**DESIGN AND FABRICATION OF TACTILE INTERFACE FOR PALPATION**

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**INTRODUCTION**

Breast lump/mass starts when cells in the breast begin to grow out of control. They could be benign or cancerous in which case, the cells invade other issues and move to other parts of the body. According to the American cancer society, about 1,650,000 women will be diagnosed with breast lumps in the United States of America in 2018 and about 40,920 women will die from breast cancer. Since 2007, breast cancer death rates have been steady in women younger than 50 but have continued to decrease in older women. These decreases are believed to be the result of finding breast cancer earlier through screening and increased awareness [1]. Some of the methods available for breast mass detection are MRI, Ultrasound, PET, Molecular based detection. But the golden method is the X-ray mammogram [3]. Unfortunately, studies reveal that low-dose radiation increases breast cancer risk among these young high-risk women, and a careful approach is warranted [2]**.** Hence, we propose an alternate screening method for the lump detection which could be followed by biopsy or mammogram once lump is identified thus reducing the unnecessary exposure to radiations. In the proposed method, tactile sensors are used to construct a wearable, the data from which can be used to detect the presence, location, size and shape of mass.

**TECHNICAL APPROACH**

The proposed hardware structural diagram is as shown in the figure. The main components we will use are the tactile senor, a readout circuit, Matlab software for data processing and the GUI/ app for data visualization. The tactile sensor will be modelled in the shape of the breast (Eg, a brasier) to form a firm covering of the breast with a slight pressure. Research shows that a pressure of 70-90kPa is applied by a physician for breast palpation. Depending on the sensitivity of the sensor, the pressure will be optimized and a control system will be developed to enable detection of small lumps. The sensor will provide voltage readings inversely proportional to the firmness of the tissue. The voltage from the senor will be obtained through a readout circuit and the data will be processed in Matlab. The sensor will have to be calibrated to relate a voltage output to the firmness of the underlying tissue. The data will be signal processed followed by segmentation to obtain the size, shape and location of the lump and further be classified to obtain the texture of the mass. The visualization of the location, size, and shape will be provided in Matlab GUI and in an app that a physician can use to infer the results.

 

Visualization using app

Via cloud

Pressure diff

Tactile sensor covers the phantom

 

Analog voltage

Breast phantom

Tactile sensor

Readout circuit

 

Processing and visualization

Fig 1. Data flow diagram

A phantom of the breast made of plastic with a covering of rubber will be used in experiments. Two kinds of lumps will be used for texture classification. One made of hard material like plastic and the other made of rubbery mass.

**KEY COMPONENTS**

**Tactile sensor:**

A low cost, pressure sensor will be made using conductive fabric (Fig. 2a). The construction involves a piezoresistive fabric (NW-SLPA from Eeonyx) sandwiched between two layers of conductive fabric (Silver coated nylon, LessEMF). The conductive fabric forms a row and column matrix, where each intersection between a row and a column constitutes a sensing element. The arrangement is then held together using non-conductive fabric fusible interface.



Fig 2. Layers of Sensor

The sensor design parameters like high density vs multilayer design, spatial resolution, sensitivity and fabric elasticity will be modelled to suit the detection of breast lumps.

**Readout circuit:**

A standard multiplexed readout circuit was used (Fig. 2b). As the resistance at each intersection decreases with increasing pressure, the pressure at each point is derived by measuring the potential difference across it. This is performed by activating each column *m* with a digital high signal (5V TTL) while deactivating other rows with a digital low. Each row *n* can then be read using a potential divider circuit, with each reading corresponding to the potential difference at point (*m,n).* The analog and digital pins are provided from the Arduino Uno board.



Fig 3. Read out circuitry

**DATA PROCESSING**

We will give a brief introduction to the techniques involved in processing the analog voltage to obtain the required information. The data obtained in represented as a matrix. The voltage values (0-5V) will be scaled to 0-255 and inverted. The matrix will then be threshold using the histogram or OTSU methods which will result in black or white regions. The connected component algorithm will then be applied to obtain the location, area (size). The shape can then be inferred from the information like the major axis, minor axis, and area. For texture detection, the output voltage will have to be related to a force applied on the senor which intern related to the hardness of the lump which can be obtained by calibration of the sensor. Calibration will be performed by applying different forces and collecting the data to perform a polynomial fit. Once the force associated with hardness in obtained, the forces associated with different objects will be classified to determine the type of lump.

**DELIVERABLES**

**Minimum deliverable:**

* Develop a tactile interface for breast lump detection
* Detect the presence, size, shape and location of lump

**Expected deliverable:**

* Detect the texture of lump
* Develop a user interface for visualization of lump estimation

**Maximum deliverable:**

* Develop a phone application for data visualizations

**TIME LINE AND MILESTONES**

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| --- |
|  **Task End Date Status**  |
| **Milestone 1 – Fabricate sensor for lump detection**  |
|  Familiarize with the environment 2/21/18 Completed |
|  Study characteristics of sensor 2/28/18 In progress |
|  Analyze sensor characteristics for different objects 3/9/18 Not Started |
| **Milestone 2 – Determine presence, location, shape and size**  |
|  Localize the lump 3/16/18 Not Started |
|  Improve localization accuracy 3/23/18 Not Started |
|  Determine the shape and size of lump 3/30/18 Not Started |
|  Document results 4/2/18 Not Started |
| **Milestone 3 – Determine the texture of lump** |
|  Calibrate sensor 4/7/18 Not Started |
|  Develop the classification algorithms 4/14/18 Not Started |
|  Experimental texture detection 4/20/18 Not Started |
| **Milestone 4- Develop user interface** |
|  Develop Matlab GUI to visualize data 4/27/18 Not Started |
|  Document the results 4/29/18 Not Started |
| **Milestone 5 – Develop an IoT** |
|  Develop an app for data visualization 5/10/18 Not Started  |

**DEPENDENCIES**

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| --- |
| **Dependency Status Fallback** |
| Training on fabrication of sensor Completed |
| Materials for sensor fabrication Completed |
| Readout circuit Completed |
| Phantom model of breast in progress Use existing model  |
| Calibration bridge Not started Make a cardboard bridge |
| Different texture samples Not Started No fallback |
| Android phone/tab Not Started Use someone’s old phone |

**MANAGEMNT PLAN**

* Weekly meetings with Dr. Brown
* Biweekly/required skype with Dr. Thakor on weekends.
* In person project review with Dr. Thakor and Dr. Brown by mid-March
* Weekly data review with Luke Osborn.

**READING LIST**

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