Development and Characterization of a Tactile Array Sensor for Parallel Grippers for Use in Object Manipulation

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Degree of Master of Science by Research

Department of Mechanical Engineering

University of Moratuwa

Sri Lanka

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DECLARATION

I hereby declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

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Signature of the Supervisor(s): ..... Date: .....

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Abstract

Within the era of modern robotics, during research as well as in industry, it is often the case to build robots that can mimic human-object interaction closely. To accomplish this goal, excellence is required in many technological aspects, where one is tactile sensing. Tactile sensing is the ability of a system to measure information arising from physical interaction with its immediate environment. These include static & dynamic force/torque sensing, vibrations sensing and thermal sensing. To fulfill these requirements, numerous types of sensors have been developed, which include but not limited to piezoresistive sensors, piezoelectric sensors, capacitive sensors and hall effect based sensors.

With any of the above sensors, it is necessary to accomplish mainly three tasks; at least one, if not all. These include contact point localization, dynamic sensing and tactile force measurement. These functionalities play a crucial role when developing human like grasping and manipulation capabilities. However, many problems arise during the design and manufacturing of these sensors due to the complexity of design, cost and difficulties in practical implementation due to size.

In order to overcome these difficulties and fulfill the above mentioned requirements, this thesis presents a tactile gripper that has been developed based on hall effect. An array of magnets and hall sensors create a unique combination of outputs for each different deformation of the dual layered silicon elastomer which houses the magnets. While allowing the interaction with non-planar surfaces due to the compliant nature of the silicon material, the sensor also facilitates accurate force recognition and contact localization using sensor readings and geometric properties of the silicon layer.

This tactile gripper can be used for object manipulation and many other forms of tactile sensing requirements with necessary modifications. Several experiments have been carried out to test and validate the operation of the sensor with successful results.

This thesis aims to provide the entire design and development of the sensor & gripper, experimentation process, results, limitations and possible future improvements to the reader with the expectation that this development will aid current research in research community and industry. The end goal is to contribute to the process of developing tactile sensors which aids the progression of robotics technology that plays a crucial role in modern scientific advancement.

***Keywords*-parallel gripper, hall sensor array, flexible silicon elastomer, tactile force sensing**

DEDICATION

This dissertation is dedicated to my parents, to whom I can trace my every success to.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CNC Computer Numerical Control

DC Direct Current

Vdc DC Voltage

PDMS Polydimethylsiloxane

CNT Carbon Nano Tubes

EMI Electromagnetic Induction

EMF Electromotive Force

PVDF Polyvinylidene fluoride

PVDF-TrFE poly[vinylidenefluoride-co-trifluoroethylene]

CCD Charge-Coupled Device

CMOS Complementary Metal-Oxide-Semiconductor

SEM Scanning Electron Microscope

CMC Carbon Micro Coils

MIS Minimally Invasive Surgery

FFT Fast Fourier Transform

SNR Signal-to-Noise Ratio

CoG Center of Gravity

PCB Printed Circuit Board

IC Integrated Circuit

SOT Small Outline Transistor

VCC Supply Voltage

GND Ground Connection

SIL Single in Line

THT Through Hole Technology

SMT Surface Mount Technology

ADC Analog to Digital Converter

op-amp Operational Amplifier

EMA Exponential Moving Average

RMSE Root Mean Square Error

GUI Graphical User Interface

USB Universal Serial Bus