DESIGN AND DEVELOPMENT OF MINIATURIZED TACTILE SENSORS FOR TACTILE IMAGING

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DECLARATION

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Name of the supervisor: Dr. Y.W.R. Amarasinghe

Signature of the supervisor: Date

ABSTRACT

Tactile sensors are devices which acquire data from the physical world through sense of touch. These acquired data may be related to either, surface roughness, texture, force, or any other tactile parameter. Even though, tactile sensor systems are identified as a feasible method to acquire force feedback in robotics and automation systems, due to the requirement of physical interaction between the sensor and application, development of tactile sensors does not come to the spotlight during the past decades. Rather, researchers were more focused on developing non-contact sensors for various sensing modalities when comparing with the tactile sensors. Currently, importance of tactile sensors has come to the spotlight, as development of robotics, automation and biomedical applications are limited due to lack of tactile feedback. Also, many application areas are identified, where tactile sensors can be incorporated such as robotics, industrial automation, biomedical imaging, biomedical robotics, etc.

Tactile imaging is one of the medical imaging technique, which mimic manual palpitation to diagnose diseases such as breast cancer, prostate cancer, etc. Tactile sensor is the foremost element in a tactile imager. Comparing with the other medical imaging techniques, it was found that tactile imaging is the most cost effective method to screen breast cancers. Also it has other advantages such as minimum exposure to radiation, simple and easy operation, etc. Hence, main aim of this research is to develop miniaturized tactile sensors for tactile imaging applications.

Working with that aim, miniaturized tactile sensors were developed during this research. In these developed sensors, Quantum Tunnelling Composite (QTC™), which is a conductive polymer composite, has been used as the sensing element. A novel structure was proposed to be incorporated with the sensing elements and analysis of the structure discussed. Proposed sensor was developed and calibrated. In the next stage of this research, a novel enclosed tactile sensor was designed and developed utilizing the same sensing and working principle as the developed 1-DOF tactile sensor. Main motive of developing this sensor is to include the proposed improvements for the 1-DOF tactile sensor based on the experimental results. An enclosed novel structure was proposed so that the sensing element and spring will be omitted from the environmental effects. Sensor was developed and calibrated so that it could be integrate with tactile imaging applications. Sensitivity of this developed tactile sensor, calculated to be 0.02 V/N and sensor displayed repeatability of ±3 N.

An experiment was carried out to evaluate the usability of developed sensors in tactile imaging applications. Using the developed sensor pressure variation of a human left hand was mapped and visual images were constructed. Applicability of sensor arrays instead of a single sensor in tactile imaging applications and miniaturization techniques to be used to construct tactile sensor arrays with high Taxel density is discussed.

A MEMS based tactile sensor design was proposed to be developed to construct tactile sensor arrays with good performance for tactile imaging applications. Proposed sensor design analysed and simulated to validate the proposed working and sensing principles. Fabrication steps for the designed MEMS sensor was proposed.

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Key Words: Tactile Imaging, Tactile Sensors, Force Sensors, MEMS

DEDICATION

I dedicate my dissertation work to my family and my teachers. A special feeling of gratitude to my loving parents, Jayasena and Padmini Perera whose words of encouragement and push for tenacity ring in my ears.

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LIST OF ABBREVIATIONS

Abbreviation	Description
ADC	Analogue to Digital Converter
BSF	Breast Self-Examination
CAD	Computer Aided Drawing
CBE	Clinical Breast Examination
CNC	Computer Numerical Controller
CT	Computed Tomography
DOF	Degrees of Freedom
DRE	Digital Rectal Examination
FEA	Finite Element Analysis
GUI	Graphical User Interface
MEMS	Micro Electro Mechanical Systems
MIS	Minimally Invasive Surgery
MRI	Magnetic Resonance Imaging
PSA	Prostate Specific Antigen
PVDF	Polyvinylidene Fluoride
PZT	Lead Zirconate Titanate
QTC	Quantum Tunneling Composite
SOI	Silicon on Insulator
TRUS	Transrectal Ultrasound
USB	Universal Serial Bus

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