An Automated Portable and Noninvasive Approach for Breast Tumor Findings using 2 D Electrical Impedance Tomography in Early Stage

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Abstract- Breast malignancy is the major and common reasons for demise due to cancer among ladies. Primary prevention is not possible since the cause of this disease is not known. The likelihood of developing breast cancer increases with age and the majority hazardous factors contribute its growth. If it is detected in its early stage the success of treatment is more thereby increasing the survival rate. Currently various screening and diagnostic methods are available such as Breast self and clinical Examination, Mammography, Ultrasonography, Infrared Thermography, Magnetic Resonance Imaging. In many cases these methods are medically insufficient for concluding the correct nature of lesion found inside breast and are costly. It has some harmful effects like radiation, pain. A better technique with less harmful effects, pain, cost, which is portable and more reliable, is the requirement of the present society. Here an automated noninvasive novel method using electrical impedance tomography is proposed for the early detection of breast cancer.

Keywords- Breast Cancer Detection (BCD), Tumor, Mammography Thermography, Electrical Impedance Tomography (EIT), Phantom, Surface electrode, Non-conducting object, conducting object

I.INTRODUCTION

Breast malignancy is most widely recognized illness among ladies around the world. Cancer is said to occur when cells in the body begin to grow in an uncontrollable manner. Typically cells develop in an organized manner, however malignant growth cells grow to develop and crowd into ordinary cells. Since, currently there is no known way of preventing breast cancer, early detection permits more treatment options before cancer spreads to different parts of the body, thereby increasing survival rate. Various advanced imaging and screening techniques are available to detect breast cancer [1].

Following are various screening techniques,

1. Breast Self Assessment (BSA) and Clinical Breast Assessment (CBA)
2. Mammography
3. Ultrasonography or Ultrasound
4. Infrared Thermography or Thermal Imaging
5. Magnetic Resonance Imaging (MRI)
6. Electrical Impedance Tomography (EIT)

1. Breast Self Assessment (BSA) and Clinical Breast Assessment (CBA):

Breast examination CBA and BSA are primary methods for breast cancer screening. Here the breasts are examined for presence of any abnormality; it doesn't indicate malignancy. So it might be destructive as well if ignored. Studies demonstrate that young ladies particularly the individuals who are not going for routine mammography checkup, they must carry out CBE and BSE. [2].

2. Mammography

Mammography is an important non-invasive tool for breast scanning, not only plays a major role in tumor findings at an early stage but also show changes in the bosom much before patient or doctor can feel them. Research has indicated that yearly mammography lead to early identification of bosom malignancies, when they are generally curable. Mammography is an imaging system which is of low dose x-ray imaging on high contrast, and high resolution film. Mammography can detect calcifications also, which are tiny mineral deposits within the breast tissue that appears as small white regions on the mammogram film. However it is very difficult for a radiologist to check each and every mammogram with bear eyes. This affects the accuracy of detection in which non-cancerous tissues might be misread as a cancerous (false-positive), while cancerous tissues can be missed (false-negative). A recent advance in mammography includes digital mammography and computer aided detection (CAD), which assists radiologists in the assessment of mammographic images. CAD system is capable to detect the region of suspicion and classify-as benign / malignant cases. This increases the prediction accuracy. [3]

3. Ultrasonography or Ultrasound

In medication ultrasound is utilized to identify changes in the presence of organs, tissues, and vessels or to recognize anomalous masses, as tumors. High frequency sound waves are used to produce pictures of the inside parts of the body. Ultrasound imaging is a noninvasive medical test that helps physicians to diagnose and treat the medical conditions. Ultrasound imaging depends on the rule that when a sound

wave strikes an item, it echoes. With estimation of these reverberation waves it is conceivable to decide the distance away the article is and its size, shape and consistency. It is widely available, simple to use and more affordable compared with other imaging techniques. Ultrasound scanning produces clear image of soft tissues that don't appear well on x-Ray images. It causes no health related issue and may be repeated frequently as is necessary. Since Ultrasound gives, real time imaging it is used for directing needle biopsies and needle aspiration. [4] Patients with dense breast are more difficult to image because tissue attenuates the sound waves as they pass deeper into body. Currently major use of breast ultrasound is to guide breast biopsy. If a breast abnormality is found and affirmed with mammography, supplementary breast imaging tests such as ultrasound (sonography) or breast biopsy may be carried out. Ultrasound methodology is also used for placement of biopsy needles. [5]

4. Infrared Thermography or Thermal Imaging

Thermal Imaging is being examined as a potential apparatus for identification of breast disease [6]. Infrared Breast thermography is an imaging system that gives data dependent on the temperature changes. A tumor is expected to be more vascularised than its neighbouring tissue, hence could be at a slightly higher temperature. The skin surface near the tumor may also show relatively higher temperature. Infrared Thermography is a non-invasive and non-ionizing method for understanding the internal system of human body which plots heat patterns which show malignant growth, infection, inflammation, surface lesions and more. It possesses many advantages, such as noninvasive, innocuous, non-contact, non-radiation, risk free and considerably less expensive but it has limited success in detection of early breast cancer [7], [8].

5. Magnetic Resonance Imaging (MRI)

Breast MRI (BMRI) is used in women who are diagnosed with breast cancer for measuring the size of the tumor and find for other tumors in the breast. The patient to be examined using MRI is placed inside a large cylinder shaped magnet having a magnetic field strength of 1 to 3 Tesla. Radio frequency waves are then sent through the body. Human body comprises of fundamentally water, and water contains hydrogen atoms. The nucleus of the hydrogen atom is utilized to create a MRI scan. Using MRI scanning it is possible to take images of all the tissues in the body from different angles. MRI scans are more detailed and it is a best technique for finding tumor in the soft tissues, also it can be used to see whether it has spread into close by tissue. By varying the frequency of radio wave pulses, information about different types of available tissues can be obtained. [9] Since patients need to lie inside a large cylinder during scanning, few people get claustrophobic during the test. Moreover the machine makes a banging noise while working, which may be unpleasant to the patient. The MRI examination poses almost no hazard to an average patient when correct safety guidelines are followed. Implanted medical devices containing metal may breakdown or causes problems during MRI scan. BMRI is an emerging tool in breast cancer diagnostic and research. These machines are very costly all the hospitals may not possess them. MRI is not used as primary screening method usually used to verify a diagnosis. The cost of BMRI is very high as compared with mammography and ultrasound hence this technique is not used as a standard in BCD.

All the above techniques are very costly, since the machines are very big and of considerable size, fixed at a particular place. Therefore patients need to visit the place to undergo this treatment. These techniques are having disadvantage of radiations. So patients may suffer its after effects. They are not suitable to use in intensive care unit during emergency. Apart from these techniques there are other non- invasive techniques discussed in the next sessions based on EIT used for early BCD to avoid the inconvenience and discomfort of other methods. It can be treated most efficiently if it is detected at an early stage.

6. Electrical Impedance Tomography (EIT):

EIT is a helpful, non-obtrusive, versatile and generally modest bedside technique and has numerous clinical applications. Human body tissues offer impedance to the flow of electric current. Human tissues are made up of cells. These cells altogether forms number of clusters enveloped by fluids containing water, electrolytes which are resistive and capacitive. EIT is used for imaging of Thorax [10], imaging of brain [11], measuring breast tissue impedance, Imaging of fetus [12], and many more [13], [14], [15].

EIT is generally new imaging system with which pictures of impedance of particular part in human is possible to take without radiation harm. Since it is not allowed to perform biomedical experiments directly on human body due to ethical reasons, the experiments are carried out on a circular plastic phantom containing saline water depicting female breast. EIT is an imaging modality in which electrical conductivity distribution of a closed region is measured at the boundary of the structure. The current-voltage relation can be described mathematically by Laplace's equation. [16] The measured readings of current and voltage distribution are reconstructed with an image. EIT makes non-invasive and non-radiating sample analysis for BCD.

Current is supplied to pair of electrodes and voltage sets are obtained. Current can be applied to the pair of electrode in various fashions such as, adjacent pattern or Neighboring Pattern [17] (ref Figure 1), Opposite Pattern or polar drive pattern [18], Cross Pattern [19] and Adaptive Pattern or trigonometric method [20]. Figure 1 shows adjacent pattern current injection method.

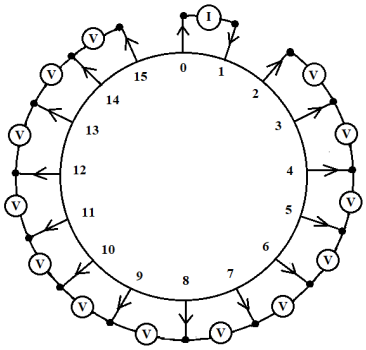

Figure 1: Adjacent Pattern

II. Experimental Work and Contribution in the paper

The aim of this study is to design and develop an automatic system which will detect the presence of cancer at an early stage. Biomedical experiments are not permitted to be carried out on human beings due to ethical reasons. So for carrying out experiments in this proposed work, a hypothetical model of phantom resembling a breast is developed.

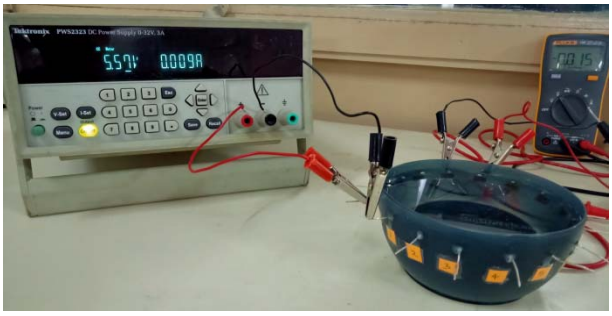

Figure 2: EIT Experimental Setup using Manual Approach with only Sodium-Chloride

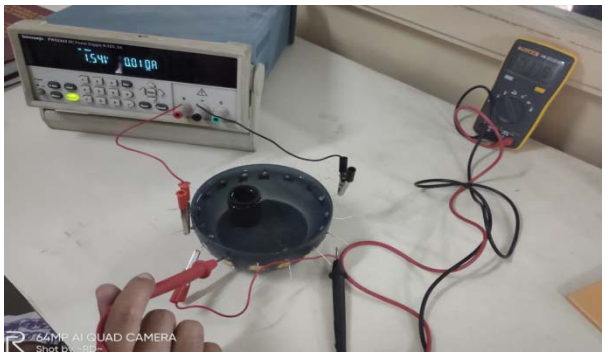

Figure 3: EIT Experimental Setup using Manual Approach by inserting Plastic object between electrode 0 and 1

Here adjacent current injection method is implemented to note down the readings manually. The setup consists of 16 silver electrodes, attached equidistantly on the inner surface of the phantom. Length of electrode is 2.7cm. The phantom is of plastic material having diameter of 12cm and oval in shape which resembles the actual breast shape. Fluke multi meter is used to measure the output voltage on the electrodes. It can measure the precise voltage of very small amplitude range. Sodium-Chloride-Injection-I.P.(0.9%w/v) is used for doing experiments. Tektronix power supply is used. Figure 2 shows EIT Experimental Setup using manual approach and figure 3 shows setup with plastic object between electrode 0 and 1.

Current is applied through a pair of adjacent electrodes and the voltage is measured sequentially from all remaining adjacent electrode pairs except the pairs containing current electrode. The current is injected through electrode 0 and 1and the potential voltages are measured across the other 13 electrode pairs 2-3, 3-4, . . . And14-15. The procedure yields 16 × 13 = 208 measurements. This is the first projection. In the second projection current is injected through electrode 1 and 2 and the voltages are measured across the other 13 electrode pairs 3-4, 4-5, . . . And15-0. Another set of 208 voltage measurements is obtained. This procedure is repeated until current has been injected between all 16 adjacent pairs of electrodes. Here each projection yields 208 readings. The readings are taken manually for input current values from 1mA to 10mA range with and without inserting the conducting and non-conducting impurities in the phantom. In this way the dataset is created. It is observed that for taking the readings every time the input and output supply electrodes needs to be changed manually and readings are noted down. This procedure is time consuming, takes around 20-25 minutes for one dataset; moreover the readings may not be accurate. By considering the disadvantages of this system, this research paper proposes the design and development of an automatic system for switching of supply electrode as well as measuring the output voltages. If the input current electrodes are switched automatically then the time required to prepare the dataset is reduced drastically. This may lead to a portable and low cost mechanism to detect any growth of unwanted tissue inside the breast at an early stage. It is using the concept that human body tissues offer impedance to the flow of current. Cancerous breast tissues have lower impedance than that of normal tissue. This method does not emit any ionizing radiation thus it can be used on women of any age and on pregnant women too. Due to its mobility, low cost and using non compression technique will be appealing to patients.

A. Block diagram of proposed EIT system:

Following Figure 3 shows is proposed block diagram of EIT system to be implemented.

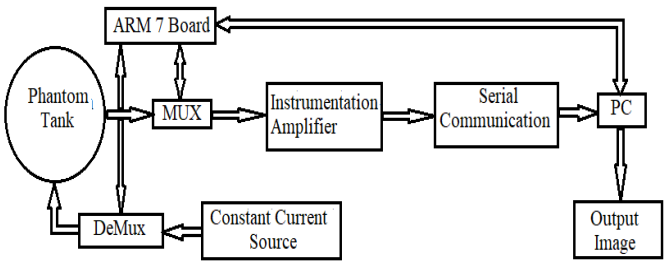

Figure 4: Block Diagram of proposed EIT Structure

Working of circuit:

Initially the experimental setup, as shown in Figure 4, is made which will consist of a plastic phantom, electrodes,

constant current source, ARM LPC2148, Dual Channel Multiplexer, Dual Channel De-multiplexer, Instrumentation Amplifier, and a PC. The electrodes will be connected equidistantly in a circular fashion on the boundary to a closed plastic phantom. The electrodes used can be of stainless steel, silver or gold material. Plastic phantom will be filled with saline water or normal water.

Flow of signal in proposed EIT System

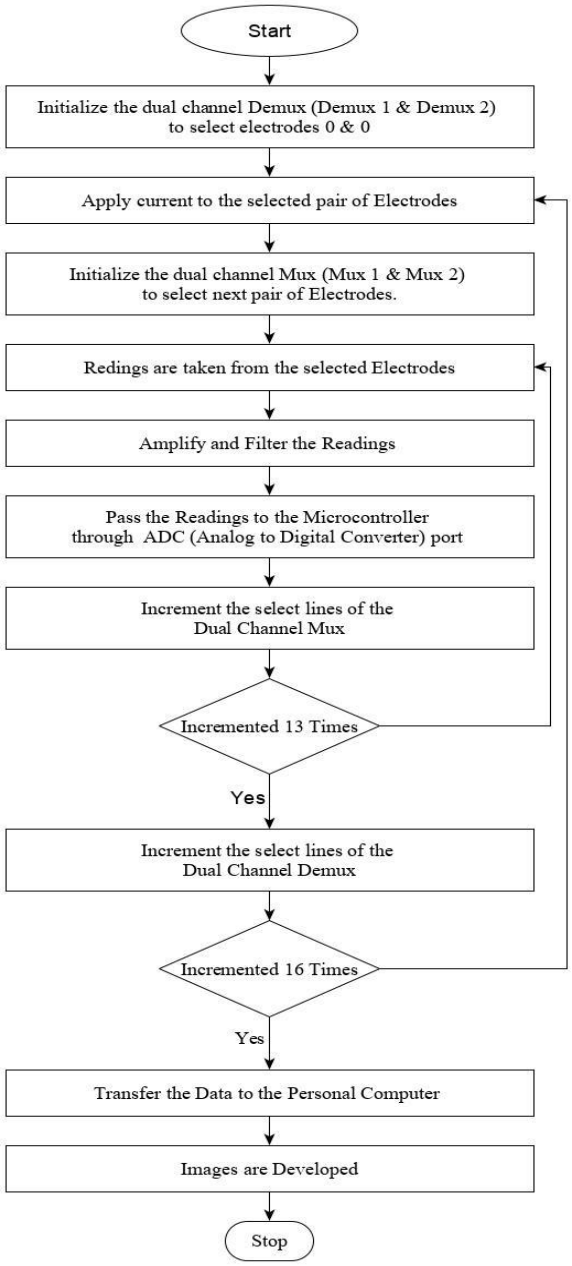

Figure 5: Flow of signal in proposed EIT System

AC constant current source of range 3mA to 10mA current and a variable frequency of 1 kHz to 100 kHz will be used. ARM LPC 2148 has two I/O ports of 32-bit wide and has 10 bit in-built two ADC modules. In adjacent pattern method, low frequency current is given to a pair of neighboring electrodes and voltage measurements are noted between remaining set of successive electrodes. ARM LPC2148 is connected to the select lines of the Dual Channel De-multiplexer (1:16) (i.e. DEMUX 1 and DEMUX 2) and to the select lines of16:1 Dual Channel multiplexer (i.e. MUX1 and MUX 2). The select line selection coding will be done in embedded programming. The current is applied to pair of electrodes based on the selection (eg. 0 - 1, 1-2…15-0). Electrodes 2 and 3 are connected to the dual channel multiplexers 16:1. These output values from the dual channel multiplexer will be passed through instrumentation amplifier to get the amplified reading. These readings are given to analog to digital converter module of LPC 2148 to provide digital output. Output will be measured between remaining electrodes, selected by the select lines of the Dual Channel MUX i.e. 2 and 3, 3 and 4, 4 and 5 and so on till electrode pair 14 and 15 (excluding the electrodes where current is given). 13 readings are noted. After this the current supply is shifted to pair 1-2 to get the next set of 13 readings. Further the procedure is repeated with current source connected to electrode pairs 2-3, 3-4, …..15-1 and for each position a set of 13 readings are obtained. Thus by adjacent method 208 (13 ×16) readings are obtained. ARM has RS-232 interface which can be directly connected to PC for storage and processing of data acquired. Human skin can bear maximum frequency of 100 kHz. So the experiments will be carried on within this range of frequency.

Figure 4 shows the flow of signal in proposed E-I-T System to be implemented for 16 electrodes. This flow chart is prepared in yEd graph editor open source software.

III. CONCLUSION AND FUTURE SCOPE

In this paper various BCD techniques for early detection are discussed briefly. It is observed that Mammography and ultrasonography technique is not suited for women with dense breasts. Thermography has many advantages but has limited success in India due the complex procedure and cost. . MRI is painless; it is costly technique and has harmful radiations. The automated system proposed here in this paper can overcome the limitations of other methods and can be made potable. EIT technique is a non-radiating, noninvasive and low cost method which can be used for early detection of tumor (malignant/benign).

By using automatic switching of pairs of electrodes through select lines by software control the time required to for the process can be reduced. Since the system can be made low weight, low cost and portable, an important advantage is that it can be made available in rural areas even for the poor community. Once the dataset is ready then it is fed to the image reconstruction software for further analysis. The images can be reconstructed by using software like EIDORS (Electrical Impedance and Diffused Optical Reconstruction Software), FEM (Finite Element Method) or COMSOL Multiphysics.

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