

UNIVERSITI TEKNOLOGI MARA

**DEVELOPMENT AND ANALYSIS OF
OPTICAL-BASED TACTILE SENSOR
FOR MEASURING SURFACE
TRACTION KINETICS**

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ABSTRACT

Research on tactile sensors is expanding due to the need for autonomous dexterous robotic gripper to perform various tasks that need manipulation skills in medical operation, humanoid robots, household work as well as space exploration. These applications need a tactile sensor that can react to the variable force or pressure similar to human tactile sensing capability. To date, several researchers have explored several materials for tactile sensors ranging from the semiconductor based materials to silicon based rubber materials. This research is focused on the development and analysis of a spherical silicone tactile sensor based on a deformation image to measure the surface traction kinetics. A spherical tactile sensor was formed from a silicon rubber. It was marked with a circular mark inside the spherical dome to show changes in the diameter and shifts of the centroid. The tactile sensor was subjected to various normal and shear forces, and the circular mark image was recorded using an optical camera probe. The deformation image was digitized using a CCD camera and analysed using several digital image processing techniques such as image conversion from color to grayscale image, thresholding and boundary detection. The final image was then analysed to find the changes in the diameter and the shifts of the centroid, which were related to the normal and shear forces applied to the tactile sensor in x-axis, y-axis and z-axis. The results were tabulated and plotted in several graphs. The graphs showed that there was a significant correlation between the deformation image and the applied forces. This newly developed tactile sensor was proven to have a stiffness (k_t) of 0.7238 N/mm and also to be able to detect the stiffness of the soft workpiece used in this research which was $k_w=0.156$ N/mm. To conclude, the sensor can distinguish between hard and soft surfaces as well as between rough and smooth surfaces.

TABLE OF CONTENTS

	Page
CONFIRMATION BY PANEL OF EXAMINERS	ii
AUTHOR'S DECLARATION	iii
ABSTRACT	iv
ACKNOWLEDGEMENT	v
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xiv
CHAPTER ONE: RESEARCH INTRODUCTION	1
1.1 Introduction	1
1.2 Background of Research	1
1.3 Problem Statement	2
1.4 Research Objectives	3
1.5 Scope of Research	3
1.6 Organisation of Thesis	4
1.7 Significance of Research	4
CHAPTER TWO: LITERATURE REVIEW	5
2.1 Introduction	5
2.2 History of Robot Development	5
2.3 Robotic Sensors	8
2.4 Tactile Sensor Development	10
2.5 Current Development	12
2.6 Advantages of Fibre Optic Sensor	17
2.6.1 High Electromagnetic Interference and High-Voltage Environments	17
2.6.2 Harsh and Hazardous Conditions	18
2.6.3 Cabling for Large Structures	18
2.6.4 Sensing in Tight Spaces	19
2.7 Digital Image Processing	19

2.7.1	Image Acquisition	20
2.7.2	Image Pre-processing	21
2.7.3	Image Restoration	22
2.7.4	Image Segmentation	22
2.8	Types of Digital Images	22
2.9	Image Processing Software	26
2.10	Surface Traction Kinetics	27
2.11	Selection of Tactile Material	27
2.12	Summary	29
CHAPTER THREE: RESEARCH METHODOLOGY		30
3.1	Introduction	30
3.2	Research Flowchart	30
3.3	Sensing Principle	33
3.3.1	Design of the Sensor	34
3.3.2	Fabrication of the Tactile Sensor	37
3.4	Proposed Design Setup	38
3.5	Olympus Fiberscope	40
3.6	Charge Couple Device (CCD) Camera	42
3.7	Preliminary Experiment	43
3.7.1	Change of radius	43
3.7.2	Center Displacement	46
3.7.3	Hysteresis loss	47
3.8	Sensor Modification	48
3.9	Actual Experimental Process	51
3.9.1	Selection of Test Surface	51
3.9.2	Experimental Set-Up	51
CHAPTER FOUR: MATHEMATICAL MODELLING OF TACTILE SENSOR		58
4.1	Introduction	58
4.2	Modelling of A Normal Force Interaction	58
4.3	Modelling of a Shear Force Interaction	62
4.4	Summary	67

CHAPTER ONE

RESEARCH INTRODUCTION

1.1 Introduction

Robotic grippers and manipulators are widely used, especially in industrial applications all over the world, to perform various tasks for repetitive and dangerous working atmosphere. However, the most used gripper to date is passive gripper. Passive gripper is operated based on the programmed gripping force. Therefore, it is limited to handle hard objects and the gripping force needs to be reprogrammed to handle different objects with varied hardness.

Advancement in robotic research has seen the development of robotic capabilities to perform various tasks that need manipulation skills such as in medical operation, humanoid robots, social robots and household work. These robots need skills and suitable sensing systems to sense the contact with the human environment. Human environment presents special challenges for robot manipulation because such an environment is complex, dynamic, uncontrolled, and difficult to perceive [1]. The range of object hardness could also change instantly while the robot is performing its duty. These applications need a dynamic gripper that can detect and react to the variable force or pressure similar to the human tactile sensing capability. In the future, studies on tactile gripper may also include the capability of sensing and reacting to the differences in temperature, touch, vibration and etc. Studies on dynamic sensors are important to develop sensors that could actively and precisely react to their working environment, while studies on passive sensors are more focused on improving imperfect grips [2]. However, tactile sensing alone can support extremely sophisticated manipulation as convincingly demonstrated by blind people [2].

1.2 Background of Research

Tactile sensing is the process of determining physical properties and events through contact with objects in the environment. It is an essential sensory device to support the robot's control system, particularly in object manipulation tasks. Unfortunately, many traditional sensing technologies do not fit the requirements of