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

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