Microwave Radar Based Imaging for Early Detection of Breast Cancer Tumor

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In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

This is to officially state that the thesis work contained in this report

"Microwave Radar Base Imaging for Breast cancer detection"

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Abstract

Breast cancer is one of the most often diagnosed cancers among women in the World. Early identification of breast cancer, which has recently gotten a lot of attention in the research community, is crucial for a quick and effective treatment. One of the most promising and appealing screening technologies now under investigation is UWB radar-based microwave imaging for early breast cancer detection. The report presents Confocal Microwave Imaging (CMI) Algorithm for breast cancer diagnosis. The said imaging technique is a simple and effective method for detecting tumors that is used to approximate the tumor's exact depth. The CMI is entirely dependent on illuminating the breast with a UWB pulse from unique antenna distances. The depth of the tumor is estimated using the respective arrival frequency and amplitudes of the backscatter signals. We have applied the Confocal Algorithm to the data obtained by the VNA in form of S_{11} and the analysis of depth of tumor at different frequencies and at different antenna position is presented. To test the effectiveness of the Confocal Microwave Imaging Algorithm for breast cancer detection, the phantom is developed with unique ingredients and simulated. The tumor at different depths in phantom is then also analyzed using CMI technique. The simulated results are found to be in good agreement with measured one.

ACKNOWLEDGEMENTS

There is no accomplishment without the desire of ALLAH Almighty. We are thankful to ALLAH, who has given us direction, quality and empowered us to achieve this assignment. Whatever we have accomplished, we owe it to Him, in totality. We are likewise thankful to our parents, friends, family and well-wishers for their excellent help and their basic audits. We want to thank our supervisor Dr. Farooq Ahmed Bhatti for his consistent direction and inspiration over the span of our task. Without their assistance we would not had the option to achieve anything.

DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

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1 INTRODUCTION

1.1 Background

Breast cancer has become one of the most common full-size disorders worldwide, posing a threat to women in contemporary society. The advancement of technology has prompted researchers to consider developing a screening device that may be used to detect tumors in their early stages and can be used by surgeons for similar diagnosis.

Researchers were attempting to develop a method for photographing the human frame using non-ionizing electromagnetic waves in order to detect most malignancies. Recently, significant progress has been made in the identification of breast malignancies. Microwave structures are unlikely to become a viable solution within the next ten years. Microwave frequencies have electric homes in breast cancers, which can be specific in comparison to healthy or daily breast tissue. The use of X-Ray as a method of detecting breast cancer has apparently resulted in negative effects to the affected person's breast tissues beneath examination. Researchers have discovered that extremely large band radar-based completely microwave imaging techniques can be used as a capacity modality.

- Low cost of implementation;
- Non-harmful radiation exposure;
- High accuracy;
- Better patient comfort than existing X-Ray mammography

- In spite of the benefits of using Ultra Wideband pulses, it presents many challenges. Particularly in,

- Hardware & antenna design;
- Imaging algorithm.

An optimal breast screening method, according to the IOM (Institute of Medicine of the United States)

- Has a low health risk;
- Has a low health risk;
- Is sensitive to malignancies;
- Can identify cancer early;
- Is non-invasive and simple to use
- Provides minimal discomfort to patients
- Is cost-effective, simple to grasp, and consistent

A regular screening of tumor and normal breast tissues is essential for the detection of tiny tumors. Medical imaging techniques have been used to identify breast cancer with varying degrees of success. Ultrasound is utilized to determine whether the lesion found is a liquid cyst or a stable tumor. Magnetic resonance imaging (MRI) is useful for studying embedded cancers but is expensive as a screening technique. Special biological properties, such as tissue elasticity, temperature, and optical or electric characteristics, are used to locate malignant tissues. We're particularly interested in hiring tactics that contrast electric belongings. Within the microwave frequency range, active processes for breast tumor detection are now being investigated [1].

The difference in dielectric strengths of ordinary and malignant tissue in microwave frequency ranges is used in ultra-wideband (UWB) Radar imaging of the breast. The backscattered indicators are measured when a UWB pulse illuminates the breast in current UWB imaging techniques. The backscattered sign is then used to create an envisioned picture of the breast tissue that is being evaluated.

The basic mechanism of tumor detection in the breast is shown in Figure 1-1, where a signal is broadcast by an antenna and then analyzed to determine the position and size of the tumor.

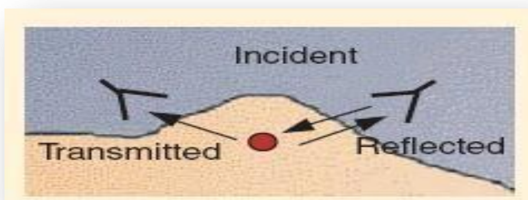


Figure 1-1: Principle of tumour detection in Breast [3]

Many scholars have presented a variety of imaging algorithms. These many algorithms are applied through various microwave imaging techniques and their efficiency is checked. On this basis a very effective technique for early detection of breast cancer tumor is Confocal Microwave Imaging technique which diagnose the breast cancer tumor in its initial stage. This technique will use different dielectric properties of back scattered signals to exactly find the depth of tumor inside the body. Further details on this technique and its experimental views are explained later on in the chapter related to details of this technique in this thesis. Confocal Microwave Imaging is applied on tumors of different depths just to check the accuracy of this technique and it has proved its efficiency is approved by exact results proving that this is a worthy technique for early detection of breast cancer tumor. The efficiency of the Confocal Microwave Imaging Algorithm with diverse materials as tumor was evaluated in this research using experimental data from a UWB microwave imaging system for radar-based breast cancer detection [3].

1.2 Motivation

The spread of breast cancer disease is said to be speeding up due to flaws in currently used screening strategies, with X-ray mammography being the most widely used screening method among MRI and Ultrasound to detect breast tumors, but it's been said to have expected fake effects for roughly 30% of women who've had a screening. The large number of fake effects obtained is a significant barrier for current screening procedures in researching dense breast tissue and the site where the tumor is most likely positioned around the chest or beneath the arm, particularly in estimating early-stage cancers. Microwave imaging technologies are now being used by researchers for non-invasive testing of breast tumors.

The motive for employing microwave methods to diagnose a patient with breast cancer at an early stage is advantageous. We show the experimental setup in this thesis to test the confocal imaging set of rules that is used in radar-based breast cancer diagnosis with a high challenge in reducing the amount of litter within the backscatter signal(s) to examine its usefulness for unique substances such as tumor [2]. Furthermore, we use the chemicals at extreme depths to detect the effect of antenna distance on tumor response.

1.3 Dissertation Outline

The rest of this dissertation consists of 6 chapters. Each bankruptcy is a self-contained file on an issue of breast most cancers detection. In this phase we offer a quick evaluation of the chapters.

Chapter two evaluates the current imaging strategies, their merits and drawbacks, and why microwave imaging has been considered in recent years, as well as the screening strategies and their limits.

Chapter three provides an introduction of microwave imaging techniques and analyzes recent imaging strategies that are being utilized as studies in many parts of the industry with perception knowledge of the imaging algorithms in use. The end of the paper includes a discussion of microwave imaging methodologies and techniques.

The fourth chapter examines the experimental setup used in recent investigations and describes the critical factors involved in the confocal microwave imaging set of rules used in detecting unusual compounds such as tumors[4].

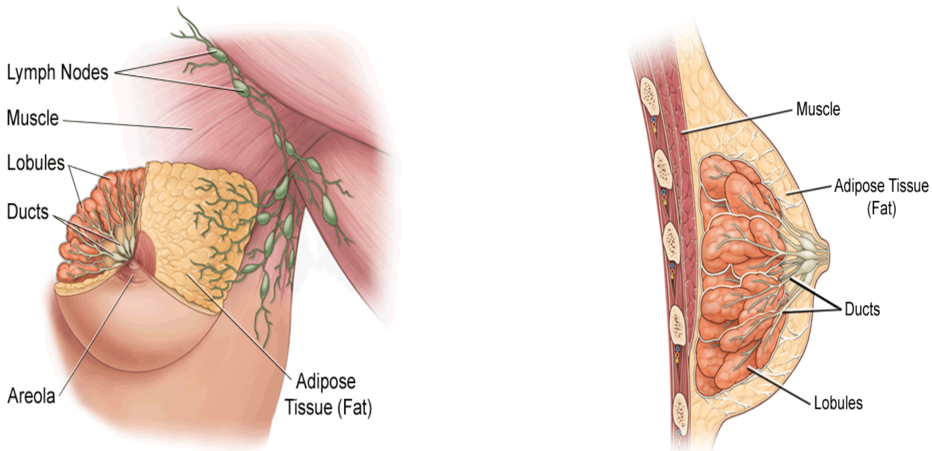
Chapter five offers the dialogue at the experimental consequences obtained.

Chapter 6 offers the belief and destiny upgrades in goal to attain a standalone non- invasive screening technique for breast tumor detection

2 STUDY ON BREAST CANCER & SCREENING METHODS

2.1 Morphology of Breast

To design an effective screening method, researchers must first examine and comprehend the internal structure of the breast. The morphological structure of the female breast is depicted in Figure 2-1.



a) Front View

(b) Side View

Figure 2-1 Anatomy of Breast [2]

The breast is divided into the following main sections.

- Breast Gland

    - Each breast has 15 to 20 sections (lobes) arranged like the petals of daisy;
    - Inside each lobe are many smaller structures called lobules ;
    - At the end of each lobule are tiny sacs (bulbs) that can produce milk
    - Lobes, Lobules and bulbs, are linked by a network of thin tubes
    - Ducts carry milk from bulbs towards the dark area of skin

- Ducts carry milk towards the dark area of skin in the center of the breast (areola);

- Ducts join together into larger ducts ending at the nipple, where milk is delivered;

Lymph nodes: Filter harmful bacteria and play a key role in fighting off infection.

There are no muscles within the breasts, however there are muscles beneath each breast that cover the ribs. Each breast also has blood arteries as well as lymphatic vessels. Lymph vessels give rise to little bean-shaped organs known as lymph nodes, which can be found in clusters below the arm, above the collarbone, and inside the chest, as well as in many other parts of the body.

2.1 What is Breast Cancer?

Breast cancer may be a tumour that has developed from cells of the breast. A malignant tumor is a cluster of cancer cells that will invade encompassing tissues or unfold to distant areas of the body.

The incidence of carcinoma in women is extremely low in their twenties, gradually rises and plateaus at the age of forty-five, and then rises dramatically once fifty, with half of all breast cancer cases diagnosed in women over the age of lxv, indicating the importance of yearly screening throughout a woman's life. The illness affects almost primarily women, but it can sometimes affect men.

One male can develop breast cancer for every hundred females diagnosed with the disease. The information on this page is only on cancer in women. Figure 2-2 depicts the proportion of diseases documented by Cancer Research UK, indicating that breast cancer affects at least 31% of women diagnosed with cancer[3].

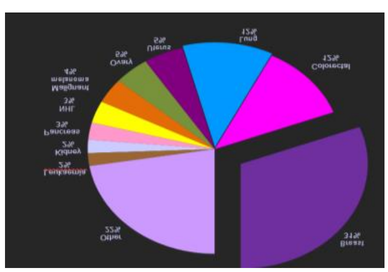


Figure 2-2 Most Commonly Diagnosed Cancers in Females, UK 2008 [5]

2.2 Symptoms and factors leading to Risk of Breast Cancer

Breast cancer is the most often diagnosed cancer in women, with an age-standardized (a measure used to compare populations with very diverse age profiles) charge of 124 per 100,000 women, accounting for roughly a third of all female cases in the UK. According to statistics from 2009, breast cancer claimed over 12000 lives each year in the United Kingdom, making it the second most common cause of cancer-related death in women behind lung cancer.

When a person is diagnosed with breast cancer, the surrounding cells are affected, and it might destroy the human body's breast tissues over time. The appearance of crimson marks is one of the most common signs and symptoms across the breast, discharge of blood from the nipples, nipple turning inward, and ache withinside the breast[21].

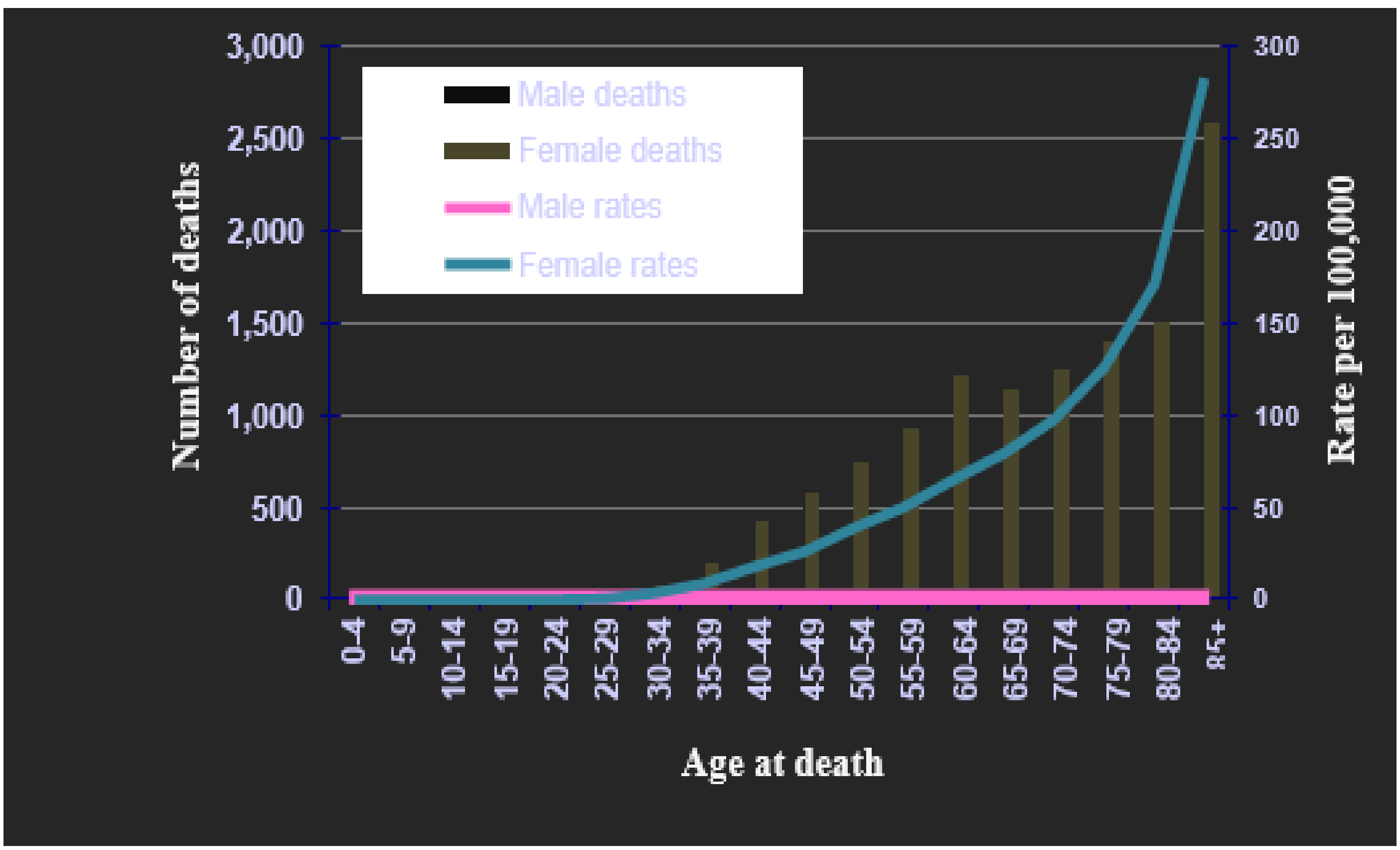


Figure 2-3 A comparison between age at death with tunor [21]

- Figure 2-three depicts the rate of increase in mortality linked to breast cancer in adult males and females. Apart from the signs and symptoms mentioned, the greatest risk is that most malignancies will spread among the surrounding cells (lymph nodes) even before any signs or symptoms of cancer appear. Breast most cancers are caused by a variety of risk factors. The following are the well-known risk factors and causes of breast cancer.
- ***Inheritance***

  Breast cancer is more risky for women whose close relatives has or had a breast cancer.
- ***Abortion***

  Doctor(s) investigation leads to the conclusion that women who have had an abortion at a young age have a high risk for breast cancer.

- ***Growth***

  As a woman gets older, her chances of developing breast cancer increase. Breast cancer is diagnosed in women between the ages of 50 and 64, according to a survey

2.3.1 Breast Tissue Electrical Properties

Microwave interaction with human body tissues causes the amplitude of the electromagnetic wave to change as it propagates through or disperses from the body tissues. Microwave frequency range (300MHz – 300GHz) research on the electric properties of human body tissues spans back more than 50 years. Relative permittivity (r) and conductivity (σ) are terms used to describe the electric properties of body tissues. Permeability (μ) is typically removed and presumed to be that of free space in these types of studies, most likely because human body tissues are considered nonmagnetic materials.

Low water content material tissues (including fat) have lower permittivity than excessive water content material tissues like muscle, skin, heart, and most malignancies tissues, according to studies. While permittivity indicates the tissue's ability to store microwave energy, conductivity indicates the amount of loss (dissipation) or attenuation (absorption) the signal experiences as it travels through the tissue. The microwave signal is lost or attenuated more effectively when the tissue has a high conductivity. Because the microwave signal passes through specific tissues in the breast, it suffers attenuation (amplitude loss) and a reflected picture due to discontinuity.

Understanding the electric properties and heterogeneities of the female breast is important because it facilitates in the development of more practical numerical or physical breast phantoms that can be used to assess the effectiveness of any microwave imaging approach for cancer diagnosis and detection. Tissue density, temperature, water content, region on the breast, and other factors influence measurements at tissue electric homes[6].

2.4 Currently Used Screening Methods

Most researchers across the world have examined and conducted breast cancer detection research and surveys, and they have used various processes and detection tools. Breast cancer can be detected using one of the methods listed below.

- X-ray Mammography
- Ultra-Sound
- MRI

The X-ray (Screening) Mammography is performed on women who have no indications or symptoms of breast cancer, and an ultrasound screening is performed if a woman is found to have malignant tissue or an abnormality.

If all of the screening techniques fail to provide any information about the development of breast cancer symptoms and symptoms, a scientific biopsy is performed, in which a pattern of breast tissue is removed with the help of a physician and tests are performed to determine whether or not the tissue is cancerous or healthy. The following are the pros and cons of the aforementioned current screening equipment.

2.4.1 X-Ray Mammography

X-ray mammography is now the most widely recommended method for detecting breast cancer among doctors. The breast is compressed between plates in this method. The X-rays are then delivered through the breast and recorded on film. An X-ray system is depicted in Figure 2-four. Ionizing radiation is used in X-ray mammography, which is hazardous. The breast is crushed between plastic plates, which the patient claims is painful.

Figure 2-4: X-Ray Mammography Imaging Unit[8]

a. Advantages

i. A high level of sensitivity.

ii. High-resolution images.

iii. The amount of time it takes to form an image is limited.

b. Disadvantages

i. Not enough sensitivity for patients having dense (thick) breast tissues.

ii. Analyzing mammography contrasts is difficult because each patient's physical appearance of the breast is different.

iii. The patient's breast is crushed between the plates, causing agony.

iv. Dangerous and unsafe due to the employment of ionizing radiations in the process.

2.4.2 Ultrasound Imaging

Ultrasonic waves are non-harmful radiation with a frequency range of 1MHz to 15MHz that can be used to diagnose an inner frame structure. It assesses whether or not the area beneath the focus of attention has malignant tissue. A biopsy will be required if a stable tissue is discovered during the examination to determine if it is malignant. Ultrasound imaging can also be created from any angle or orientation. Figure 2-five suggests an Ultrasound Imaging System.

Figure 2-5: Ultrasound Imaging System [8]

a. Advantages

i. Non-harmful radiation makes this a safe screening tool.
ii. Detection and examination are appropriate for young women with thick breasts and women who have breast implants.
iii. The image contrast and resolution are strong, allowing for a clear difference between normal and questionable tissue.

b. Disadvantages

i. System performance is determined by the technician's abilities and the knowledge of the operator.
ii. Deep-lying lesions are difficult to detect.

2.4.3 Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is a non-invasive imaging technique that uses strong magnets and radio waves to create images. It is now possible to distinguish between smooth and brittle tissues. The MRI machine operates at high frequencies, and it is placed in a covered and shielded room to avoid any interference from the environment[15].

Figure 2-6 shows how the patient must lie down on a desk during the examination. Small scanners or gadgets are also placed over the breast to examine and embellish the quality of the photo that is yet to be generated. A single exam usually necessitates a large number of images in order to complete the test, which takes hours and is time intensive. At some point throughout the process, the device makes loud thumping and buzzing noises. Patients are given ear caps to help them cope with the loudness.

Figure 2-6: Magnetic Resonance Imaging Machine[13]

a. Advantages

i. MRI can successfully check patients with thick breasts.

ii. Technique for non-ionizing imaging.

iii. Images can be acquired from various angles.

iv. The ability to spot tiny cancers.

iv. Cancers with many foci can be recognised.

v. Useful in evaluating whether the malignancy has spread to the chest wall.

vi. It is possible to identify breast implants and ruptures.

b. Disadvantages

i. Extremely expensive.

ii. Immobile and fixed.

iii. Contrast agent injection is required for operative testing.

iv. Calcifications cannot be detected.

v. The patient is afraid of being in a confined environment (claustrophobia).

vi. Time-consuming when compared to X-ray and ultrasound scanning.

2.5 Comparison between screening techniques

Early detection and diagnosis of breast cancer has been shown to increase the likelihood of a quick and successful treatment, as well as the patient's long-term welfare. Screening options for breast cancer detection include X-ray mammography, ultrasound, and magnetic resonance imaging (MRI); the differences between these strategies are as follows.

X-ray mammography, which is the most widely used approach for early-stage breast cancer screening, is currently the most common method used in breast cancer detection. During the screening, the breast is tightly crushed between plastic plates, forming an X-ray image. In comparison to other methods, X-ray mammography has a number of advantages, including high-quality image decision, high detection sensitivity, and a short time to image production. However, this strategy has a number of disadvantages over the other screening methods discussed in sections 2.5.1 to 2.5.3.

2.5.1 Comparison of X-ray with Ultrasound and MRI Techniques

X-ray mammography has a number of disadvantages over ultrasound and magnetic resonance imaging (MRI) screening modalities, including the extreme pain associated with the procedure.

compressing the breast between plates and therefore recording the image onto film, which is painful for the patient and causes soreness due to the breast compression, and it is also no longer safe for patients with dense (thick) breast tissues.

Furthermore, the screening approach is extremely costly and causes breast damage since it exposes the breast to ionizing radiation, which is harmful to breast tissues. Most importantly, it has difficulty detecting early and tiny breast tumors, as well as tumors that are located close to the chest wall or arm. Furthermore, analyzing mammography contrasts is more challenging due to the fact that each patient's breasts have a different appearance[33].

2.5.2 Ultrasound comparison over X-ray Mammography

Ultrasound scanning uses ultrasonic waves with a frequency range of 1MHz to 15MHz to diagnose an inner frame structure. In comparison to X-ray mammography, ultrasound is a safe screening method since it uses non-harmful radiation that causes no discomfort to the patient. Ultrasound can also be used to detect and examine younger women with thick breasts and women who have breast implants.

The photo evaluation and judgement are extensive, as in the case of X-ray mammography, which gives a large difference between normal tissue and worrisome regions despite the fact that tumors buried deep within the breast are difficult to detect with Ultrasound. It's also difficult to tell the difference between a stable mass and a stable tissue, thus a biopsy is required to determine whether the tumor is malignant or not. In comparison to X-ray Mammography, the usual device overall performance of Ultrasound is dependent on the technician's abilities and operator expertise, which is a drawback.

2.5.3 MRI comparison over X-ray Mammography and Ultrasound

When compared to X-ray mammography, Magnetic Resonance Imaging (MRI) is a non-invasive method that uses strong and effective magnets to provide radio waves a good means to generate images. In comparison to Ultrasound, the sensitivity of identifying smooth tissues from brittle ones is increased due to the effective magnets. Patients with thick breasts can be effectively examined using MRI.

In comparison to X-ray mammography, the safe non-ionizing radiation allows for tumour detection without causing any side effects.

Images can be acquired from unusual angles to determine the precise location of a tumour, and as a result, it's possible to find multi-focal tumors. In comparison to X-ray mammography and Ultrasound, it is also capable of detecting tiny tumors due to its higher sensitivity. MRI screening is helpful in determining if the majority of malignancies reach the chest wall, as well as detecting breast implants and ruptures. Apart from its sensitivity and tumor detecting functionality, it has a number of flaws.

Because MRI screening necessitates a large area for the device to be put, it is constant and difficult to relocate, making it unsuitable for large-scale screening programmers. It requires for contrasting dealers to be injected for operative testing in order to improve the visibility of inner frame shape in MRI screening (the most commonly used compounds for assessment enhancement are gadolinium-based). For an MRI screening, patients must lie down inside a large cylindrical shape at some time throughout the scanning procedure, which might produce claustrophobic feelings in patients due to the fear of being trapped in a small space[14].

These hurdles have sparked a burgeoning interest in the development of a more powerful and affordable early detection and diagnosis tool for breast cancer. Microwave imaging has long been promoted by various research organizations as a technology for detecting and diagnosing early breast cancer. Microwave imaging allows for low-cost scanners that are non-invasive, harmless, and operate within the non-ionizing frequency range specified in Chapter 3.

3 OVERVIEW OF MICROWAVE IMAGING TECHNIQUES

For decades, tumor identification has been a pastime of microwave imaging. Microwave imaging has many advantages, including a wide range of frequencies, the ability to recognize energy, a wide range of simulation tools, a low risk of injury, and a low cost. Because of recent advancements in imaging algorithms, microwave imaging for early tumor identification has sparked a lot of attention. Microwave imaging is a non-ionizing technology that is far less expensive than MRI and X-ray and is thus being considered as a potential imaging method for breast cancer detection in the future.

3.1 Types of microwave imaging

For breast cancer diagnosis, three types of microwave imaging techniques, namely passive, hybrid, and active approaches, are explored.

3.1.1 Passive microwave imaging

Passive microwave imaging involves comparing the temperature of malignant tissue to the temperature of healthy tissue. Many investigators studying patients with breast cancer have found evidence of a temperature difference within the presence of malignant tissues, concluding that the cancerous tissues are more active and transport more heat. It is also believed that tumours lack the thermoregulatory capability (the ability of tissues to keep their temperature within positive bounds) of normal tissues[17].

Radiometers are employed in the Passive Microwave Imaging technique to detect the presence of malignant tissue in the breast by measuring temperature fluctuations within the breast. In comparison to normal breast tissue, the tumors shows a greater increase in temperature when illuminated by microwave radiation. This method fundamentally measures and maps the extrude in temperature measured on the breast's floor to the bodily extrude in temperature on the tissue's taken into account location. This type of imaging system is depicted in Figure 3-1.

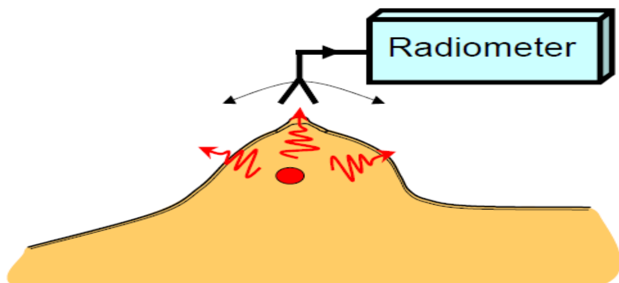


Figure 3-1: Passive Microwave Imaging [29]

3.1.2 Hybrid microwave imaging

Microwave electricity is lit at the breast in the hybrid technique, after which strain waves caused by the growth of heated tumors are recognized. This method provides tumors sensitivity as well as high-decision images. In comparison to normal tissue, a tumors with higher conductivity absorbs more microwave electricity, resulting in more strong strain waves. Microwaves are utilised in hybrid (acoustic) microwave imaging structures to quickly warm selected parts of the breast, and ultrasound transducers are used to find the strain waves created by the growth of the heated tissues. Extra electricity is deposited in tumors when microwaves are used to illuminate them, compared to normal breast tissue. provides additional details on this strategy. Figure 3-2 depicts an example of the important of hybrid system.

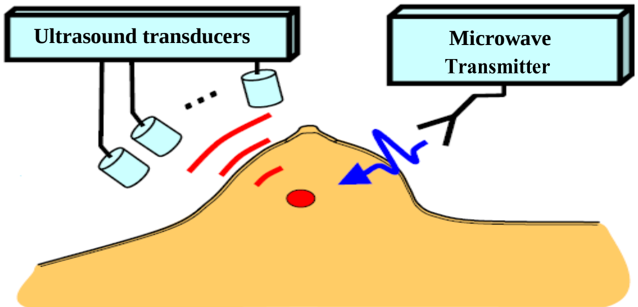


Figure 3-2: Hybrid Microwave Imaging [29]

Apart from passive and hybrid imaging techniques, active microwave imaging has shown to be effective in the early diagnosis of breast cancer, as detailed in section 3.1.3 of the study.

3.1.3 Active microwave imaging

For many years, active microwave imaging strategies have been a hobby. As previously stated, these solutions rely on common electric houses and microwave frequency comparisons between malignant and non-malignant breast tissues. Figure 3-3 depicts the three remarkable microwave breast imaging procedures.

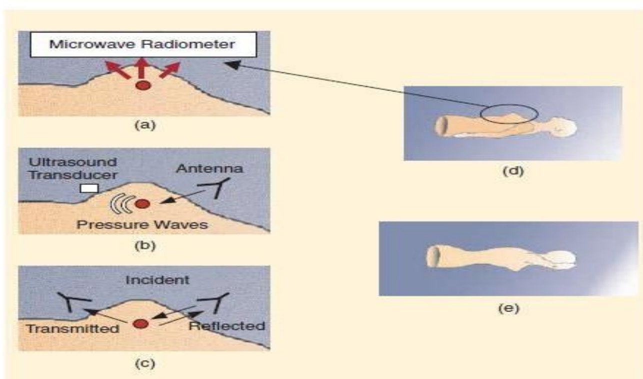


Figure 3-3: Breast imaging techniques using microwave frequencies. (a) Passive methods entail detecting areas of elevated temperature that correspond to tumors. (b) Microwaves are used in hybrid ways to heat. The pressure waves generated by tissue expansion are detected by ultrasound transducers. (c) Active techniques entail using microwaves to illuminate the breast and then creating images with energy transmitted through or reflected from the breast. Patient orientations for (d) planar and (e) cylindrical systems are shown in the figures on the right.

Active microwave approaches for breast imaging are classed as microwave tomography and radar-based microwave imaging. Low-power microwave waves are sent into the breast via a set of antennas, which then form the image using backscatter signals. These strategies have shown to be effective.

3.1.4 Microwave Tomography

The Microwave Tomography imaging approach uses several alarms gathered from sensors (antennas) placed at specified positions (locations) on the breast floor. The extent of permittivity in the breast that permits you to generate a dielectric suggestion, such as the bodily and electric houses of the breast, is determined using these accumulated warnings (measured data). Some inverse scattering problems are used to mount the dielectric profile.

The microwave tomography technology is being taught at Dartmouth College. It uses narrowband alerts and scattered alerts collected through antennas to build a suggestion of electrical houses of the breast using algorithms that effectively translate healthy measurements of the microwave signal scattered across the breast to results computed with a model. Tumors' lives diminish the power of the scattered signal, resulting in areas of increased permittivity and conductivity on pictures.

Figure three-four shows the device used at Dartmouth College, which incorporates a sixteen multi-static antenna array for measurements and an inverse scattering set of rules with a frequency range of 0.five to 2.three GHz .

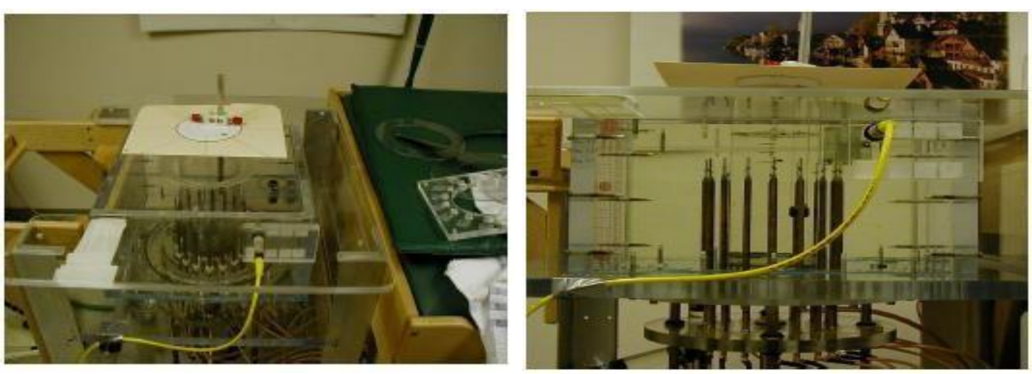


Figure 3-4: The Dartmouth College microwave imaging system. [10]

3.2 UWB Radar Based Microwave Imaging

The present screening techniques in use and their limitations have sparked an interest in developing a reliable and cost-effective solution for early breast tumour diagnosis. For the past ten years, researchers have proposed novel and long-term imaging technologies for use in clinical settings to detect breast cancer. Most researchers are utilising a UWB Radar-based completely Microwave Imaging approach to expand a capability screening modality that isn't confined like the previously mentioned strategies discussed in phase 2.4.

The main feature of this procedure is that it uses the dielectric properties of breast tissue to image out the distinction between malignant and healthy tissue. The electromagnetic symbol is absorbed or diffused as it is lit. This scattering is employed to create a map-like image that allows the location of the strong reflections to be distinguished. Tumor diagnosis using UWB Radar focuses on recognising and focusing the life of a strong reflection rather than attempting to reconstruct the dielectric residences of the breast[24].

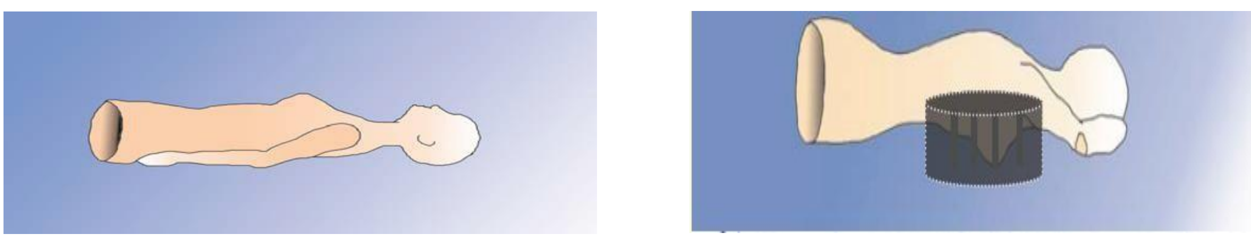
As a result, the method is more computationally green than microwave tomography, which recreates the dielectric homes of the breast. This method has been provided a method by Dartmouth College. The UWB radar uses a brief pulse to illuminate the breast and obtain data from within the pondered scatter. The acquired or pondered sign, also known as backscatter in radar jargon, is processed to produce a visual image depicting the region and location of the target.

3.3.1 MIST System

Hagness et al. introduced the Microwave Imaging through Space Time (MIST) beam-forming technology at the University of Wisconsin. The following configurations are taken into account in the system, as indicated in Figure 3-5.

i. i. Breast screening of a woman lying flat on her back, with an antenna array placed on the breast's surface.

ii. ii. A woman in the pendant position, with her breast projecting through an opening in a treatment table, is screened for breast cancer.



(a) (b)

Figure 3-5 (a) Prone & (b) Supine Position for MIST System at the University of Wisconsin [9]

The incoming signals must be processed in order to create an image at a specific location in the breast. The Confocal Microwave Imaging algorithm, which is detailed later in Chapter 4, is applied after the received signal.

3.3.1 TSAR System

The TSAR (Tissue Sensing Adaptive Radar) device was developed at the Universities of Calgary and Victoria. The procedure is similar to that described in MIST, in which the breast is inserted into a cavity within the exam table. The breast extends into a tank containing a calibration liquid and an antenna in the device. The purpose of using calibration liquid is to decrease electric fluctuations between the environment and the breast, allowing for less litter and better outcomes.

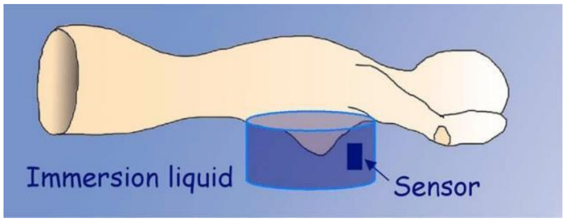


Figure 3-6: Patient to be imaged lies on her stomach with the breast extending through a hole in the examination table [9]

To do the scan in TSAR, a monostatic (single) antenna is employed, which is spun around across the breast to generate an antenna array, as shown in Figure 3-6. The antenna is roughly a centimetre from the breast. To construct an image, a state-of-the-art computational set of criteria is used to further suppress litter. The most common way is to first detect the breast, then recognise the pores and skin reflections to approximate the pores and skin reaction from the sign. The obtained sign is then subtracted from this reaction, and focussing is performed to build a map of the right tumour region.

In order to enhance the TSAR gadget, presently new and suitable designs of sensors are being made with a excessive issue at the imaging set of rules to lessen computational time and the feasibility of making a gadget to check on breast models [32].

3.3.2 Confocal Microwave Imaging Algorithm

In recent years, the Confocal or Delay-and-Sum Imaging Algorithm is commonly used as part of UWB architectures. The concept of using CMI for breast cancer was born. detection turned into first delivered with the aid of using Hagness at al. and Fear at al . The confocal microwave imaging (CMI) method makes use of backscattered facts accrued with the aid of using antenna(s) positioned at specific locations, and an UWB pulse is illuminated as an excitation sign on the transmitting antenna. A dimensional imaging set of rules which makes use of planar structures turned into recommend and tested for MRI-primarily based totally simulation facts[41].

In [29] a cylindrical CMI gadget proven is provided and examined with simulation facts. It turned into discovered and established the usage of 3 dimensional simulations, simulating breast fashions that the planar and the cylindrical gadget has the equal performance . Experimental setups and effects have additionally been accomplished to validate and guide the simulation effects. For a Confocal Algorithm to be carried out at the obtained sign, first the vicinity of the breast area beneath neath attention is split in a grid like shape referred to as focal points.

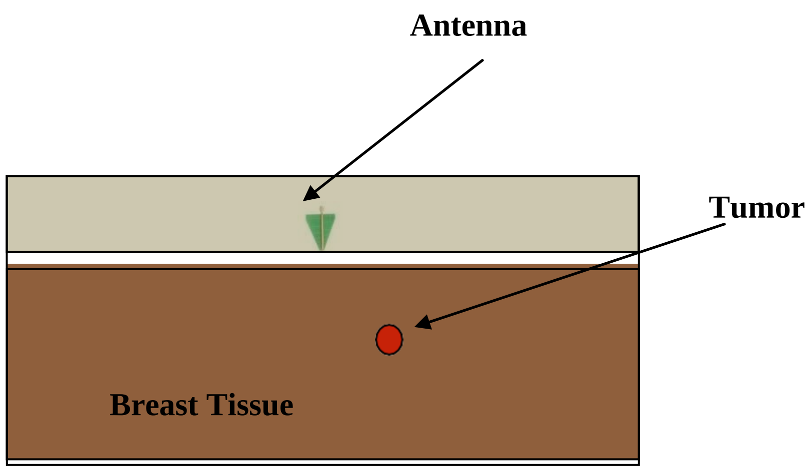


Figure 3-7: Planar Configuration [17]

In order to analyze the effectiveness of the confocal microwave imaging algorithm, an experimental setup is performed and the results are analyzed and discussed in chapter 4.

The effectiveness of this is measured from

- Antenna position
- Antenna frequency
- Type of material used for phantom
- Depth of tumor
- Strength of back scattered signal

Experimental setups and effects have additionally been accomplished to validate and guide the simulation effects. For a Confocal Algorithm to be carried out at the obtained sign, first the vicinity of the breast area beneath neath attention is split in a grid like shape referred to as focal points. The confocal microwave imaging (CMI) method makes use of backscattered facts accrued with the aid of using antenna(s) positioned at specific locations, and an UWB pulse is illuminated as an excitation sign on the transmitting antenna. A dimensional imaging set of rules which makes use of planar structures turned into recommend and tested for MRI-primarily based totally simulation facts. And The concept of using CMI for breast cancer was born. detection turned into first delivered with the aid of using tumors at different depth.

3.3 Assessment of Microwave Imaging Techniques & Methodology

Because of the limitations of the modern screening procedures discussed in Chapter 2, microwave breast cancer detection has been promoted as a potent and inexpensive opportunity technology for early detection and diagnosis of breast cancer.

Microwave imaging has been used by various research agencies for a long time as an imaging technology for early breast cancer detection and diagnosis. In contrast to the three microwave imaging methodologies discussed in section 3.1 (passive, hybrid, and energetic), passive microwave imaging uses temperature differences to pinpoint the location of malignant tissue within the breast. The main goal of this technology is to find a completely low-level energy source that can be radiated with the help of tumours, although this raises technological issues. The estimation of the temperature distribution within the body is a distinct issue. The single frequency radiometry allows for the measurement of a specific area's average temperature. As a result, distinguishing between a fantastic goal near you is really difficult[36].

Hybrid microwave imaging, on the other hand, uses microwave pulses with energies ranging from one to several tens of kilowatts for imaging (Zhurbenko, 2011, p. 95), which is far superior to the microwave imaging systems now in use. Because microwave electricity lighted at the breast floor causes a non-uniform reaction to be obtained, which necessitates complex algorithms to build the image, inhomogeneity (uneven nature) of the breast is a major project being faced with the help of this technology. The tissues are heated with the help of microwave electricity in the hybrid method, and it is required that the tissues be heated uniformly; otherwise, the indicators may be prompted with the help of.

In this method the breast pores and skin, breast tissues, chest wall, and the tumour take in microwave electricity and convert it to warmness electricity. This warmness electricity accrued on the receiver is known as the thermal acoustic indicators. Hence the measured thermal acoustic sign consists of responses from the tumour, in addition to from different wholesome breast tissues.

The alerts generated with the assistance of the pores and skin are a lot more strong than those generated by little tumours due to the excessive conductivity of the pores and skin. The high sign electricity obtained with the aid of using acoustic sensors (the sensors employed in this method for collecting data) is also due to the fact that the sensors are close to the skin . Because of the inhomogeneous structure of the breast, the velocity of the acoustic signal produced is non-uniform, making it difficult to determine the time of the acoustic pulse created at a specific location. All of these factors make estimating the tumor's location within the body difficult. However the difficult technique is applied to achive the desired results.

Active microwave imaging, as opposed to passive and hybrid microwave imaging, allows for low-cost scanners, non-invasive, non-ionizing frequency range, and inside non-ionizing frequency range because microwaves have the ability to penetrate internal dielectric substances and interact with their internal shape, making them an excellent candidate for non-invasive and non-ionizing inspection of dielectric media and tumours. This technique, which is separated into micro-wave tomography and radar-based fully microwave imaging, is one of the most difficult and appealing. Both methods rely on a contrast between the electromagnetic properties of normal and cancerous breast tissues.

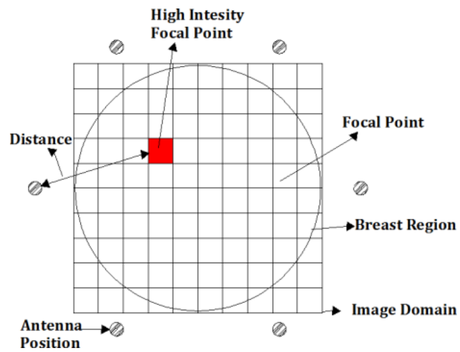
Microwave tomography, also known as inverse scattering, uses a narrowband signal to illuminate the breast, and the accumulated (backscatter) signal is used in an advanced set of rules to reconstruct the dielectric (permittivity and conductivity) properties of the breast. Inverse scattering is a non-linear and difficult problem that necessitates a significant amount of effort. Its solution is based on the iterative set of rules optimization to reduce the difference between the accumulated warnings and the numerical model (simulation). There are various research organisations working on this area, including Dartmouth College in the United States, which has proposed a scientific prototype and preliminary scientific testing outcomes in[48].

Unlike the previous technique, UWB (Ultra Wide Band) radar-based fully microwave imaging does not seek to rebuild the dielectric properties of the breast, but instead merely tries to find and locate the presence of strong scatter (cancerous tissue). As a result, compared to microwave tomography, this technology is far less computationally demanding. The breast is lighted with a short UWB microwave pulse at certain antenna locations, and the backscatter signal is processed to form an image of the tumour. Microwave imaging in space time is a feature of radar-based imaging systems.
(MIST) beam forming and tissue sensing adaptive radar (TSAR). In TSAR the affected person lies in As mentioned in segments 3.3.1 and 3.3.2, the affected person lies in each susceptible and supine function and the breast is illuminated with UWB radar waves with a single antenna in round configuration, whereas in MIST the affected person lies in each susceptible and supine function and the breast is illuminated with UWB radar waves with an array of antennas in round and planar configuration respectively.

UWB Microwave Radar Imaging is a potential technique for detecting early-stage millimeter-sized cancers. The advantages of this generation are that UWB covers a wide frequency range, so low frequencies are required to ensure a high penetration depth (useful for detecting tumours at deeper depths), while high frequencies are required to achieve a high spatial resolution (useful for detecting tumours close to the pores and skin). Furthermore, it does not involve any breast compression or ionising radiation, making it far less intrusive than X-Ray Mammography. Finally, because microwave imaging uses very low power, fitness risks are significantly reduced compared to previous screening methods.

The mono-static put off-and-sum beam-forming or confocal microwave imaging set of rules divides the breast area into first-class grid or pixel (focal) factors, and is one of the most well-known algorithms in this approach (as in Figure 3-9). The distance between the antenna sites and the pixel factors is computed and converted to propagation time depending on the average wave speed. The depth associated to the pixel (focal) factors is evaluated by including and squaring the put off variations of all of the collected alerts to build an image[12].

Figure 3-9 A representation of mono-static confocal imaging [12]



4. EFFECTIVENESS OF CMI ALGORITHM

4.1 Overview

4.1.1 Process Flow Diagram of Algorithm

The Confocal Algorithm will be implemented in this part. The complete steps followed in our chosen technique Confocal Microwave Imaging are described in details. Specifications about each step followed to achieve our desired results is given in this chapter. Our experimental setup to apply the CMI technique in practical is also briefly explained in this Chapter.

We at first upload the collected back scattered signals to the MATLAB software where we apply all the steps of confocal microwave imaging technique and at the end we achieve the desired image of tumor that indicates the depth of tumor inside the body. Those steps are given in flow chart diagram of CMI and then explained further in this chapter with all the details required to understand them.
Figure 4-2 shows the flowchart of CMI:

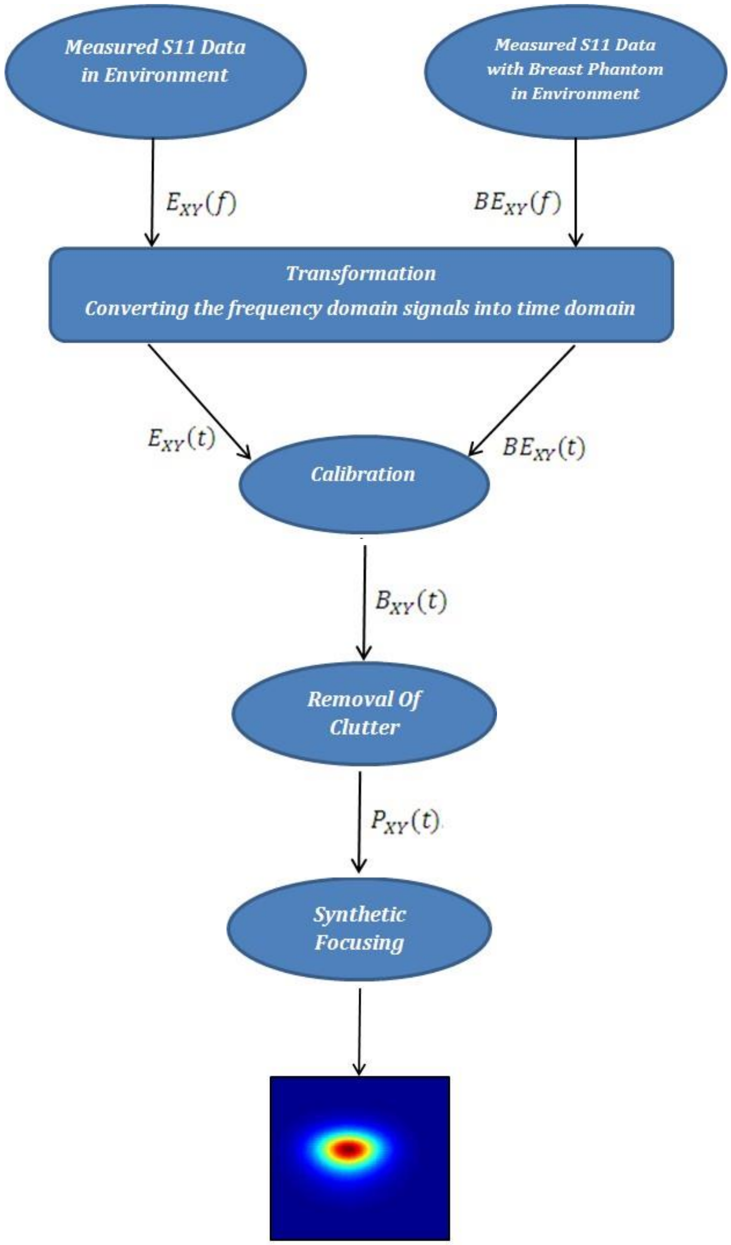


Figure 4-2: Process Flow Diagram of Confocal Algorithm [30]

As indicated the confocal algorithm is used to create the picture of the tumour. Two sets of frequency domain data are obtained using the VNA at various antenna placements.

i. In the Natural Setting involves reflections from different sources which are used for experimental work.

ii. When there is a breast phantom different readings are taken on that breast phantom to analyze working of CMI.

The frequency domain observations of with tumor and without tumor at antenna sites are converted into time domain data using the Inverse Fast Fourier Transform (IFFT). The time domain signals are then calibrated via the calibration technique, which involves subtracting the response of the Breast Phantom from the response of the Environment signal(s) to get the time domain signals.

The Breast Phantom signal(s) still contain reflection due to the antenna. To erase or eliminate antenna reflections, the Breast Phantom signal(s) are averaged, and the averaged signal is then deleted from each of the Breast Phantom signal(s). The signal(s) received after subtraction are referred to as the processed signal(s) The signal(s) is/are synthetically focused to generate a rough picture of a Breast Phantom tumour. The process flow represented in Figure 4-2 is further explored in Section 4.2.2.

4.1.2 Explanation of the Process Flow

VNA delivers frequency domain data when the antenna is exposed to the environment and when the antenna is exposed to the breast phantom in the environment (scattering parameters). The frequency domain data is then translated to the time domain and processed further. The next sections go through the details of each technique.

We at first upload the collected back scattered signals to the MATLAB software where we apply all the steps of confocal microwave imaging technique and at the end we achieve the desired image of tumor that indicates the depth of tumor inside the body. Those steps are given in flow chart diagram of CMI and then explained further in this chapter with all the details required to understand them. Specifications about each step followed to achieve our desired results is given in this chapter. Our experimental setup to apply the CMI technique in practical is also briefly explained in this Chapter.

Each step of our CMI technique is explained briefly one by one and in following chapter explaining how to apply CMI on back scattered signals to achieve the results related to the depth of breast tumor present in skin . Transformation is explained as following

i. Transformation

The antenna is activated by a sweep signal generated by the Vector Network Analyzer (VNA) at varying heights (1cm and 3cm) from the tumour.

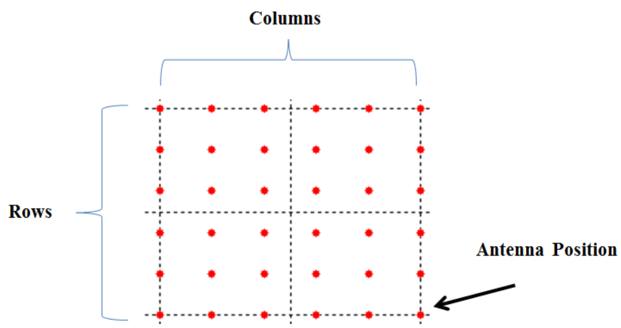


Figure 4-3: Antenna positions covered in an area of 100mm by 100mm [31]

The frequency domain data collected from the VNA (Environment and Breast Phantom in Environment) is first windowed using the Hamming window. To lower the level of side lobes, a Hamming window is applied to the signal(s). After that, the signal is translated into the time domain using the Inverse Fast Fourier Transform (IFFT) (s).

$$E_{XY}(f)_{windowed} = E_{XY}(f) * w$$

$$BE_{XY}(f)_{windowed} = E_{XY}(f) * w$$

$$E_{XY}(t) = ifft(E_{XY}(f)_{windowed})$$

$$BE_{XY}(t) = ifft(BE_{XY}(f)_{windowed})$$

Where;

w is the Hamming window signal;

The antenna placements in a grid are determined by row X and column Y. A matrix with six rows and six columns represents the grid. The matrix for 36 antenna sites is as follows:

$$\begin{bmatrix} (1,1) & (1,2) & (1,3) & (1,4) & (1,5) & (1,6) \\ (2,1) & (2,2) & (2,3) & (2,4) & (2,5) & (2,6) \\ (3,1) & (3,2) & (3,3) & (3,4) & (3,5) & (3,6) \\ (4,1) & (4,2) & (4,3) & (4,4) & (4,5) & (4,6) \\ (5,1) & (5,2) & (5,3) & (5,4) & (5,5) & (5,6) \\ (6,1) & (6,2) & (6,3) & (6,4) & (6,5) & (6,6) \end{bmatrix}$$

$E_{XY}(t)$ $BE_{XY}(t)$ And are the time domain signals for Environment and Breast phantom in environment at time *t* respectively.

Therefore for 36 antenna positions $E_{XY}(t)$ and $BE_{XY}(t)$ can be represented as;

$$\begin{bmatrix} E_{11}(t) & E_{12}(t) & E_{13}(t) & E_{14}(t) & E_{15}(t) & E_{16}(t) \\ E_{21}(t) & E_{22}(t) & E_{23}(t) & E_{24}(t) & E_{25}(t) & E_{26}(t) \\ E_{31}(t) & E_{32}(t) & E_{33}(t) & E_{34}(t) & E_{35}(t) & E_{36}(t) \\ E_{41}(t) & E_{42}(t) & E_{43}(t) & E_{44}(t) & E_{45}(t) & E_{46}(t) \\ E_{51}(t) & E_{52}(t) & E_{53}(t) & E_{54}(t) & E_{55}(t) & E_{56}(t) \\ E_{61}(t) & E_{62}(t) & E_{63}(t) & E_{64}(t) & E_{65}(t) & E_{66}(t) \end{bmatrix} \quad \begin{bmatrix} BE_{11}(t) & BE_{12}(t) & BE_{13}(t) & BE_{14}(t) & BE_{15}(t) & BE_{16}(t) \\ BE_{21}(t) & BE_{22}(t) & BE_{23}(t) & BE_{24}(t) & BE_{25}(t) & BE_{26}(t) \\ BE_{31}(t) & BE_{32}(t) & BE_{33}(t) & BE_{34}(t) & BE_{35}(t) & BE_{36}(t) \\ BE_{41}(t) & BE_{42}(t) & BE_{43}(t) & BE_{44}(t) & BE_{45}(t) & BE_{46}(t) \\ BE_{51}(t) & BE_{52}(t) & BE_{53}(t) & BE_{54}(t) & BE_{55}(t) & BE_{56}(t) \\ BE_{61}(t) & BE_{62}(t) & BE_{63}(t) & BE_{64}(t) & BE_{65}(t) & BE_{66}(t) \end{bmatrix}$$

ii. Calibration

To eliminate the Environment signal(s) and produce an approximated Breast Phantom signal, the calibration technique involves subtracting the Environment's reaction from the Breast Phantom's response in the environment (s). This subtraction provides a larger peak at the tumor's location by subtracting the environment response from the target signal. The deleted signal contains the Breast phantom signal.

Where $B_{XY}(t)$ is the Breast phantom signal at time t for 36 antenna positions;

$$B_{XY}(t) = BE_{XY}(t) - E_{XY}(t)$$

iii. Clutter Removal

Reflections from the antenna and the environment still dominate the breast phantom signals $B_{XY}(t)$ at X and Y. To eliminate reflections due to antenna and environment, the Breast Phantom signal(s) are first averaged. The Breast Phantom signal(s) $B_{XY}(t)$ in a given grid row (6 6) are multiplied by the total number of antenna points in that row N to achieve averaging (total of 6 antenna positions $B_{XY}(t)$ in a given row for our experiment). Signals that have been averaged are referred to as averaged signals. $A_X(t)$.

The breast phantom signals at X and Y still contain reflections that are dominated by the antenna and the environment. The Breast Phantom signal(s) $B_{XY}(t)$ are first averaged to reduce reflections due to antenna and environment. Averaging is accomplished by multiplying the Breast Phantom signal(s) $B_{XY}(t)$ in a given grid row (6 × 6) by the total number of antenna points in that row N. (total of 6 antenna positions in a given row for our experiment). The averaged signals are the signals that have been averaged

$$A_X(t) = \frac{\sum_{Y=1}^{N} B_{XY}(t)}{N}$$

Where N is the total number of antenna sites in a row, is the averaged signal at time t for row X.

The signals for six rows are as follows;

$$\begin{bmatrix} A_1(t) \\ A_2(t) \\ A_3(t) \\ A_4(t) \\ A_5(t) \\ A_6(t) \end{bmatrix}$$

After that, the averaged signals are subtracted from each of the Breast Phantom signals (s).

The Processed Signal(s) are the signals that have been removed $P_{XY}(t)$.

$$P_{XY}(t) = B_{XY}(t) - A_X(t)$$

$P_{XY}(t)$ is the processed signal(s) at location *XY* at time t. For 36 antenna positions the signals can be represented as;

$$\begin{bmatrix} P_{11}(t) & P_{12}(t) & P_{13}(t) & P_{14}(t) & P_{15}(t) & P_{16}(t) \\ P_{21}(t) & P_{22}(t) & P_{23}(t) & P_{24}(t) & P_{25}(t) & P_{26}(t) \\ P_{31}(t) & P_{32}(t) & P_{33}(t) & P_{34}(t) & P_{35}(t) & P_{36}(t) \\ P_{41}(t) & P_{42}(t) & P_{43}(t) & P_{44}(t) & P_{45}(t) & P_{46}(t) \\ P_{51}(t) & P_{52}(t) & P_{53}(t) & P_{54}(t) & P_{55}(t) & P_{56}(t) \\ P_{61}(t) & P_{62}(t) & P_{63}(t) & P_{64}(t) & P_{65}(t) & P_{66}(t) \end{bmatrix}$$

The signal(s) that have been processed, i.e. the intensity values created at time t for picture formation, will be used next. We also need the round trip time to generate the intensity values, in addition to the processed signals. To acquire the round trip time, synthetic focusing, which is discussed in detail, is required[22].

i. Synthetic Focusing

Computing the round trip time is used to accomplish synthetic focussing. The following processes were taken to determine the round trip time:

a) Create pixel points in step one.
b) Calculate the distance between each antenna and each pixel point.
c) Calculate the total travel time.

a) Generate Pixel points

We constructed the pixel points at coordinates xi and yj using an area of (300 mm by 300 mm) rather than the area covered by the antenna placements (100mm by 100mm) for better image resolution. In a 300mm 300mm covered area.

Figure 4-4 displays the locations of pixel points (represented by blue dots). On a 300mm by 300mm grid, pixel point positions are arranged in a grid.

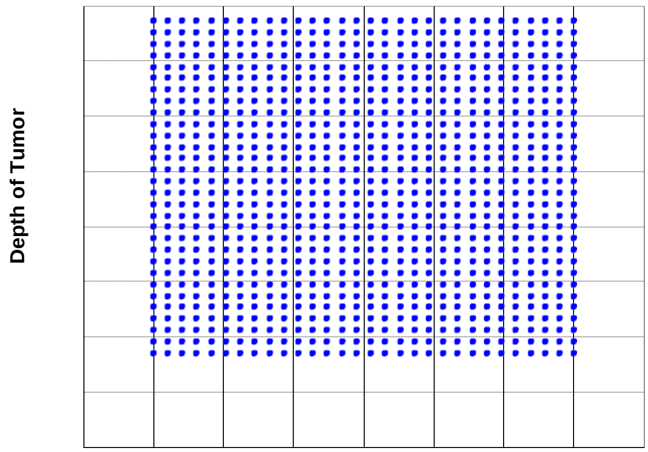


Figure 4-4 distance(s) of each antenna location to the pixel point(s) [30]

b) Evaluate the distance(s) of each antenna location to the pixel point(s)

The following equation was used to calculate the distance(s) between each antenna point XY and the pixel:

$$D_{XY}(x_i, y_j) = 2\sqrt{(X - x_i)^2 + \left(Y - y_j\right)^2 + h^2}$$

Where;

h is the height of the antenna (1cm or 3cm) from the tumor;

x_i and y_j define the coordinates of the pixel points as shown in Figure 4-4; The antenna positions are defined by X and Y;

$D_{XY}(x_i, y_j)$ is the round trip distance for antenna position XY to the pixel (x_i, y_j).

In this experiment, the transmitter and receiver were both a single antenna. As a result, the transmitter and receiver will travel the identical distance to each pixel point. As a result, the distance is divided in half. Figure 4-5 depicts the method for computing the round trip distance between each antenna position and each pixel point[30].

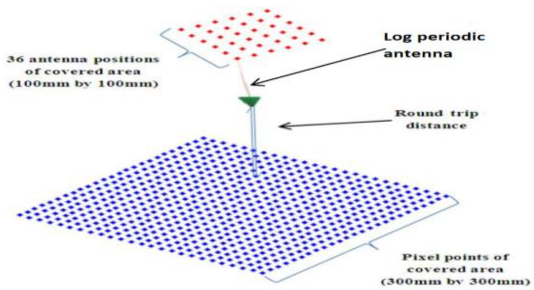


Figure 4-5: Representation of finding the round trip distance of each Antenna position to the Pixel points [8]

c) Generate the round trip time

The following equation is used to compute the round trip time for antenna location XY at pixel (xi, yj):

$$t_{XY}(x_i, y_j) = \frac{D_{XY}(x_i, y_j)}{c/\sqrt{\varepsilon_r}}$$

Where *c* is the speed of light in *cm/s;*

ε_r is the permittivity of the medium (air ε_r = 1 for our experiment)

$t_{XY}(x_i, y_j)$ is the round trip time from antenna position *XY* to pixel (x_i , y_j).

ii. Image

As previously stated, time data are necessary in addition to the processed signal to generate the intensity values that constitute the image. The Intensity values for each pixel point are determined by analysing the signal value of the processed signal at time after computing the time values for each antenna location XY at pixel. Each pixel's intensity values are expressed mathematically as

$$I(x_i, y_j) = \left[\sum_{X=1}^{r}\sum_{Y=1}^{c} P_{XY}\left(t_{XY}(x_i, y_j)\right)\right]^4 \qquad [39]$$

Where

r is the total number of antenna positions in a row;

c is the total number of antenna positions in a column;

I (xi , yj) is the intensity value at pixel point .

5. DISCUSSIONS & EXPERIMENTAL RESULTS

The following section discusses the practical measurements in identifying the tumor in the phantom. The experiment setup of the whole system to measure the reflected signal is shown in Figure 13. In the experimental analysis, for measuring s11 from the breast phantom, the VNA is used. .

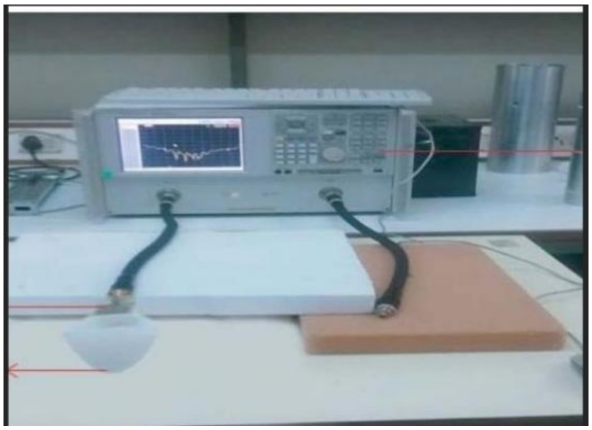


Figure 5-1 Experimentally measuring S_{11} Signals

During measurement, the UWB antenna is placed directly above the locality of the phantom. The measured impedance bandwidth of the UWB antenna ranges from 2.4 GHz to 9 GHz.
To receive and transmit the EM wave, the end terminal of the VNA is connected with UWB antenna. The freq range from 2.4 GHz to 9 GHz is adjusted in VNA. The transmitting antenna is located at the focus of the phantom. The UWB antenna illuminates the phantom using a microwave signal. The reflected signal (s11) is taken down by the same antenna which is used for transmission in the range of frequency from 2.4 GHz to 9 GHz. As the same Antenna is transmitting as well a receiving back that scattered signal that is Radar based technique. Further we had a Matlab code of confocal microwave imaging algorithm that will construct a Image in Matlab to detect the exact position of the tumor as well as the depth of this tumor. Confocal Microwave Imaging algorithm also considers antenna position from breast phantom and with this distance the depth of tumor is also changed. For this initial experimental setup we have placed antenna very close to Breast phantom . So the value of distance we have taken for this set of s11 values was 5mm and we run our code according to that.

Then we applied the confocal microwave imaging on our measured values to check the depth of tumor inside the body.first of all we measured the values with an UWB Antenna operating at frequency of 9 GHz. We have used same antenna to transmit and receive the signals so our collected values are according to a radar based techinique.We have operated our antenna at different frequencies and at different depths of tumor and analyzed our measured results according to the required ones.

Our first obtained image of tumor is shown in following segment with exact depth of tumor that is according to the depth we have given to tumor in phantom .When we performed Matlab analysis on this set of s11 values we detected the depth of tumor that appears to 13mm.

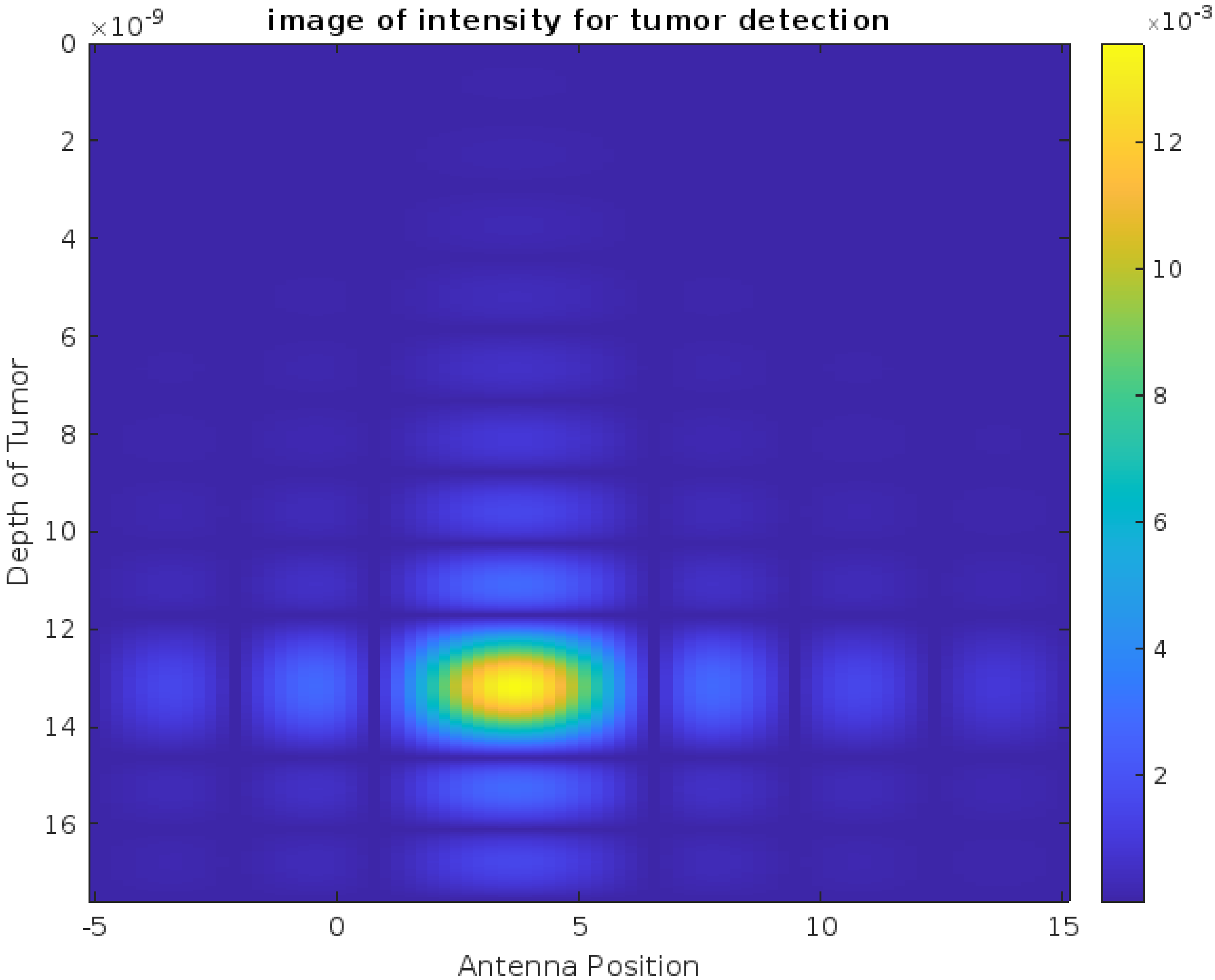


Figure 5-2 Matlab image of tumor at the depth of 13mm

As in first setup we used Antenna Frequency of 9 GHz and distance of Antenna from Breast phantom was 5mm. With that we calculated a set of s11 values from that. This set of s11 values gives a tumor of 13mm depth . The distance is kept so less so that microwaves can scatter completely on the breast phantom. Now we will change the frequency of our Antenna and check the change in results.

Now we change our transceiver antenna frequency to 7 GHz and kepth the distance same, take the measurements again Running matlab code on this set of values give us a tumor of depth 4mm. A picture of that result is placed below

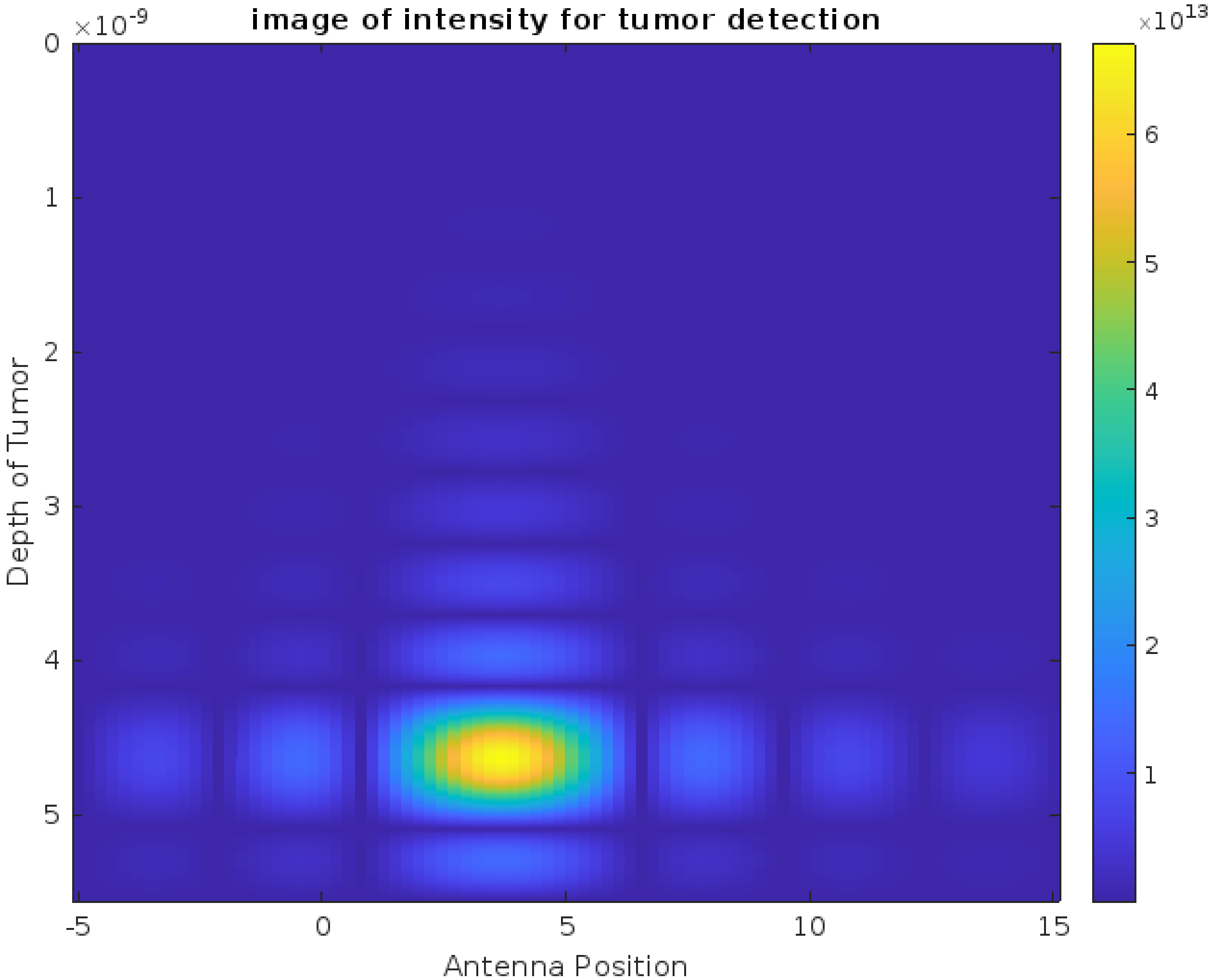


Figure 5-3 Matlab image of tumor at the depth of 4mm

As by changing our Antenna Frequency the depth of tumor is also changed. Tumor of depth is also changed with Antenna position but here we have discussed results of Tumor dependency on Antenna frequency only.

So now we change our Antenna Frequency to 3 GHz with same Antenna position and measure s11 values . By running that set of s11 values in matlab code we got tumor of depth 16mm. Result is shown as following

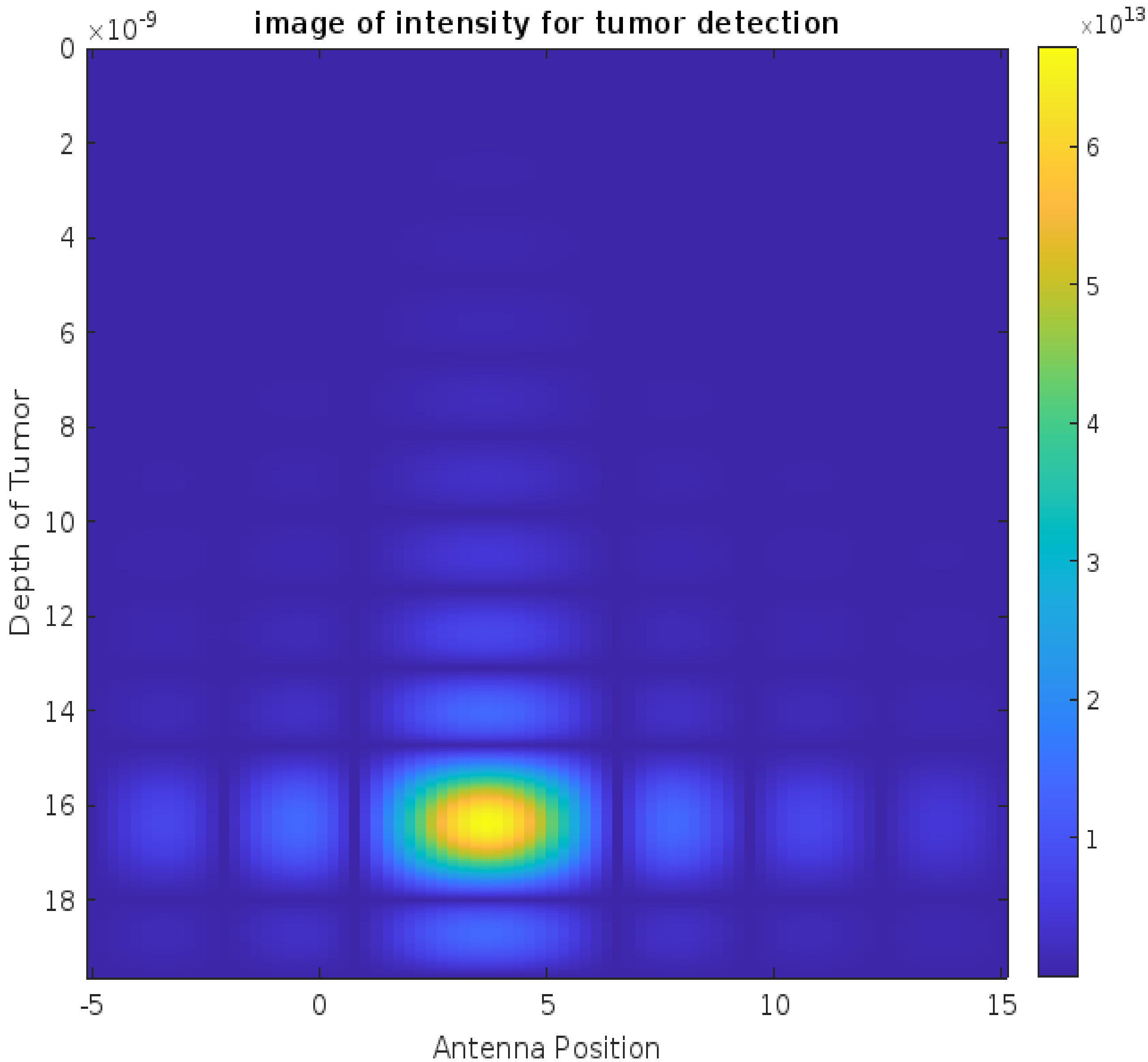


Figure 5-4 Matlab image of tumor at the depth of 16mm

The effectiveness of the Confocal Microwave Imaging Algorithm for breast cancer detection, the tumor is developed with unique depths and measured accordingly . Furthermore, the tumor at different depths in phantom is also analyzed using CMI technique . The simulated results are found to be in good agreement with measured one.to determine the efficiency of used technique.

6 CONCLUSION & FUTURE IMPROVEMENTS

6.1 CONCLUSION

Microwave imaging for the detection of breast cancer has become one of the most important research topics in recent years. With investigations at Military College of signals, National University of Science and Technology researchers have presented various ways for medical deployment of microwave imaging. Radar-based Microwave imaging for breast tumor identification provides a safe and comfortable experience for patients undergoing the procedure. The evaluation of the dielectric properties of breast tissues, both normal and malignant, is a critical feature for tumor identification using microwave signals.

The Confocal Microwave Imaging Algorithm is the post-processing set of rules employed, and we present the outcomes that represent the effectiveness of this radar-based imaging technique. The experimental outcomes of CMI technique are presented in this research, where we verify the detection of tumors from 03 - 16 mm depth and generate the viability of using the confocal set of rules for early breast cancer diagnosis. The accuracy of CMI technique is tested by experimentally changing the depth of tumor in phantom. By analyzing the information obtained from our method we can accurately tell the depth of tumor inside the body.

6.2 FUTURE IMPROVEMENTS

- Work can be done on breast model to simulate a real breast tissue, using varying permittivity of tumor tissues to establish the base of Confocal Microwave Imaging Algorithm as the prime tumor detection technique for microwave imaging.

- This project can be taken to next level if future researchers work on making a 3-D image from the backscattered signals rather than a 2-D image.

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