INVESTIGATION OF TOUCH BASED PERCEPTION FOR MANIPULATING OBJECT BY USING *GLOVEMAP*

by

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ABSTRAK

Perkembangan dalam penggunaan teknologi telah meningkat berdasarkan permintaan orang ramai bagi memenuhi keperluan harian mereka. Peralatan teknologi mesra pengguna boleh membantu orang ramai supaya lebih mudah dalam mengendalikan dan menyiapkan tugasan dalam kehidupan mereka. Projek ini adalah mengenai rekacipta system sarung tangan berwayar kos rendah yang dipanggil *GloveMAP*.Matlamat projek ini adalah untuk mencipta semula 'sarung tangan berwayar' versi UniMAP yang turut menyediakan fungsi yang sama dengan sarung tangan data konvensional. Sistem ini melibatkan pergerakan jari dengan beberapa aktiviti menggenggam pelbagai jenis objek dan berat. Daya perintang penderiaan (FSR) dilekatkan pada sarung tangan di ibu jari, jari telunjuk dan jari tengah untuk mendapatkan perubahan voltan daripada genggaman jari. Isyarat output voltan kemudiannya ditukarkan ke isyarat output daya dengan melaksanakan beberapa pengiraan yang melibatkan persamaan regresi polinomial. Terdapat dua puluh sampel berat bagi setiap tiga jenis objek berlainan bentuk yang terdiri daripada silinder, segi empat tepat dan sfera yang telah diuji untuk menyiasat hubungan di antara berat, bentuk objek dan daya terhasil daripada aktiviti genggaman.Beberapa operasi matematik seperti fungsi normal, dan fungsi pekali korelasi telah digunakan untuk mencari hubungan antara ketiga-tiga faktor. Dua puluh subjek manusia telah terlibat dalam melaksanakan eksperimen menggunakan lima objek yang terpilih. Data daya output hasil daripada eksperimen ini kemudiannya dianalisa dengan mencari ciri-ciri daya genggaman objek. Sisihan piawai dan kawasan dibawah graf telah dipilih sebagai ciri-ciri tersebut berdasarkan oleh graf daya melawan berat yang telah diplotkan bagi semua objek. Kaedah klasifikasi yang digunakan dalam kajian ini telah berjaya untuk mengenali objek mengikutdata output kuasa menggenggam dari ibu jari, jari telunjuk dan jari tengah. Kombinasi maklumat dari ketiga-tiga jari telah membantu mengenal pasti objek dengan mudah berdasarkan kadar klasifikasi yang diperolehi untuk semua objek adalah melebihi 85%.

Investigation of Touch Based Perception for Manipulating Object by Using *GloveMAP*

ABSTRACT

The development in use of technology is increased due to the need of public demand in their daily life. User friendly technology tools can help people more in handling and preparing for assignment in their lives. Thisresearch is about designing of a low cost wired glove system called *GloveMAP*. The purpose of the project is to reinvent the 'Wired Glove' UniMAP version that provides similar function with the conventional dataglove.The system involves the finger movements with some of grasping activities to investigate the force exerted on the fingertips during grasping of various types of objects and weights. Force sensing resistors (FSR) are attached to the thumb, index and middle fingers to the glove to obtain the voltage changes from the fingers grasping. The outputvoltage signalsare then changed to force output signals by implementing polynomial regression equation. There are twenty samples of weight for each three types of object with different shapes which are cylinder, rectangular and spherical that has been tested to investigate the relationship between weights, shape of object and force obtained from the grasping activities.The mathematical operations such as normalization function, gradient function and also average function has been used in order to find the relationship between these three factors. Twenty human subjects are involved in carrying out the experiment for five selected objects.The output force data obtained from the experiments are then analyzed by finding the features of force object grasping. Standard deviationand area under graph has been selected as features due to the force versus weight graph plotted for all objects. The classification method used in this research has successfully recognized the objects according to the grasping force output data from thumb, index and middle fingers. The combination information of these three fingers helps to recognize the objects easily as results of the classification rate for all objects are above 85%.

CHAPTER 1

INTRODUCTION

1.1 Introduction

There are too many applications in this era that are related to human gesture which include parts of human body such as hands, face, body and many more. Hand gesture is one of the famous gestures used in daily life. People use hand gesture to enhance the communication with others to deliver the information of thoughts effectively. This hand gesture will give a lot of important information of fingers or hand movement that can be implemented in the industrial applications such as video games industry, biomedical instrument, sports science, surveillance systems and many more. A device known as a dataglove is presented as a medium to measure the information gain from hand or fingers activities.Dataglove is known as cyberglove or wired glove and it is a device that can be donned by human as shown in Fig. 1. Any physical data can be captured by this technology using various sensors such as bending sensor or mostly known as flexible bend sensor, force sensor or force resistive sensor, tactile sensor and other types of sensor.Dataglove is also known as parts of “Haptic Science”, which is one of the science application tactile sensation to human interaction through computer.Datagloves are one of several types of electromechanical devices used in haptics applications.Haptics refers to sensing and manipulation through touch while haptic device usually is a device which involves all aspect of information acquisition and object manipulation through humans, machines or combination of them. It is called

physical contact between computer and user through a device that senses movement of body such as mouse, joystick, keyboard or an input / output device. Here, researches have been conducted to build other version of dataglove that share similar purpose known as *GloveMAP*. *GloveMAP* is a low cost dataglove that are design to capture all data information of fingers grasping. An essential element will be used to ensure a perfect reading of fingers grasping force. Suitable sensor is needed to detect any smallest changes in any portion of fingers. The sample of output data gain from the grasping activities will transmit to CoolTerm software. This software will capture all the physical data and store it in one file. CoolTerm software allows us to see all the changes of fingers grasping data. Information data of fingers are then will be analysed and synthesized through MATLAB 2010 software.

1.2 Problem Statement

One of the purposes of dataglove is to research the grasping activities of human. However, a study on the correlations between weights and force obtained from the grasping task is not given detailed attention by the previous researchers. The relationship of these two parameters will give important information to further the research of grasping for various tasks. Most of the researchers back then developed a good framework for the experimental of investigating the force obtained by grasping activities. However, the system of object recognition in utilizing the Force Sensing Resistor (FSR) is less being used. Therefore, based on the lacks stated, a good solution is required.

1.3 Objectives

I. To obtain the signal from sensor by grasping activities and change the form of signal from voltage output to force output.

II. To analyse the effect of object's weight to the grasping force and to analyse data force of grasping tasks for different shape of object.

III. To extract features of grasping force.

IV. To implement classification method for trained the system and to recognize object shape based on dataset.

1.4 Scope

I. Developing a dataglove system by using low cost Force Sensing Resistor (FSR) sensor.

II. Obtaining output signal information of grasping activities by using Arduino microcontroller as a tool.

III. Transform the voltage output signal to the force output signal.

IV. Analysis the effect of weights towards the grasping force by obtaining raw data from grasping three types of objects with 20 samples of weights.

V. Providing the features information data of grasping force for five different shapes of objects to be used in the classification and recognition process.

1.5 Research Description

This research is generally about to create a low cost dataglove (*GloveMAP*) which can be used in obtaining the information of fingers movement. The increasingly widespread use of technology throughout the world has facilitated our daily lives. Dataglove is one of the technologies that have been used in industries. Most of the small industries cannot afford to use this high technology because of the high cost. So, this research will create a low cost dataglove which uses sensor as an input to detect any changes of physical data of fingers movement from grasping activities. The force sensor will be connected to suitable sensor circuit which then connect to computer through interphase Arduinomicrocontroller and then, attempt to connect to CoolTerm software to acquire the raw data of grasping activities. After successful communication with sensor and collect the raw data of fingers grasping for various weights and shapes of

object, the relationship between these three factors (weight, force and shapes of object) will be analyzed by implementing the mathematical equations (procedures). MATLAB 2010 software will be used as a medium to process the collected data. The processes are extraction features of grasping force and classification objects. The classification method used in this research are LDA (Linear Discriminant Analysis) and Neural Network.

1.6 The Outline of the Thesis

The thesis consists of 5 chapters. Chapter 1 describes the introduction of the research works. Besides, it will define proper objectives and scope for the research, deciding an appropriate method to accomplish the research and to build up preparation for the research. Chapter 2 explains the literature review of previous and related research. Literature review also provides a research background of the research and gives an outline and path for the research. Chapter 3 describes methodology of *GloveMAP* development. This chapter discusses all the methods that used to fulfill the objectives of the research. Chapter 4 consists of experimental data and result acquire through a series of experiment to completed *GloveMAP* while Chapter 5 mainly about conclusion obtain upon completing the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

World booming growth led to the use of technology in various fields to manage the daily tasks at home, school and also in the workplace.Nowadays, there are many applications that have been created and marketed to fulfil the human needs and to help people complete the necessary tasks more efficiently(Yang & Chen, 2009).Human Computer Interaction (HCI) is one of the biggest areas of research in developing the technology devices for human used(Collazos, Granollers, & Rusu, 2011). HCI is the design and implementation of interactive computing systems that users can interact with(Mathew, Hajj, & Abri, 2011). Thestudies of HCI is aimed to improve the efficiency, effectiveness and adaptation of the interaction between user and computers(Jamilah, Yusof, Amin, Zainudin, & Baker, 2004). Providing a system that can reduce the barrier between user and computer to accomplish the user's task is one of the main goals of HCI(Winograd, 1990).Computer has become a powerful machine that allows the development of innovation of various applications and device such as keyboard, mouse, pen, joystick to interact with computer.However, there are much more to improve in order to reduce the obstruction between Human and Computer.The computer itself has lacks in many areas, especially from the perception of taste, smell, vision, hear and touch compared to human. The recent years, researchers show their interest to overcome the lacks by exploring more about the applications in HCI. There

has been an increased extent in trying to introduce other human-to-human communication modalities in HCI.Human hand gesture has become the hot topics in developing the applications device because it has the capability of producing the information of hand and fingers which can be interpreted by computer (Sharma & Verma, 2015).

Dataglove or also known as wired glove is one of the instrumented application devices which have the ability to track and capture the physical information of the hand gesture of the wearer(Memberg & Crago, 1997). Over the centuries, various prototypes of dataglove have been developed by researcher. Advancement of HCI paired with dataglove allowing user to control robotic hand essentially toward Tele-Robotics, handling industrial robot hand, and humanoid robotic hand. Utilizing dataglove capability, sign language recognition for muted person(NeelaHarish & S.Poonguzhali, 2015), hand diagnosis, and glove based rehabilitation for stroke patient(Hao, Qingxiang, & CAO, 2010)were also possible. Apart from controlling robotic hand and usage on medical field, dataglove enable the innovation of controlling virtual reality application for education, control character animation directly, and can be used as gaming controller. In this chapter, a survey of the various efforts that researchers have been making for the past decade in the area of human hand grasping recognition was presented.

2.2 Dataglove

The studies of the human hand gesture tend to the development of dataglove. Dataglove is one of the best medium presented by researchers with the attachment of essential elements to measure the physical data changed made by fingers.

After a while, the researchers focus not only on how the information of the hand which obtained from some of activities will be recorded, but now more focused on applications that can be developed by using certain information. Various types of sensor such as flexible bend sensor, force resistive sensor, tactile sensor, magnetic tracking device and many more has been employed to the dataglove system for enhancing the output information.

There are various types of dataglove has been designed according to the specific tasks such as dataglove for finger bending, dataglove for force distribution, and high-end dataglove capable to provide haptic feedback(Ben-tzvi, 2015; Glove, Bouzit, Burdea, Member, & Popescu, 2002; Moon et al., 2006; Winter & Bouzit, 2006). Dongchul Lee & Choihave published a research on the development of wireless dataglove system by using ZigBee wireless communication protocol. The glove was attached with eight flex sensorsto carry out the experiment in investigation ofthe bending fingers involved in grasping for rock-paper-scissors hand postures. Another application was the development of wheelchair system controlled by fingers movement that has been researched and developed by Akmeliawati, Tis, & Wani, (2011). The purposed of the system was to use the dataglove which were embedded with flex sensors to control the direction movement of wheel chair by giving the instruction based on the fingers bending. Each finger has its own task in determined the direction forward, backward, right side, left side and the speed of the wheel chair was controlled by the

degrees angle of fingers bending. Next custom-made dataglove was designed by Swee, Ariff, Salleh, Seng, & Huat,(2007)to be used by the deaf person in daily communication. The development of the dataglovewas involved 5 units of flex sensor and 3 units of accelerometers to translate the Malaysia Sign Language (BIM) into speech (sound).The system has succeed to recognize 25 BIM word by using Hidden Markov Model (HMM).

The development and design of data glove was not only focused on the use of flex bend sensor but also the use of the other sensor in developing a device that can interpret data of hand.Force sensor has been used for more than decade to investigate the force obtained from the fingertips by completing some of the task. Various methods have been developed by the researchers in refining their objectives in the grasping force research. Some of the researchers back then were used the existing commercial glove that were equipped with the flex bend sensor to upgrade the glove with the attachment of the force sensor.The Sensor Glove MKII has been altered by the group of researchers to be used for conducting the operation of hand grasping(Sato, Shimojo, Sen, Takahashi, & Shimizu, 1996). The glass bottle has been chosen as an object in grasping task to obtain the distribution of force. The subject was asked to open and close the bottle cap for 60 seconds. Due to the results obtained, the system was successful in measuring the grasping force. Next researchers,Vecchi et al., (2001)discussed briefly about the optimum location of placing the force sensor on the fingers.The existing commercial Human Glove has been modified with the placement of 8 units force sensors to perform the grasping task of 6 objects which were tennis ball, disk, cylinder, key, screwdriver and tube according to the six gripping types. The finding of the research was the sensor located on distal part of the thumb fingers was very useful because of the extensive usage for all objects.

Besides the upgrade of existing flex bend sensor glove, the researchers come out with the idea of developing the new force sensor glove for their own use in the research fields(Carpaneto, Micera, Zaccone, Vecchi, & Dario, 2003; Culjat et al., 2010; Flynn et al., 2013).Castro & Jr, (2000)have designed and made a custom glove with force sensor and position transducer to evaluate the grasping force of drinking tasks. They used cylinder with different diameters and weights (but does not mentioned the exact weights) as the tools. Based on the overall observations, the authors found that the largest force exerted was on thumb finger followed by index finger and the long finger (middle finger) was become as a support for the stability of grasping. Meanwhile,Tarchanidis & Lygouras, (2003)published a research paper on how to measure the force occurs on fingers while grasping and the explanationof the theoretical calculation of the sensor also stated in the paper.The session of collecting force data has been conducted by instructing the human subjects to wear the glove with installationof force sensor to carry out the pick ball task. Next researchers,Kong & Lowe, (2005)have designed the framework to be completed by human subjects in handling the cylinder object with different size of diameters. A force glove system was developed by attached 16 units of force sensor to measure the force exerted on fingers during the grasping task.The contribution of force on the fingers was increased as the handle cylinder diameter increased was founded as the final result of the research.Another dataglove has been developed and been tested subsequently(Sagisaka, Ohmura, Kuniyoshi, Nagakubo, & Ozaki, 2011). Thepurpose of their research was to maximize thelocated force sensor area to get the maximum information of hand grasping of 4 objects which are scissors, ball, card and cup. The researchers found that the glove succeeds in measuring force obtained in the small area contact between fingers and objects. Intelligent Force Glove (I-Force Glove) was one of the dataglove designs that have been developed byLee et

al.,(2008). The research outcome has been presented in a neat way in this paper. Every detail about the conducted experiment was articulated well. The development of the dataglove was contrast compared to the other researchers where this research has been focus on the left hand. The relationship between handle diameter and force distribution was the objective of the research. The cylinder with different size of diameter and same in weights has been used as a handle tools. Based on the result, the thumb finger obtained more force when grasping the cylinder object with large diameter whereas the third (middle) and little finger were obtained higher force when grasping the cylinder with the small diameter compared to the thumb finger. For the overall observation, the forces obtained were increased as the diameter increased even though the weight of the handle was constant.

After reviewing the past literature whichare related to the construction of dataglove that was carried out by other researchers, this leadsto motivation to undertake a study on the correlation between the weights of object and forces resulting from the grasping process.This study was expanded by using various objects and various weights in order to produce more information and the findings will be clarified by implementing the mathematical algorithm into the system.A dataglove named as *GloveMAP*- force sensor has been used in this research. Through the speciality of the *GloveMAP*- force sensor, the adjustment of the force sensor can be made by the user personally according to their fingertips without give a problem to the system.FSR sensor used for the system has flexible design which can adapted to suit any geometrical environment and it is suitable for laboratory use for carrying out the experiment.The summary of previous researches on dataglove was show in the Table 2.1.

Table 2.1: The summary of the dataglove researches.

Authors	Title	Sensor type	Application usage
Sagisaka et al., (2011)	High-density Conformable Tactile Sensing Glove	Force sensor	Grasping force / Object grasp
Akmeliawati et al., (2011)	Design and Development of a Hand-glove Controlled Wheel Chair	Flex sensor	Finger Bend
Dongchul Lee & Choi, (2010)	Development of compact data glove system	Flex sensor	Finger Bend
Lee et al., (2008)	A Study on the Human Grip Force Distribution on the Cylindrical Handle by Intelligent Force Glove(I-Force Glove)	Force sensor	Grasping force / Object grasp
Swee et al.,(2007)	Wireless Data Gloves Malay Sign Language Recognition System	Flex sensor	Finger Bend
Kong & Lowe, (2005)	Optimal cylindrical handle diameter for grip force tasks	Force sensor	Grasping force / Object grasp
Tarchanidis & Lygouras, (2003)	Data Glove With a Force Sensor	Force sensor	Grasping force / Object grasp
Vecchi et al.,(2001)	A Sensorized Glove For Applications In Biomechanics And Motor Control	Force sensor	Grasping force / Object grasp
Castro & Jr,(2000)	An artificial grasping evaluation system for the paralysed hand	Force sensor	Grasping force / Object grasp
Sato et al., (1996)	Measuring System for Grasping	Force sensor	Grasping force / Object grasp