ENHANCEMENT OF ROBOT HAPTIC SENSOR TECHNOLOGY

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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DECLARATION

I hereby, declared this report entitled “Enhancement of Robot Haptic Sensor Technology is the result of my own research except as cited in references.

Signature : ……
Author’s Name : FONG ZUYANG
Date : 31 December 2018

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons.). The member of the supervisory are as follow:

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(Dr. Fairul Azni Bin Jafar)

ABSTRAK

Teknologi pengesan haptic digunakan secara meluas dalam bidang robotic dan pembedahan. Teknologi haptic menggunakan peranti haptic yang berkomunikasi dengan mesin manusia melalui sentuhan. Di dalam syarikat pembuatan, biasanya manusia mengawal operasi pengukuran tahap kekasaran permukaan secara manual dan menyebabkan ketidak tepatan berbanding dengan kawalan otomatik oleh robot. Kerja-kerja kajian ini telah bermula semenjak beberapa tahun lalu. Permasaalahan dalam kajian ini adalah berdasarkan pencapaian yang lepas yang mana ianya menghasilkan keputusan yang agak kurang memberansangkan dari segi ketepatan. Matlamat kajian ini adalah untuk meningkatkan tahap kepekaan pengesan melalui cara menukar reka bentuk, bahan dan fabrikasi alat-alat pengesan. Pertamanya, bahan untuk *poly-jet* dikenal pasti melalui CES dengan cara mendapatkan sifat-sifat bahan dan graf X-Y. Keduanya, rekabentuk semula reka bentuk *poly-jet* dan tips jarum menggunakan *Solidwork*. Seterusnya, tips jarum dan *poly-jet* yang dipilih, melalui beberapa siri ujikaji dengan menggunakan pengesan akhir robot Comau di dalam Makmal Robotik FKP. Keputusan ujikaji ini ditunjukkan melalui ADC. ADC dihasilkan melalui GUI dan ditukarkan kepada graf dan jadual secara manual. Di dalam setiap seksyen, perbandingan di antara bahan dan reka bentuk dijalankan. Di dalam seksyen pertama, ianya adalah berkaitan perbandingan reka bentuk di antara tips jarum di mana Ujikaji 1 dibandingkan dengan Ujikaji 2, dan keputusan menunjukkan yang Ujikaji 1 lebih baik dari Ujikaji 2, dan ini membuktikan bahawa Reka bentuk 1 tips jarum yang baru adalah lebih baik. Dalam seksyen kedua, prestasi hasil bahan tidak sama seperti yang dijangkakan di mana tiada perbezaan di antara bahan TPU dan PLA. Di dalam seksyen yang terakhir, ujikaji telah diuji terhadap prestasi reka bentuk *poly-jet* di mana reka bentuk pertama *poly-jet* lebih baik daripada Reka bentuk 2 dan Reka bentuk 3. Reka bentuk keseluruhan untuk pemasangan adalah Reka bentuk 1 tips jarum, Reka bentuk 1 *poly-jet* dan TPU telah dipilih berdasarkan fleksibiliti bahan tersebut dan kelebihan dalam sifat-sifat bahan.

ABSTRACT

Haptic sensor technology is widely used in robotic and surgery application. Haptic technology is using haptic device which communicate with the human machine through touch. In manufacturing company, human manually operated surface roughness measurement tester that causes for inaccuracy compare to robot operated automatically. This research work has been started a few years ago. The problem of this study is due to the previous achievement of the research work that produced a poor result in term of accuracy. The aim of this study is to enhance the sensitivity of the sensor in the way of changing the design, material and fabrication of the parts of sensor. Firstly, the material of the poly-jet is identified through CES by getting the material properties and X-Y graph. Secondly, redesign the design of the poly-jet and needle tips by using Solidwork. Then, needle tips and needle tips together with selected poly-jet are undergo a series of experiment by using the robot end effector of Comau Robot in the FKP Robotic Laboratory. Results of the experiments are showed through ADC. ADC is generated through GUI and converted manually into graph and table. In every section, there is comparison within material and design. In the first section, it is about design comparison of needle tips where Experiment 1 was compared to Experiment 2 and the result for Experiment 1 is better than Experiment 2 which proved that the new design of needle tips is better. In the second section, the performance of material outcome is not the same as expected where there is no different between TPU and PLA material. In the last section, the experiment is tested on the performance design of poly-jet where the first design of Poly-jet is better than second and third design. The overall design for assembly are new of needle tips, first design of poly-jet and TPU that have been selected due to the flexibility of the material and better in material properties.

DEDICATION

Only

my beloved father, Fong Chen Kwong

my appreciated mother, Yeo Leh Cheng

for giving me moral support, money, cooperation, encouragement and understandings

Thank You So Much & Love You All Forever

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Furthermore, I would also like to thank my faculty for providing such platform for the final year student to hone and practice their academic and hand-on skills in doing the final year project within a certain amount of time. From there, we learnt how to preserve, disciplined critical thinking skills while striving to achieve the objectives of the project.

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LIST OF ABBREVATIONS

PZT	-	Lead Zirconate Titanate
QC	-	Quality Control
LVDT	-	Linear Variable Differential
MEMS	-	Microelectromechanical System
PVDF	-	Polyvinylidene Fluoride
PLA	-	Polylactic Acid
TPU	-	Thermoplastic Polyurethane
ADC	-	Alternating Direct Current
UV	-	Ultraviolet
GUI	-	Graphical User Interface
FDM	-	Fused Deposition Modelling
STL	-	Stereolithography
CNC	-	Computer Numerical Control
NC	-	Numerical Control
PC	-	Personal Computer
USB	-	Universal Serial Bus
CAD	-	Computer Aided Design
3D	-	Three dimensional

LIST OF SYMBOLS

kHz	-	Kilo Hertz
kPa	-	Kilo Pascal
m in	-	Meter Inch
Hz	-	Hertz
mm	-	Millimeter
kg/m^3	-	Kilogram per Meter Squart
MPa	-	Mega Pascal
J/kg°C	-	Joule per Kilogram Celcius
µm	-	Micro Meter

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Haptic technology is using haptic device which communicate with the human machine through touch. The force from the mechanical production with usable information that is sensed by human kinesthetic system is feedback through haptic interface. A haptic interface comprised of haptic device together with the software base computer control mechanism which allow the human-machine communication via sense of touch. Human can sense the feel and manipulate 3-dimensional virtual entity by using haptic on the objects in term of features such as surface textures, shape weight and temperature.

Haptic is the science of applying touch sensation and control for interaction with virtual or physical applications. It is a tactile feedback technology which takes advantage of sense of touch by applying motions, vibrations or forces to the user.

On the other hands, haptic device also competent to measure large amount of force applied by human. Besides that, textile sensor is totally different from haptic sensor in which it measures pressure and force exerted by human. After both technology synthesis, human can sense the touch of work and interact with computer by movement and body sensation through haptic interface.

In manufacturing industry, the QC department is crucial on making sure the products' quality is as good as possible from time to time. Besides, in manufacturing industry, robot uses haptic sensor for measuring surface roughness. The surface roughness of a product in this research is tile which can be measured by any surface roughness tester in the market today. Standard abrasion tester is one of the most well-known testers used by most of the

companies today. The surface roughness tester measure by using the tips in contact with the surface of the object and then variation of graph is generated. The study is conducted at tile industry which is for QC department to examine the surface roughness of every tile. The study is about to develop a haptic sensor for robot application on identifying surface roughness. This project is a continuation to the previous achievement. But since the previous researches didn't achieved the optimum performance of the robot haptic sensing technology, this project aims to enhance the haptic sensor in term of mechanism, material and operational concept.

1.2 Problem Statement

The current method of roughness measurement in manufacturing industry is by vision or profile-meter machine which is non-economical and require high maintenance cost. The operation of the machine requires for skillful operator which increases the cost of manpower and training. When the testing is carried out by operator instead of robot, it will increase the human error which will lead to quality problem on the production line. Human manually operated surface roughness measurement tester which is less accurate than robot. This situation leads to the introduction of robot haptic sensor to have robot perform the surface roughness measurement instead of human operator

The previous developed finger type robot haptic sensor (refer to Figure 1.1) has not providing a good result in term of roughness measuring performance (refer to Figure 1.2). The result shows a big variation of result from finger type haptic sensor as compare to the reference result. The factors that lead to high error produced from the surface roughness measurement of the previous researched product are design aspect, material aspect and process aspect. The main problem brings to current research work is the expected results are deviated from the experiment result.

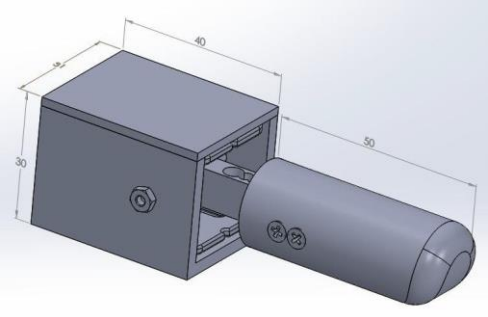
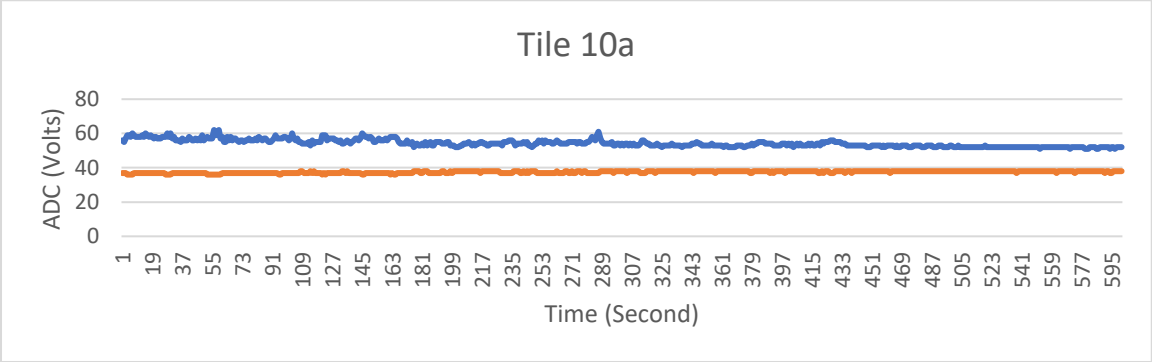


Figure 1.1: Finger type haptic sensor (previous)

Figure 1.2: Graph of 5.11µm tile sample (previous)



1.3 Objectives

The objectives are as follows:

a) To select the suitable material for poly-jet.

b) To design the fingertips and needle tips.

c) To analyze the newly develop finger type haptic sensor from the surface roughness measurement graph generated.

1.4 Scopes of the Research

The scopes of research are as follows:

a) Research on the material and design of the poly-jet; design of needle tips of finger type haptic sensor respectively. The research is focus on the geometry of the fingertips and finger like material.

b) Study the haptic sensing technology and finger type sensor to provide accurate result from surface roughness measurement of tile.
c) Focus is put on the accuracy of the result product by the newly develop sensor.
d) Design three different shapes of poly-jet and two different type of needle tips for finger type haptic sensor. From the experiment, result from the graph can clearly shows the best poly-jet and needle tips design.
e) Select two types of material for poly-jet. From the experiment, result from the graph can clearly indicate the most suitable material for poly-jet.
f) Three different geometries of poly-jet and two different geometry of needle tips in total will form a series of experiment which will compare between each other in the end. The comparison between results of graph will give the best matching of material and geometry.

1.5 Significant of Study

The achievement of the study brings advantages to tile industry. One of the main advantages is human error can be eliminated by substitute human into robot. The following advantages is that finger type haptic sensor is more economical than textile sensor technology which is commonly used by industry. The finger type haptic sensor also improves the of surface roughness testing. Haptic sensor is first introducing in surface roughness measurement machine which improve the efficiency of measurement.

1.6 Report Structure

This report basically consists of five chapters. The report is divided into two parts which three of the first chapter is done in Final Year Project 1 while the last two chapters will continue in Final Year Project 2. In FYP1, the report included Chapter 1 (Introduction), Chapter 2 (Literature Review) and Chapter 3 (Methodology).

Chapter 1 (Introduction) introduce the work on haptic sensor technology which mainly used in robotic and surgery. While in this chapter also discuss about the

manufacturing company facing the problem of measure surface roughness. This chapter included few topics that are organized as follow: background study, problem statement, objectives and scopes of research.

Chapter 2 (Literature Review) explained the haptic sensor technology, surface roughness measurement, fingertips sensor and material consideration of haptic sensor. This chapter consisted of literature review describing about the facts and researcher work done previously that are related to the project. The references are taken from books, journals and websites.

Chapter 3 (Methodology) describing the methodology of work of research started with overall flow chart for planning the research work. The overall flow chart consists of five main parts which are literature review, material selection, poly-jet's design, fabrication of parts and analysis & result. These five parts described and discussed about the flow process of research work and development of sensor in more details.

Chapter 4 (Results and discussion) focused on data collection and graph that gain from experiments and questionnaire. This chapter also explained deeply the final data and result from the experiments performed. The results of the experiments are illustrated in a graph and further discussion on the results is justified by each sub sections in this chapter.

Chapter 5 summarized about the conclusion of the experiments that are conducted either successful or not and the objectives are achieved or not. Other than that, the improvement for the future work and research contribution of this research work is covered on this chapter.

CHAPTER 2
LITERATURE REVIEW

This chapter is basically explaining about the research and works which have been carried out by most of the researchers in this world. The chapter will be divided into three topics which are haptic sensor technology, surface roughness measurement and tactile sensor. These three topics will help research to be done in an orderly manner. The topic will also support for further modification of the previous project.

In this section, there will have three main topics that will discuss regarding Haptic Sensor Technology. The primary topic is discussed about haptic sensor technology follow by fingertip sensor and surface roughness measurement. The three-main topic discussion from sources and content are organized in three type of organizing method that are Chronological, Thematic and Methodological.

2.1 Haptic Sensor Technology

Based on Eid & Al Osman (2015), stated that the meaning of Haptic is refer to science of sensing and controlling via touch and the term is derived from Greek verb ”haptesthai”. Jyothi & Krishnaiah (2013) has point out that Haptic Technology is a tactile feedback that gives benefit to human sense of touch by applying forces, vibration and motion to the human in the beginning of twentieth century. In other words, Haptic Technology is an rising of intrigue field that deals with acknowledgment of human haptic, machine haptic and with the evolution of computer haptic that permit physical interactions with genuine or virtual situation through touch (Jyothi & Krishnaiah, 2013). Haptic was introduced in the scope of experimental psychology by researcher which referred to active touch of true object. During the early stage of the researcher focus haptic stimulation application for helping blind or