Microwave Imaging of Breast Tumor Cancer Detection Using UWB Antenna

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in partial fulfillment for the requirements of B.E Degree in Electrical (Telecom) Engineering.

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 Imaging Of Breast Tumor Cancer Detection Using UWB Antenna”

is carried out by

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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Department of EE, MCS

Date: ___________

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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Our parents, colleagues and most of all supervisor, **Dr. Farooq Ahmed Bhatti** supported us to complete our Final Year Project and without their guidance, it would have been a difficult task.

The group members, who through all adversities, worked steadfastly.

Plagiarism Certificate (Turnitin Report)

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ABSTRACT

Microwave imaging is an advanced and effective technique for detection of breast cancer tumor by calculating the electrical difference between the non-malignant and malignant tissues present in the breast. Scientific evidence in literature reviews and surveys that detection of the depth of tumor is essential for precise identification of tumor and the affected area. Therefore, the ground penetrating radar (GPR) algorithm is successfully applied to detect the exact depth of malignant tissue. In general, GPR was originally designed for archaeological research, assessment of building condition, discovery of buried mines, and more. However, attempts were made here to apply GPR to radar-based breast cancer detection. The simulated bandwidth of the proposed UWB antenna starts at 2.4 GHz and ends at 9 GHz. The electromagnetic wave reflection due to dielectric property variation is used by GPR algorithm to identify the depth of the tumor. Before applying a depth migration technique, preprocessing steps like Cartesian form transformation, Hermitian Signal Processing, and Inverse Fast Fourier Transform (IFFT) have to be followed in the backscattered signal to convert positive frequency data into time-domain data. The details of the depth can be found in the migrated image that is produced after migration procedure. The result indicates that the GPR algorithm is proved effective in detection of tumor embedded in the breast tissue. To understand the effectiveness of this imaging theme, associate experimental analysis is finished employing a combination of flour and water-petroleum jelly. The measured electric resistance information measure of the UWB antenna ranges from 2.4 GHz to 9 GHz. The observation is finished for a renowned spherical tumor of diameter 13mm that is placed at completely different depths from the skin layer imaging approach for depth of the tumor.

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CHAPTER 1: INTRODUCTION

Globally breast cancer is the second most threatening cancer disease among women. There are many ways in which it can be detected. For example, X-ray mammography is the most common and successful technique being used for treating breast cancer[1–4]. Mammography on the other hand is painful procedure as it is done by using high intensity ionization radiation which can also effect other tissues that are healthy and can cause cancer among them.to overcome these issue a new and advanced technique was introduced i.e. radar-base microwave imaging. Radar techniques are used in detecting land mines, presence of injuries imaging a human body. Here radar method is being used for creating image of the breast tissue. The procedure includes the transmission of short impulse from antenna onto breast tissue. The method that is used to receive the backscattered signal is signal processing method. It basically then detects highly scattering region i.e. malignant tumor the effected part.

1.1 Overview

Numerous imaging techniques and algorithms measure the depth and growth of tumor. Microwave Imaging through reference frame (MIST) beamforming rule, Parallel plate conductor port technique, Time of Arrival (TOA) information fusion technique, Delay and total (DAS) beamforming rule, etc. to sight the depth of the tumor. On the opposite hand, the on top of techniques have various restrictions. complicated antenna array arrangement is needed for growth detection, Associate in Nursing planning an ultra-wideband (UWB) antenna is difficult. Moreover, the array setup is very usurious and needs longer to sight the growth. The present article pivoted chiefly through one antenna to localize the growth by simply applying GPR rule. The image obtained mistreatment the GPR rule is termed B-scan. style and simulation of the UWB antenna and breast phantom square measure evolved with technique Technology

(CST) software package[12]. MATLAB simulation software package is employed to reconstruct the image from the Backscattered signal.

1.2 Problem Statement

The previously used methods for the detection of breast cancer tumors were not able to detect the cancer in its early stages and the methods were costly and not suitable for health.

Microwave Radar base technique will be used to detect breast cancer in its early stages performing microwave imaging.

1.3 Proposed Solution

The basic goal was to detect the tumor in its early stage. For that we have used GPR technique for microwave imaging. GPR Ground Penetrating Radar is a geophysical locating method in which radio waves are used to capture images. It is very helpful in pinpoint location of the tumor and its produce the image without disturbing the breast

1.4 Objectives

- To overcome the limitation of existing techniques to detect cancer in early stage
- Design an antenna array
- Implementation of existing microwave imaging techniques

1.5 Scope

- Improvement in Biomedical engineering for early detection of breast cancer.
- Detection of Breast cancer in early stages decrease death rate.

1.6 Relevant Sustainable Development Goals

- Good health and well being of people.
- Industry , inovation and infrastructure

1.7 Structure of Thesis

Chapter 2 contains the literature review and the background and analysis study this thesis is based upon.

Chapter 3 contains the methodology of our microwave imaging technique

Chapter 4 contains the signal processing procedure, MATLAB code

Chapter 5 discusses the results and conclusion of the project.

CHAPTER 2: LITERATURE REVIEW

2.1 Existing Microwave Imaging Techniques

2.1.1 MRI (Magnetic Resonance Imaging)

MRI of the breast is primarily used as an additional tool for breast examination with mammography or ultrasound. Breast MRI is widely used in women who have been diagnosed with breast cancer to help measure the size of the cancer, to look at other tumours in the breast, and examine the tumours in another breast. An MRI scan and an annual mammogram are recommended for some women at high risk for breast cancer[4]. MRI is known to give false results that mean further tests and patient biopsies

Wound morphology, development and washout kinetics help differentiate breast cancer from malignant lesions. The use of contrast-enhanced magnetic resonance imaging is based on NE angiogenesis. Tumor-related blood vessels increased vascular stiffness, resulting in gadolinium absorption after its administration. The sensitivity of breast MRI is reported to be very high (over 90%) but still low to moderate (72%), rendering discrimination between malignant and malignant lesions challenging.

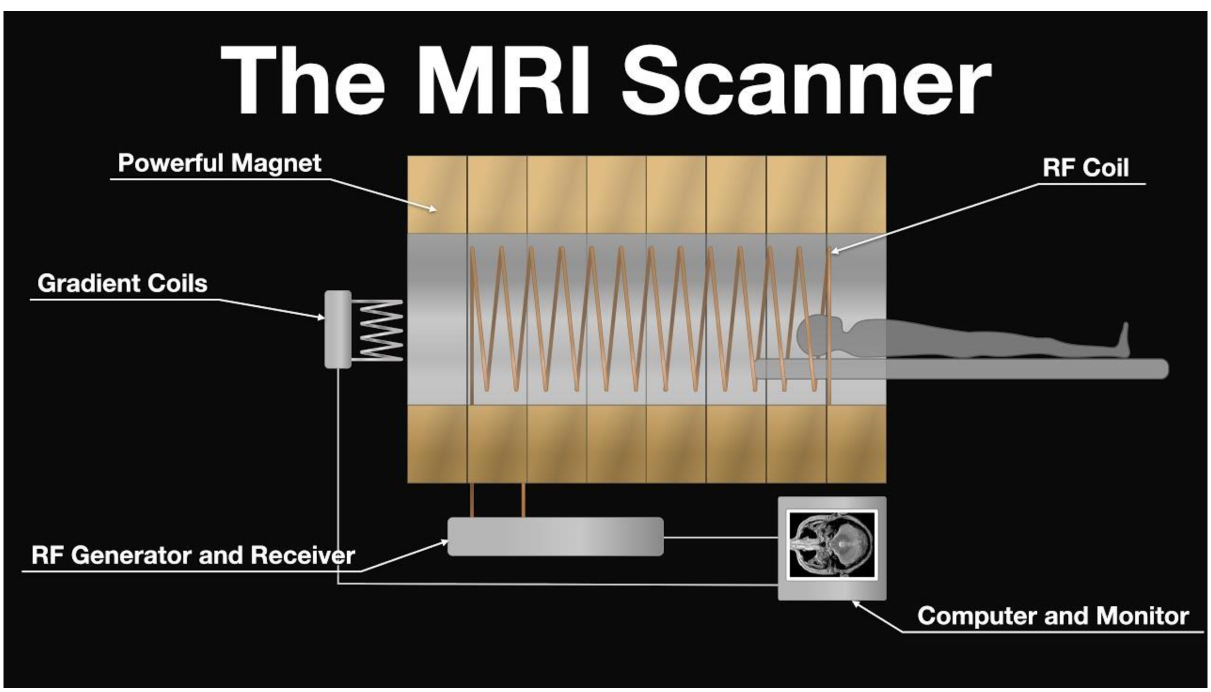

Figure 2.1 Working Principle of MRI

MRI scans have not been very popular with women at risk because of concerns about low specifications leading to additional biopsies, time and cost of technology.

MRI is also used to do the following:

Measure the specific molecules in the brain that separate the brain tumour from the brain tumour

Find abnormalities in female genitals and fractures of the hip and pelvis

Help doctors diagnose arthritis (such as tears in the arteries or cartilage of the knee) and sprains

Help doctors diagnose bleeding and infections.

2.1.2 Mammography

A mammography is an X-ray picture of the breast. We use a mammogram to look for early symptoms of breast cancer. Regular mammograms are the best tests we have to find breast cancer early, sometimes up to three years before it can be felt.

Mammography is currently the only diagnostic imaging method suitable for screening and evaluating rats with clinical symptoms[3,4]. It is also a widely available method with established standards for evaluating and conducting audits. Mammography is a sensitive method for detecting malignant tumors of breast adipose tissue and is also the best method for detecting micro calcifications. However, dense breast tissue can make the diagnosis of malignant lesions difficult.

For many years experience has increased and a recommendation from the American college of radiology on how to interpret mammography has been used for many years, BIRADS (Brest imaging rerating and data system)

Mammography is the most important method in breast diagnostics since many years. Digital imaging, which is currently under development, expands the possibilities of mammography and reduces the radiation dose and has great diagnostic advantages.

The image of the breast is called a mammogram. The background of the image is black, and the chest is grey and white.

Dense tissue, including connective tissue and glands, appears white.

Some people have dense breast tissue. Tumors are composed of dense tissue and appear white, making it difficult to detect abnormalities in the mammogram.

As age grows breast become less dense. Dense tissues such as fat are greyed out in the mammogram.

Standard mammograms are usually mostly grey, with some white areas showing healthy and dense tissue.

The whiter you have in your photo, the less likely you will have a health problem.

2.2 Drawbacks of Existing Microwave Imaging Techniques

2.2.1 Drawbacks of MRI

The required time for MRI is longer than required for CT. Also, MRI is less likely to be diagnosed sooner than CT. Therefore, CT may be better in emergencies, such as severe injuries and stroke. MRI is also more expensive than CT.

Claustrophobia and difficulty are sometimes installing an MRI scanner because it is a small, closed area.

The effects of magnetic field on metal devices embedded in the body

Response to the highlighting agent

2.2.2 Problems related to the small enclosed space

The space in the MRI scanner is small and closed, making some people feel claustrophobic, even people who usually do not worry about closed spaces. Some obese people have trouble getting inside the scanner. Some MRI scans (called open MRI scanners) have a wider side and a more extensive interior. People may feel a little claustrophobic in them, and obese people may quickly get into it. Images generated by open MRI scans may be lower than those produced by encrypted scanners but may still be used for diagnostic purposes[1-4].

People concerned about MRI may be given an anti-anxiety drug, such as alprazolam or lorazepam, 15 to 30 minutes before the scan.

2.2.3 Drawbacks of Mammography

The breast cancer screening results every two years for 20 years are as follows.

Waiting time and anxiety when additional testing is required

Almost half of the women screened for four years (453 out of 1,000) have at least one other test. This is 156 more women than 1,000 who do not participate in the screening.

Possibility of overdiagnosis Of the 77 diagnoses of

breast cancer, ten are overdiagnosed.

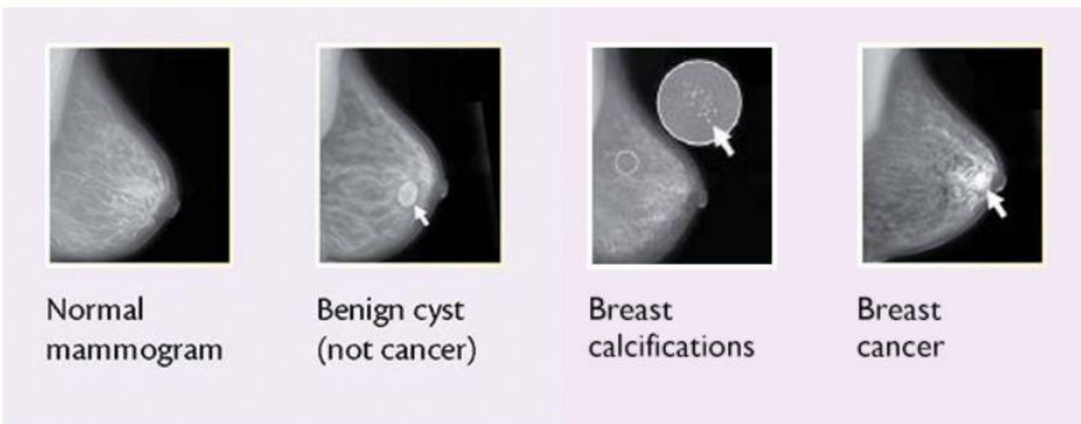

Figure 2.2 Imaging using Mammography

2.3 Ground Penetrating Radar(GPR) Microwave Imaging Technique

A real time techique that uses high-frequency radio waves, yielding data with very high resolution quickly. Electromagnetic waves that travels at a specific velocity is used in GPR determined by permittivity of the material. Rates will differ based on the kind of material due to the difference in electrical properties and will thus respond at different times[5-6]. Along a survey line, series of traces are collected as antenna move along it.

The main components that makes GPR include

1.single transducer comprises emitting and receiving antenna

2.data storage or display unit

3.Waveform generator

GPR is most commonly used for locating spacing and depth for breast cancer tumors. With the growing discovery and development of GPR processing software, research has found that it can be used as a status check under FRP compounds.

Ground Penetrating Radar (GPR) algorithm is applied successfully to detect the exact depth of the malignant tissue. The simulated bandwidth of the proposed UWB antenna starts at 2.4 GHz and ends at 9 GHz. The GPR algorithm uses the electromagnetic wave reflected due to dielectric property variation to identify the depth of the tumor. Before applying a depth migration technique, preprocessing steps like Cartesian form transformation, Hermitian Signal Processing, and Inverse Fast Fourier Transform (IFFT) have to be followed in the backscattered signal to convert positive frequency data into time-domain data. After applying the migration procedure, the depth details can be noticed in the migrated image. Results show that the GPR algorithm can be effectively used for detecting the tumor embedded in the depth of the breast tissue.

CHAPTER 3: METHODOLOGY

3.1 Principle of Microwave Imaging

By using the Microwave Imaging technique, we can successfully find the location of the target tumor. This can be done from the backscattered microwaves. When a microwave from a region of less dielectric constant enters into a region of high dielectric constant, according the the basic principle of the Microwave Imaging, these microwaves are scattered. Figure very clearly shows the Basic Principle of Microwave Imaging[9].

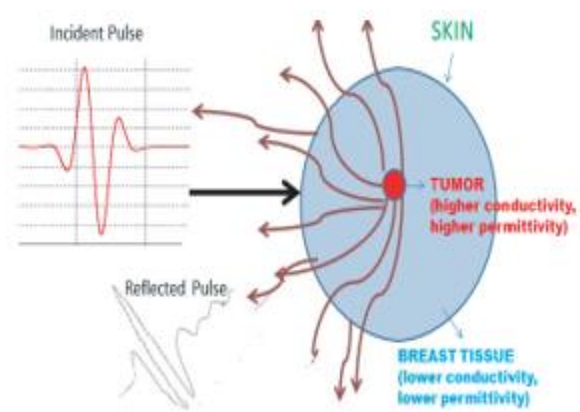

Figure 3.1 Principle of Microwave Imaging

When these Microwaves are scattered, they are received by the same antenna which transmits them. So the antenna acts as both the receiver and the transmitter. Then these microwaves are processed which results in the creation of an image. This image clearly distinguishes the location from a normal tumor tissue and the strong reflected tumor tissue.

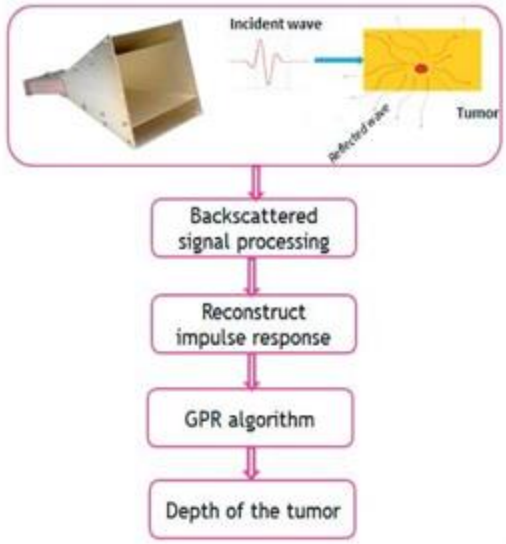

Figure 3.2 Flow Diagram of Microwave Brest Imaging

3.2 Ultra Wideband Antenna

We are using Ultra Wide Band Antenna covering frequency range from 2.4 Ghz to 9 GHz in our Microwave imaging technique. To identify the tumors at deep location, we have to make sure the deep penetration of microwaves in the breast phantom and for that we require low frequency range. This is why we are using low frequency ranges[9-10]. To identify the tumors neighboring to the skin level which results in achieving the acceptable spatial resolution we require high frequency band and that is why we are using high frequency band.

3.2 Breast Phantom

Breast phantoms have been developed after extensive anatomical research. To avoid the complexity of the real system, a homogenous phantom is designed to mimic the dielectric constant of the breast phantom. Figure 4 depicts the ideal placements for the antenna and tumour in the breast.

An homogeneous numerical hemispherical breast phantom is used for all measurements. At first, a 1 mm thick skin is planned out with a 60 mm radius. Then, fat expands to fill the area under the skin. A 3-millimeter-diameter tumour is implanted subcutaneously. CST Microwave studio 2010[4] breast phantom with tumour implanted at 25 mm depth.

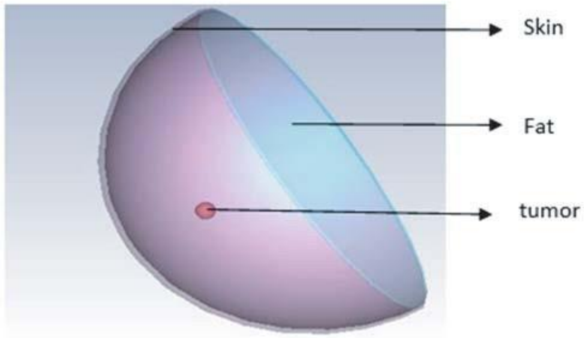

Figure 3.3 Structure of homogeneous breast tissue.

3.3 Physical Model of Breast Phantom

The breast phantom responds to the microwave signal emitted by the UWB antenna. A hemispherical breast phantom, as shown in Figure 3.4, is placed above the UWB antenna for tumour depth analysis.

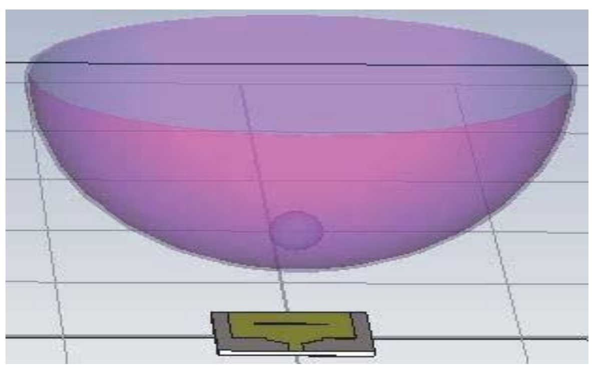

Figure 3.4 Hemispherical breast phantom with a transmitter.

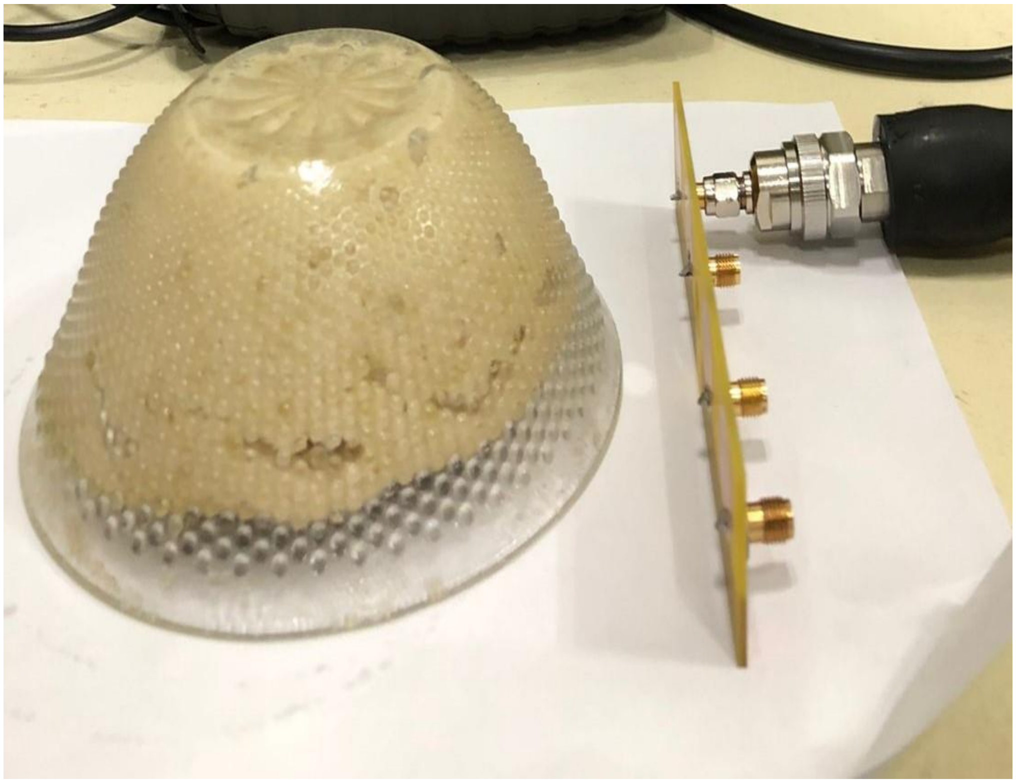

Figure 3.5 Real Time Interaction of Breast Phantom And UWB Anternna

3.4 Backscattered Signal Processing

Figure 6 depicts the stages of a reflected signal's initial processing. An equivalent frequency domain model of the reflected signal is obtained. Processing radar signals requires a temporal representation of data[5-6]. To determine the impulse response of the reflected data, we must first perform an inverse fast fourier transform (IFFT) on S11, which contains positive frequency information. Figure 3.6 depicts the steps taken before the IFFT method was used.

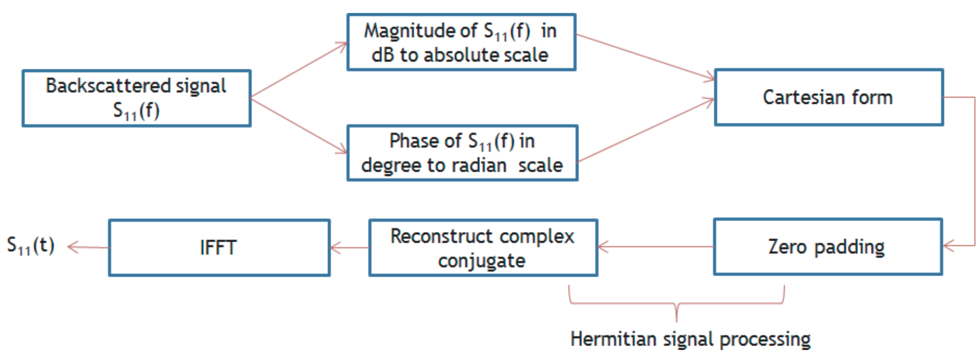

Figure 3.6 Steps for signal pre-processing

In polar configuration ((f) phase (f)), an antenna will record a wave that has been reflected back to it. The reflected signal strength (S11) is converted from a relative dB scale to an absolute dB scale. Phase constraints from the reflected signal are converted from degrees to radians. This means that the Cartesian form of S11, $z = a + bj$, must be used in subsequent processing steps.

CHAPTER 4: SIGNAL PROCESSING PROCEDURE

4.1 Hermitian Signal Processing

The FT function of the real value function is said to be symmetric, according to the Hermitian approach. Since S11(t) is a real-valued function, the frequency f must satisfy Hermītian symmetry.Although the full frequency (f) ranges from [fstop, fstop], only the positive frequency ranges are represented in the data obtained from S11(f). The ranges of frequencies with negative values are just as useless as the ranges with positive values. Figure 4.1 depicts the frequency variation from fstart to fstop that is characteristic of S11(f), which is necessary for generating the impulse function S11(t) (a).. Beginning with the frequencies [0, fstart], zero padding must be done as shown in Figure 4.1. (b). The following equation accounts for the necessary number of leading zeros in zero padding:

$$\text{Number of zeros to be padded} = \frac{f_{start}}{\Delta f - 1}$$

where Δf is the step frequency which can be defined as Δf = f (2) − f (1). (1).

After the zero padding procedure is finished, S11(f) is measured between f = 0 and fstop. This section details the procedure for generating S11(f) in the frequency range f = [fstop, 0]. As shown in Figure 4.1, this is achieved by adhering to the Hermitian signal property (c).An example of an impulse function in the time domain obtained using the IFFT function is shown in Figure 4.1. (d).

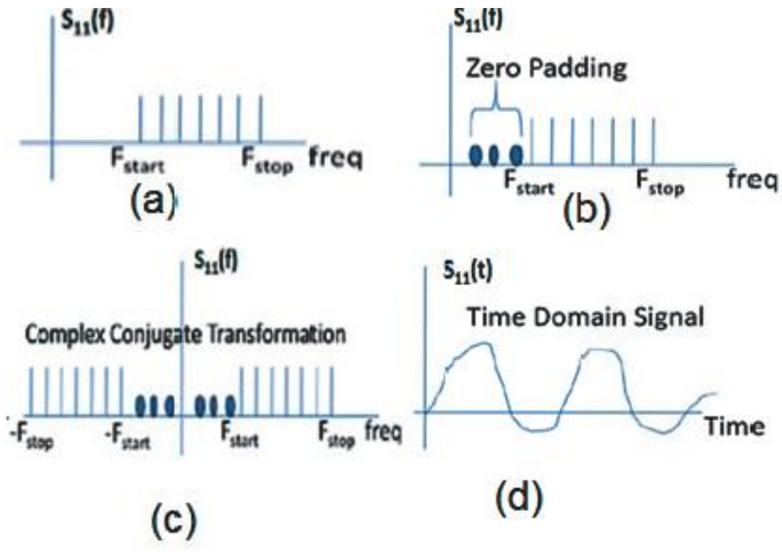

Figure 4.1 Backscattered signal pre-processing steps, (a) acquired S_{11} signal, (b) zero padded signal, (c) complex conjugate signal and (d) $S_{11}(t)$ signal.

4.2 Reconstruct Impulse Response

The Inverse Fourier Transform is a straightforward method for converting the frequency domain-stored backscattered signal into the time-domain-stored time-frequency representation. The purpose of this research is to determine where in the breast phantom the target is located by analysing the backscattered signal. In Figure 8 we see the steps taken to alter the reflected signal's impulse response.

In order to measure the depth of a tumour, two types of reflected signals are collected from a breast phantom. The reflected signal is measured twice, once from a healthy breast and once from a breast that has a tumour. The two backscattered signals are then processed using an IFFT and a Hermitian scheme[7]. Add the impulse responses of the transmitted signal, the noise disturbance, the antenna cross-coupling factors, and the tumour response to get the impulse response of the backscattered signal.In comparison to the other background response, the tumour response factor is negligible. The impulse response caused by the tumour can be improved by subtracting the impulse responses of the backscattered signal with and without the tumour.

$$S_{11d}(t) = S_{11wt}(t) - S_{11wot}(t)$$

S11wt(t) is the impulse response factor for the backscattered signal containing the tumour, and S11wot(t) is the corresponding factor for the backscattered signal without the tumour (t).

4.3 Estimation of GPR Depth Algorithm

The tumor's depth is estimated using a GPR algorithm. Frequency-wavenumber image migration (F-K) is the imaging migration procedure used to pinpoint the true position of the target. In order to determine the tumor's depth, this migration method compares the patient's horizontal position to the windowed backscattered signal[8]. In this case, [zmin, zmax] represent the minimum and maximum depths at which the target must be reached, as depicted in Figure 4.2.

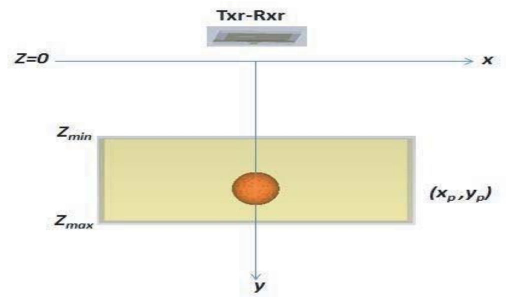

Figure 4.2. Environmental medium for imaging.

The backscattered signal's discrete impulse response in time and depth is denoted by S11d(t).

$$\Delta t = 1/f_s \quad (4)$$

To be more precise, let's say that fs is the sampling frequency.

$$f_s = 3 * f_{stop} \quad (5)$$

$$\Delta d = \upsilon * \Delta t/2 \quad (6)$$

In this equation, the speed of the electromagnetic wave, v, is used.

We can estimate the depth vector z = (0, 4087)d by using the depth resolution d. In the end, the data are windowed using the following equation:

When the reflected signal is plotted as a function of X coordinate, we can learn about the tumor's 3D architecture.

4.4 MATLAB Code

```
clc;
clear all;
clear all
opts = delimitedTextImportOptions("NumVariables", 3);
opts.DataLines = [13, Inf];
opts.Delimiter = "\t";
opts.VariableNames = ["Freq", "Mag", "Phase"];
opts.VariableTypes = ["double", "double", "double"];
opts.ExtraColumnsRule = "ignore";
opts.EmptyLineRule = "read";
File37 = readtable("File_0123.s1p", opts);
clear opts
%% read file 39
opts = delimitedTextImportOptions("NumVariables", 3);
opts.DataLines = [13, Inf];
opts.Delimiter = "\t";
opts.VariableNames = ["Freq", "Mag", "Phase"];
opts.VariableTypes = ["double", "double", "double"];
opts.ExtraColumnsRule = "ignore";
opts.EmptyLineRule = "read";
File39 = readtable("File_0125.s1p", opts);
clear opts
Without_mag = File37.Freq;
```

```
Without_mag =[Without_mag,File37.Mag];
Without_Phase =[File37.Freq,File37.Phase];
With_mag = File39.Freq;
With_mag =[With_mag,File39.Mag];
With_Phase =[File39.Freq,File39.Phase];
writematrix(Without_mag,"Without_mag.txt",'Delimiter','\t')
writematrix(Without_Phase,"Without_phase.txt",'Delimiter','\t')
writematrix(With_mag,"With_mag.txt",'Delimiter','\t')
writematrix(With_Phase,"With_phase.txt",'Delimiter','\t')
%window=hamming(N-1); window1=zeros(N,M); window1(2:end,1)=window;
dB=load('With_mag.txt');
%db=decimate(dB,2);
fre=dB(:,1);
% fre=decimate(fre,2);
[a,b]= size(fre);
fre=fre(1:a,end);
mag=dB(:,2);
% mag=decimate(mag,2);
mag=db2mag(mag);
mag=mag(1:a,end);
arg=load('With_phase.txt');
arg=arg(:,2);
% arg=decimate(arg,2);
arg=deg2rad(arg);
```

```
arg=arg(1:a,end);

df=fre(2)-fre(1); fs=3*fre(end); dt=1/fs;

lowfre=fliplr((fre(1)-df):-df:0);

sig=mag.*exp(i*arg); lowzeros=length(lowfre);

sig1=[zeros(lowzeros,1);sig];

neg=flipud(conj(sig1(2:end,:)));

signal1=[sig1;neg];

final1=(ifft(signal1));

t=(0:length(signal1)-1)*dt; t=t';

dB=load('Without_mag.txt');

fre=dB(:,1);

mag2=dB(:,2);

mag2=db2mag(mag2);

arg=load('Without_phase.txt');

arg=arg(:,2);

arg=deg2rad(arg);

sig=mag2.*exp(1i*arg);

sig1=[zeros(lowzeros,1);sig];

neg=flipud(conj(sig1(2:end,:)));

signal2=[sig1;neg];

final2=(ifft(signal2)); %diff1=abs(final2-final1);

diff1=(final2-final1);

 hold on;

 plot(t,diff1,'linewidth',2);
```

```
%  xlim([0,2]);
 xlabel('Time(ns)');
t=t(4:15,:);
diff1(1:3,:)=0;
diff1=diff1(4:15,:); diff1(4,1)=0;
[N, M]=size(diff1);diff2=zeros(N,1); diff3=zeros(N,1); diff4=zeros(N,1);
%diff1(4,1)=0;%diff2=diff2(2:20,:); diff3=diff3(2:20,:); diff4=diff4(2:20,:);
for i=1:N
    if diff1(i)== max(diff1)
        diff1(i) = diff1(i);
    else
        diff1(i) = 0;
    end
end
diff=[diff4,diff3,diff2,diff1,diff2,diff3,diff4];
diff=diff'; diff=resample(diff,12,1);
diff=diff'; diff=resample(diff,12,1);
%diff=diff/max(max(diff));
v=3e2/sqrt(4.9289);  dx=v*dt/2; plotx=0:dx:(length(diff1)-1)*dx;
diff=resample(diff,12,1);
 %hold on; plot(t,diff1); xlim([0,2]);
% figure; plot(t,diff2); xlim([0,2]);
% figure; plot(t,diff3); xlim([0,2]);
% figure; plot(t,diff4); xlim([0,2]);
```

```
x=linspace(-10,20,10); figure, imagesc(x,plotx*10^9,abs(diff)); colorbar;xlabel('x antenna position(mm)');
ylabel('y(mm)','fontsize',15);set(gca,'fontsize',15);
```

Chapter 5: Results and Conclusion

5.1 Results and Discussions

The following section discusses the practical measurements in identifying the tumor in the phantom. The experimental setup of the whole system to measure the reflected signal is shown in Figure 5.1. In the experimental analysis, for measuring S_{11} from the breast phantom, the VNA is used.

Figure 5.1 Real Time Measurement of S11 using VNA

During measurement, the UWB antenna is placed directly above the locality of the phantom. The measured impedance bandwidth of the UWB antenna ranges from 2.8 GHz to 9 GHz.

To receive and transmit the EM wave, the end terminal of the VNA is connected with UWB antenna. The frequency 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 (S_{11}) is taken down by the same antenna which is used for transmission in the range of frequency from 2.4 GHz to 9 GHz.

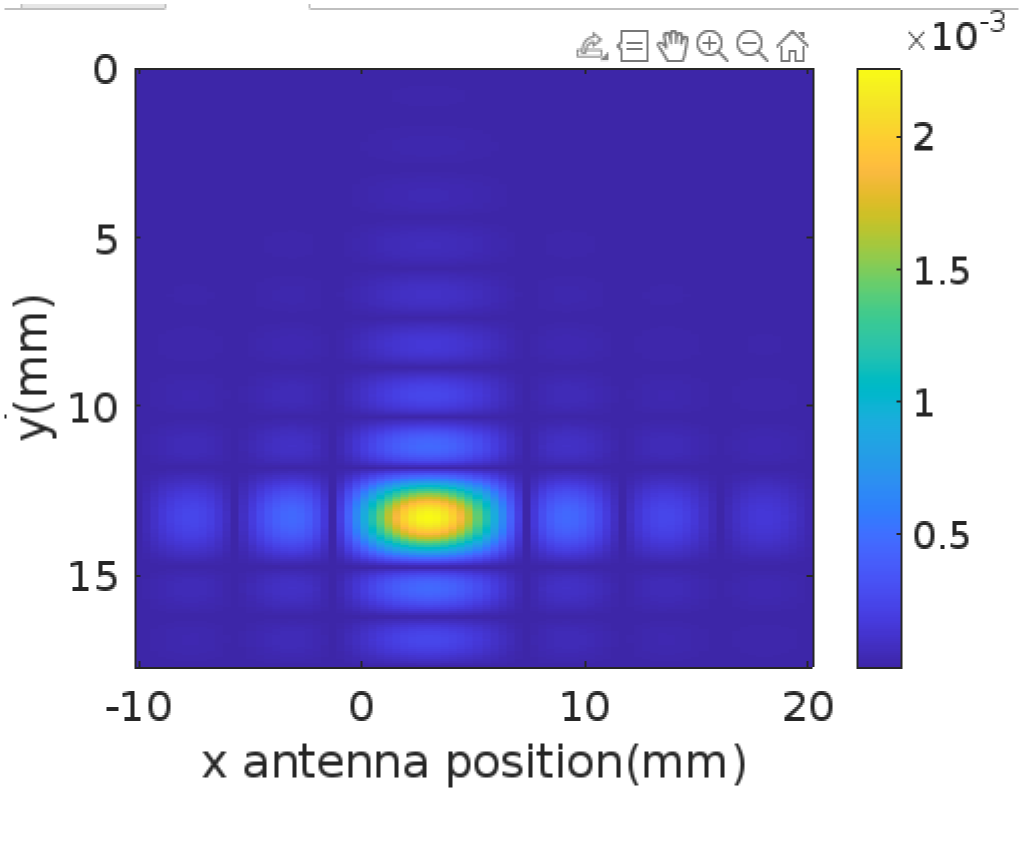

Figure 5.2 Reconstructed image with a tumor at the depth of 13mm

The Y-axis in the above diagram shows the depth of the tumor in millimeters(mm) and the X-axis shows the position of the antenna in millimeters(mm).

First of all, we used the antenna of frequency 9GHz and the tumor was placed at the depth of 13mm and the antenna was located at the surface of the phantom. It was placed just at the surface so that the microwaves could be scattered in the breast phantom completely.

Then, we changed the frequency to 7GHz at placed the tumor at the depth of almost 3mm. The antenna position was same. We get the following results.

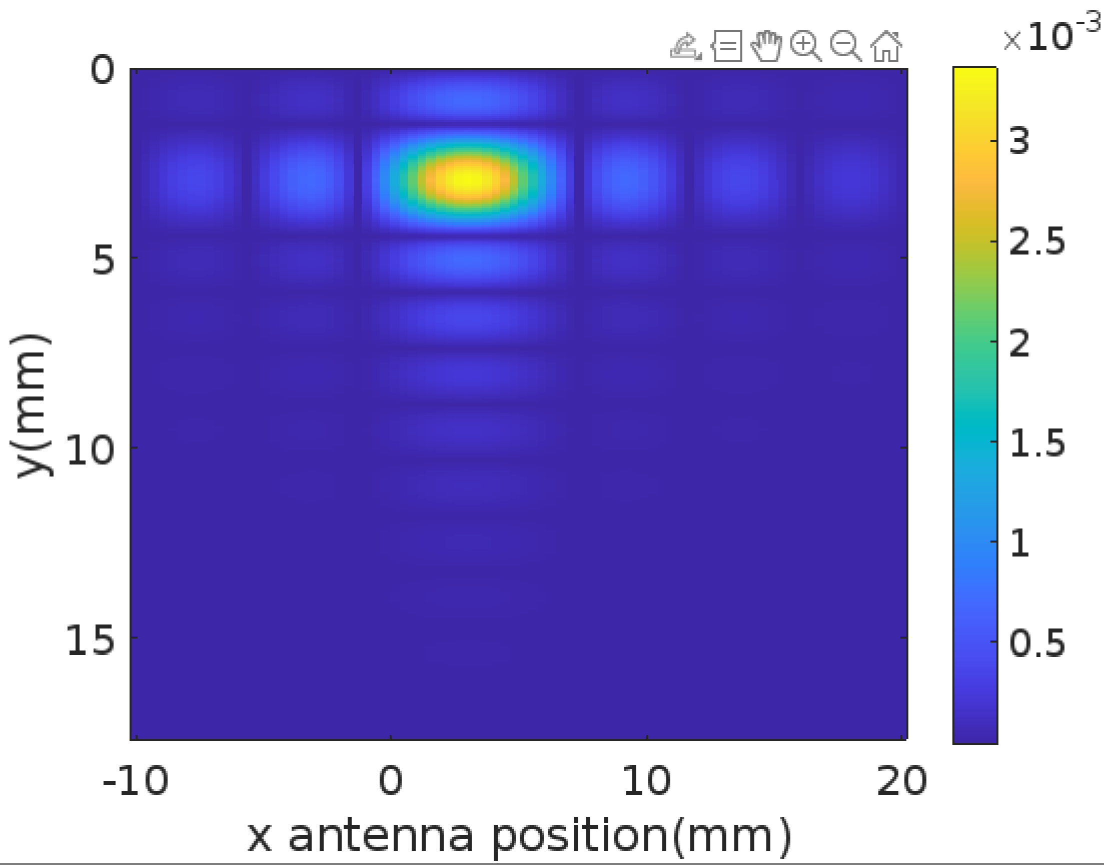

Figure 5.3 Reconstructed image with a tumor at the depth of 3mm

The Y-axis in the above diagram shows the depth of the tumor in millimeters(mm) and the X-axis shows the position of the antenna in millimeters(mm).

After this we further changed the frequency of the antenna to 3GHz to check whether we are getting the image at low frequency or not. We placed the tumor at this time at the depth of 16mm. The antenna position was same and we get the following results.

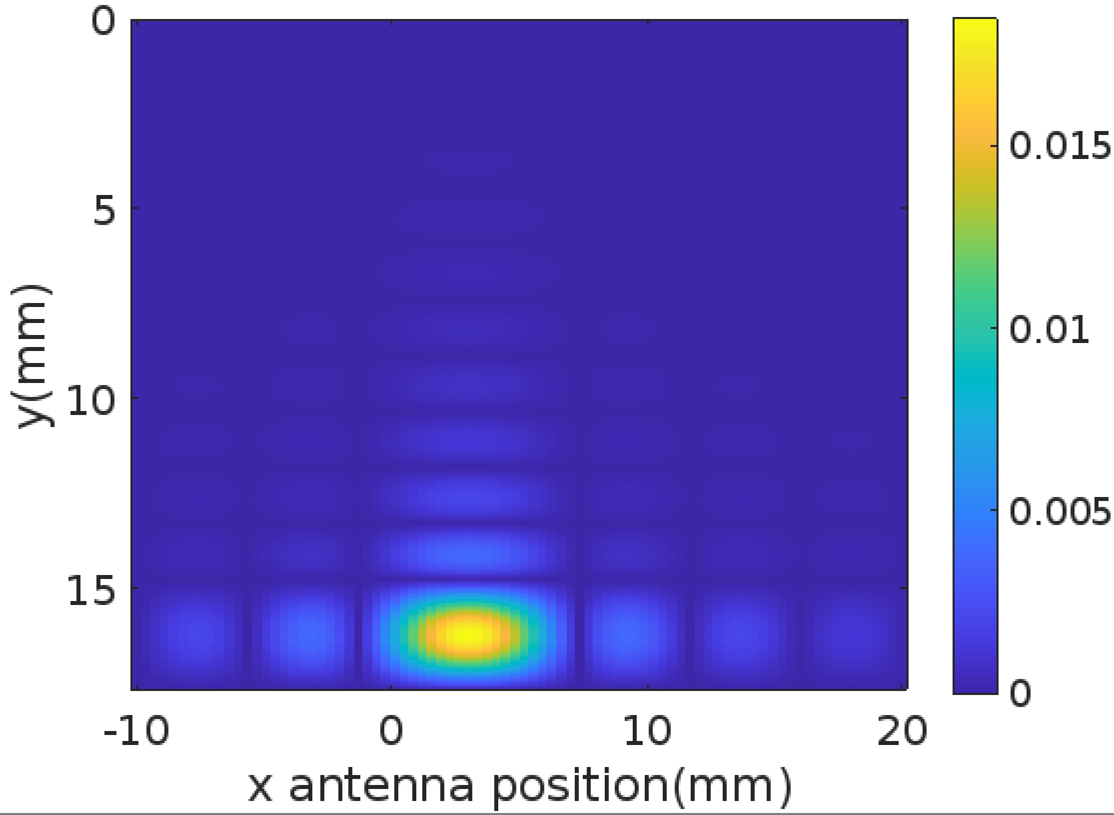

Figure 5.4 Reconstructed image with a tumor at the depth of 16mm

The Y-axis in the above diagram shows the depth of the tumor in millimeters(mm) and the X-axis shows the position of the antenna in millimeters(mm).

5.2 Conclusion

In this paper, we explore the feasibility of using microwave imaging to detect tumours by comparing tissue dielectric properties. Developed ultra-wideband (UWB) antenna operates between 2.4 and 9 GHz. In order to study breast cancer at a low cost, we create a simple, homogenous, rectangular model made of skin, fat, and tumour tissue. This method can be used to gauge the reflected signal from a phantom placed near the tumour. By analysing the information, we can make an educated guess as to how far the tumour has spread inside the body.This technique can detect a tumour 45 mm below the skin's surface. Following this, the same method is used to determine the tumor's depth in the complex phantom.

Future Work

The best direction to do the further job in this area is to take the position of the tumor in 3D dimension so that we can find r, θ and φ and the exact location of the tumor in the breast.

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