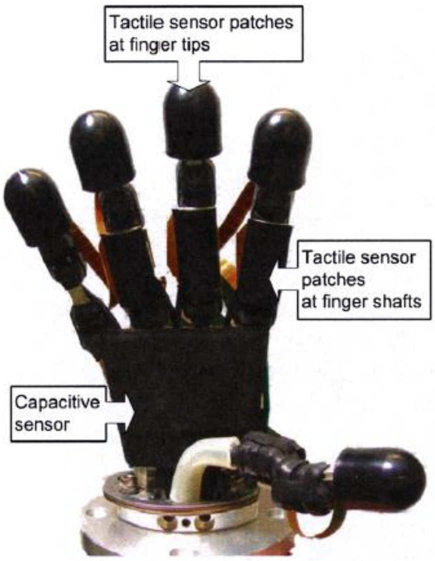

Figure 2.20: The robot hand with tactile and capacitive sensors [6]

Nicolas Gorges, Andreas J. Schmid, Dirk Gager and *Heinz Warn* discussed about Grasping and Guiding a Human with a Humanoid Robot shown in Figure 2.20. They all describe novel approach for tightly coupled human-robot interaction that consists of a robot actively grasping and guiding a human being [6]. Then overall of that system comprises a combination of different sensor modalities to supervise the grasping and guiding procedure and to guarantee a safe human-robot interaction. Multi sensor such as visual sensor, capacitive sensor, tactile sensor and force-torque sensor mount at this robot. The grasping procedure is based on the work describes a reactive grasping procedure which is triggered by tactile sensor feedback which deals with the coordination of hand and arm movements. Then, capacitive sensor also enables the robot to sense the human in grasping range without any physical contact. After that, the guiding procedure is triggered as soon as a steady contact with the human is established. For guiding the human, combination of position and force control used [7]. Finally, the procedure of approaching, grasping and guiding a human considers different movement phases whereas each sensor is dedicated to certain stages of this procedure according to its operating distance.

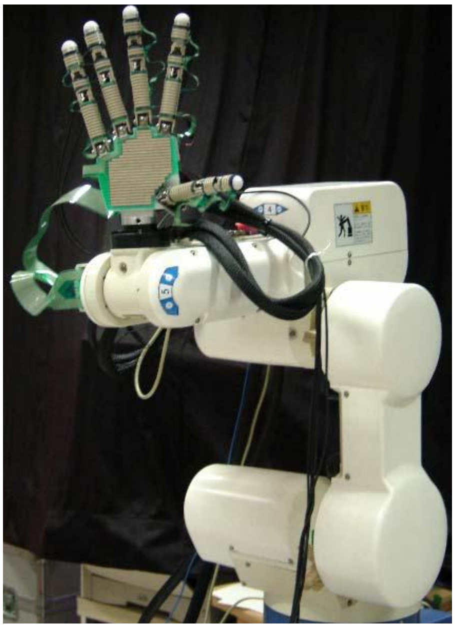

Figure 2.21: Kinetic Humanoid [8]

Tetsuya Mouri, *Haruhisa Kawasaki*, and *Katsuya Umebayashi* presented the Developments of New Anthropomorphic Robot Hand and its Master-Slave System improved robot hand called KH (Kinetic Humanoid) Hand type S for sign language of, Japanese finger alphabet which requires the fingertip velocity. Refer to Figure 2.21, the shape and freedom of motion of our developed robot hands are equivalent to that of human. Therefore, we incorporate the robot hand in not only grasping and manipulating objects but also communication tools such as a sign language. Hence, the new robot hand, which can be driven at same speed of human, is developed based on the kinetic humanoid hand [8].Servomotors used in this project hand have 20 joints with 15 DOF. Then, an operator and a robot are master and slave, respectively. The operator controls the robot by using a finger joint angle, hand position and orientation. In experiment, the measured tactile data is transported to a Force Feedback Glove control PC through a TCP/IP. The sampling cycle of the hand and arm controller is 1 (ms).Finally these results denote that the KH Hand type S has a higher potential to perform not only the hand's shape display tasks but also grasping and manipulating the objects like the human hand.

Shifterbot shown in Figure 2.22 was conducted in year 2009 by an undergraduate FKE student. The project is to build two wheel-driven and Bluetooth interfaced mobile robots to perform task. The task planned which is to pick and shift two boxes from one point to another using line following as a path planning technique. This project use PIC16F877A as the robots' microcontroller to control the robot based on some features of the chip which can use up to 8K x 14 words of FLASH 8 Program Memory, the only 35 single word instructions to be learnt with Assembly, has an interrupt capabilities and can be purchased with low price. For the movement mechanism, the robot used a pair of DC motor and joined with a custom made wheel to move from one point to another and a 6.0V with 7.00 kg-cm maximum torque servo motor for the forklift movement application. The robots work as a group to lift and move the object from a point to another desired point using Bluetooth application. The robot used a Bluetooth application through using KC-21 Wirefree Bluetooth module to get a better and larger radius for transmission and receiving data from other external devices. Most significant usage of a Bluetooth module is the level of connectivity where at most 12 Bluetooth modules can interact with each other in a piconet but a RF module only able to make two agents communicate. The communication mechanism in this project done by the master robot M-0F4C will send command order to slave to turn towards correct path. The first command achieved to be received by the slave robot S-1136 is the "Connection Up" command line in ASCII string. The second command would be the turning right decision command line. The slave robot S-1136 waits for the master robot M-0F4C to respond first regardless of the time taken for it to send next command line .The weakness to this project is the stability of the robot is very poor due to heavy duty battery. A 12V lead acid rechargeable battery was used to reduce the cost of the project. Though, the usage of such battery gave in too fast for the acrylic that holds most of the machine screws attached to the body to bend. Thus, there was an idea to reduce the centre of gravity of the robot so that the acrylic plane does not crack or bend. The wheels of the robot must be wide enough to hold the centre of the gravity. In addition, the usage of tricycle where a same height wheel is attached at the middle front of the robot was implemented [9][10].

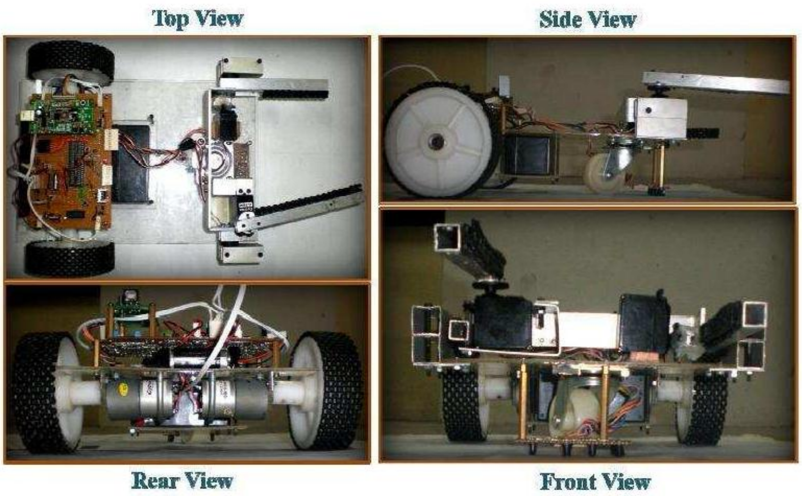

Figure 2.22: A complete Shifterbot [9]

2.3 Summary

A great number of robotics technologies nowadays are competing among researches to widen their expertise in developing anthropomorphic dexterous multi-finger robot either wired or by wireless teleoperation. Teleoperation have been done successfully previous researches and industries. Many others model of teleoperation are like U.Tokyo hand, SBC hand, ACT hand, and DEKA hand. Data collected summarize in Figure 2.23 below.

Characteristic/ Robot hand	Type of Actuator	Number of finger	Joint of thumb	Total Degree of freedom	Motion Transmission
UTAH/MIT	Pneumatic	4	4	16	Pulley-cord
Belgrade/USC model II	Electrical	5	2	16	Special mechanism
JPL Standford	Electrical	3	3	9	Pulley-cord
METUHAND	Electrical	3	3	9	Pulley-cord
MAT/METU	Pneumatic	4	2	4	Pulley-cord

Figure 2.23: Characteristic of previous robot hand.

Reseachers used various types of design and controller to direct the multifingers performance. Some approaches they used FPGA to control the movement of fingers. This robot hand is HIT/DLR hand with Dataglove and CyberGrasp. The hand is designed considering the dexterity and the size suited for human tools and has tactile sensors equipped on the fingertips of thumb, index finger and middle finger. Nowadays, latest technology shown by Shadow Company that developed precise and antromorphopic hand with various controller, actuator and design.

Finally, by previous research and case study of multi-fingered robot hand and Bluetooth teleoperation are suitable for this project. The ideas of the above researches were extracted to accommodate this project. Certain important elements of each research were taken into consideration. In this project, the usage of wireless communication by Bluetooth becomes the main element.

CHAPTER III

METHODOLOGY

This chapter describes the methodology employed and considerations taken into account for this project. It begins with the discussion of the project flow, followed by the system design procedure, techniques and tools utilized in this work. A economical, suitable and good material selection plays an important role in determining a successful and perfect project. Here, it is very important to choose the most appropriate components with correct specifications in order to establish well-operated circuits. The idea applies for the hardware construction and software development.

3.1 Introduction

In order to start any project, a lot of relevant and important information need to be obtained. By research and doing the literature review, not only a lot of information can be obtained but also it gain the knowledge of the technology used in world today. Most of the information that related with the project can be obtained by surfing the internet, reading the books and also with the aid of supervisor in charge. Research is one of the most important stages in this project to make sure that this project will be succeeding. Through these researches, a lot of information and knowledge can be collected to know which method will work and which will not. At this level, the idea to make an ideal project is generated. In this project, the selection of the suitable Bluetooth module for the system is needed. The most suitable Bluetooth module with the specified range and other specification must be choose properly in order to achieve the expected result.

This project consists of two parts which are hardware part and programming for the software part. For the hardware part, all the components used need to be list down to proceed to the next stage. Every and each idea is analyse to determine whether it is appropriate with the project and when the idea is fit and suitable, the project can be started to assemble. The circuitry for the hardware is going to be developed. During this time, experimenting is the most important. If there is any incompatibility during interfacing with the hardware, the cause of it must be tracked in order to make sure those circuits are fully functional.

For the software part, the PIC microcontroller needs to be program to interface the hardware part in order to control the whole project. After the integration or interfacing of the hardware and the software, test and debug the system and make the verification of the outcome. The most important element in this stage is to integrate the hardware as those circuits may behave differently when they are assembled together. If there is any problem occurred, the system need to be troubleshoot in order to find the causes of the problem. On the contrary, the project can proceed to the final report. The methodology flowchart of the project discussed above shown in Figure 3.1

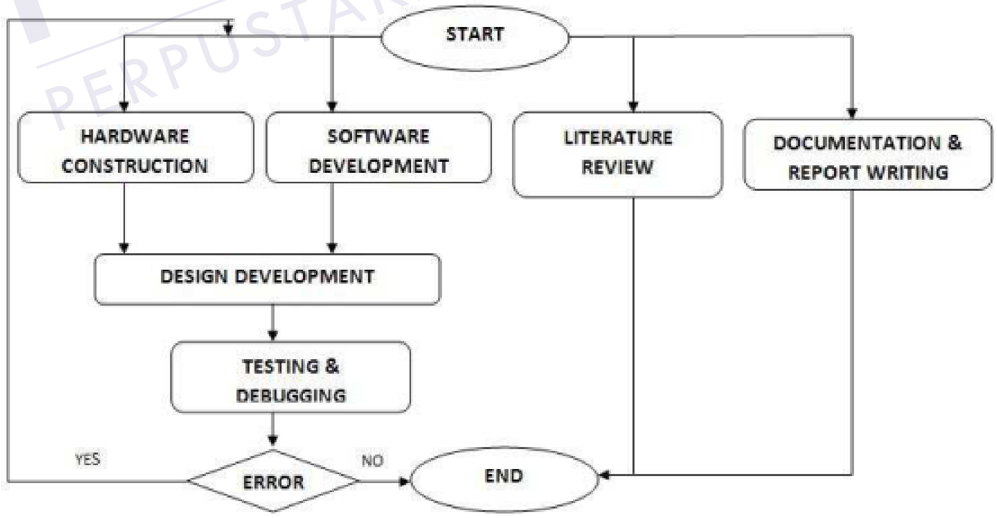

Figure 3.1: Flowchart of project methodology.

3.2 System Operation

The goal of this project is to realize wireless teleoperation of robot hand using SKKCA v1.2 Bluetooth module embedded with KC-11 radio data communication and glove as interface device. After review overall of others literature in fields of robotics and teleoperation, some method to tackle have to be discussed.

Table 3.1: Overall Description of Multi-finger Robot

Multi-Fingered Robot Hand		
Parameter	**Description**	**Unit**
Master	Hand Glove : Bell Type Motorcycle Rider Glove	1
Slave	Finger Robot: Igus Energy Cable Chain	1
Controller	Microchip PIC18F4520	2
Teleoperation	KC-21 Bluetooth Module: SKKCA v1.2	2
Sensor	Flex Sensor: Bend Sensing Resistance	10
Hardware	298:1 Micro metal DC geared motor	5
Software	MPLab IDE v8.43, Proteus7, SOLIDWORK 2010 x64	-
Method/Architecture	USART and ADC	-

Table 3.1 above show the overall components needed in this project. Every single part of this project encountered and listed depends on demand and usage in this research. Most overall parts in this project still using updated software and hardware which is suitable in this project.

In order to build up robotic hand in this project it consists of a controller for Master and Slave part, glove embedded with bend sensor at each finger for operator usage, Cytron SKKCA v1.2 Bluetooth wireless Module and 298:1 micro metal DC geared motor. The controller using Microchip PIC18F4520 microcontrollers embedded system and Cytron SK40C circuit boards being developed to integrate with Bluetooth wireless modules. Bluetooth wireless modules as communication platform between two board Master and Slave.

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