

**DEVELOPMENT OF MICROWAVE IMAGING TECHNIQUE USING
SYNTHETIC APERTURE RADAR FOR EARLY CANCER DETECTION**


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 FOR EARLY CANCER DETECTION

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ABSTRACT

Imaging modalities used for breast cancer detection currently are not sufficient for society's need. Microwave imaging has gaining a lot of consideration among researcher due to accurately tumor detected and effective treatment with low cost especially for early cancer detection. UWB radar that based on microwave imaging for early breast cancer detection is one of the most attractive and promising modality lately under investigate. The main point for using microwaves technique for tumor detection which is by the observation at microwaves frequencies, the dielectric contrast of permittivity and conductivity between normal and malignant tissues. This project focuses on the experimental of reflection coefficient in complex frequency domain is obtained using Vector Network Analyzer (VNA N5242A) right after the RF Horn antenna is exposed to the breast phantom. VNA enable the time domain approaches instead of common frequency domain measurement. Through this modality, a breast(cooking oil and stone) is illuminate from various point with short UWB microwave pulse that is generate by RF Horn antenna with frequency of 1 to 10 GHz and the collected backscattered energy is being analyze to identify the presence and location of the cancerous tissue. Time domain simulations by two different experimental setups are performed. Here, the MIST beamforming algorithms have been applied for this study to the numerical data generated by VNA to get the tumor location.

ABSTRAK

Pengimejan gelombang mikro telah diambil perhatian serius di kalangan pengkaji disebabkan oleh kajituan dalam pengesanan tumor dan rawatan yang berkesan dengan kos yang rendah terutamanya untuk pengesanan kanser pada peringkat awal. Ultra jalur lebar yang berasaskan pengimejan gelombang mikro untuk pengesanan kanser pada peringkat awal adalah merupakan kaedah yang menarik dan berkesan yang telah mendapat perhatian khusus dewasa ini. Perkara utama menggunakan pengimejan gelombang mikro bagi mengesan kanser adalah melalui pemerhatian pada frekuensi gelombang mikro, perbezaan dielektrik dari segi ketelusan dan konduktiviti antara tisu normal dan tisu yang mengandungi kanser. Projek, ini fokus kepada satu experiment tindak balas dalam frekuensi yang kompleks diperolehi dengan menggunakan Vector Network Analyzer (VNA N5242A) selepas RF Horn antenna diletakkan pada atas permukaan sampel payudara. VNA membolehkan pengukuran masa domain dilakukan selain daripada pengukuran frekuensi domain. Melalui kaedah ini sampel payudara dipancarkan dengan gelombang mikro singkat yang dihasilkan oleh RF Horn antenna dengan frekuensi 110GHz hingga 10GHz dan tenaga tindak balas radiasi yang terhasil dianalisis bagi mengetahui kewujudan dan kedudukan kanser. Kaedah MIST beamforming algorithm diaplikasikan untuk data yang dihasilkan oleh VNA untuk mendapatkan kedudukan tumor.

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LIST OF ABBREVIATIONS

Abbreviations	Definitions
MI	Microwave Imaging
EM	Electromagnetic
MIST	Imaging Via Space Time
VNA	Vector Network Analyzer
MRI	Magnetic Resonance Imaging
BIM	Born Interactive Method
2D	Two Dimensional
3D	Three Dimensional
FDTD	Finite Different Time Domain
IFFT	Inverse Fast Fourier Transform
TSAR	Tissue Sensing Adaptive Radar
CMI	Confocal Microwave Imaging

NOMENCLATURE

Permittivity	Measure the resistance when an electric field occurs in the Medium
Conductivity	Measure the ability of materials to produce an electric field or Current
Phantom	A sample intended to mimic the properties of some biological of breast tissue.
Sensitivity	A measurement of an imaging modality's with the ability to detect a cancerous tissue
Contrast	the factors by which one medium's dielectric properties are higher than anothers.
Voxel	A combination of volumetric and pixel that represent the value in 3D space on a regular grid
Metastasize	Ability to spread from one part of the body to another.

CHAPTER I

INTRODUCTION

1.1 Overview

This chapter will explain about the introduction of the project, the objectives of the project, problem statement of the project and also discussed about the scope of work of the project.

1.2 Introduction

Nowadays, breast cancer become one of a great course of women death and become a concern for every person including a group of healthcare professionals who stands struggle against breast cancer. One of the main reasons for incremented of the disease due to lack of awareness about early breast cancer detection with the importance of regular breast scans. Mammography is currently become the most

widely significant clinically accepted for breast cancer imaging detection instead of Ultrasound imaging. However, there are a few weakness of this technique which is it lead to the discomfort condition for patient due to breast compression during the therapy and also harmful causes by the ionizing radiation exposure. Thus, microwave imaging has become one of the promising techniques in breast cancer detection especially at early stage detection.

Microwave Imaging technique in Biomedical imaging is one of the main modalities of promising cancer detection mainly due to many benefits including accessibility without effect harmful for tissue, real time monitoring, simple to perform, non- invasiveness, wide ranges of time and size scales, highly sensitivity and functionality, comfortable for patient and also inexpensive compare to others techniques such as Magnetic Resonance Imaging (MRI). It is widely used in all stages of cancer monitoring. Microwave imaging are able to contribute important information for therapy planning and staging performance in cancer detection.

Microwave Imaging (MI) for breast cancer detection, as a screening and monitoring tools has recently attracted attention among a large number of researcher groups [1-5]. This approaches based on the significant contrast of electrical properties, permittivity and conductivity between normal and cancerous tissue at microwave frequencies [6-8]. MI becomes one of the most promising imaging modalities for biomedical applications like strokes and cancer monitoring. Therefore, MI can serve substantial functional knowledge for breast health and can be used for breast cancer detection and treatment response monitoring tools since it can detect the cancer at earlier stage.

A study on a development of Microwave Imaging technique for earlier tumor detections using Synthetic Aperture Radar (SAR) has been carried out in this paper by focusing more on breast cancer detection since it is a leading factor of women death worldwide according to American Cancer Society (ACS) [9]. Breast cancer is a common type of cancer in women [10-13] compared to others killer cancer. Hence, early detection is very significant for effective treatment [14] in order to long live

survival promises. The studies also focus on the developments of the imaging algorithms.

A simple experiment has been setup by using a two different electrical contrast material which is soy oil (normal tissue) and pieces of stone (malignant tissue) contained in the size of 6cm x 6cm x 10cm of a rectangular tank. Then, a piece of 1cm diameter stone was place at the middle of tank. By using Horn antenna at the frequency range of 1GHz to 10GHz, the location of the stone has being measured in region of 6cm x 6cm which is approximately to location of stone and the scattered wave was seen through Vector Network Analyzer (VNA) and the data is recorded. Then, the data recorded was analyzed in Matlab to get the 2D and 3D plotting graph by using Matlab algorithms.

The main objectives of this project are the research of radar based on Microwave Imaging modalities for early cancer detection by using Vector Network Analyzer (VNA) which can capture pulses of bandwidth up to 20GHZ. The VNA will enable the frequency domain measurement of scattered waves that reflected from the breast sample with UWB microwaves pulse transform to time domain using IFFT. The purpose of the project is to design a method for breast cancer imaging technique that can produce the most accurate performance analysis. This technique is possibly to capture the more accurate about the existing and the features of tumor in the breast from microwaves frequency. Thus, this project can help radiologists to ease their diagnosis as well.

1.3 Objectives

The objectives of developing this project are list as below:

1. To study and understand microwave imaging to characterized the electromagnetic radiation exposure on earlier tumor detection.

2. To simulate the scattered data in frequency domain format to time domain using IFFT.
3. To analyze the electromagnetic radiation exposure on difference dielectric (permittivity and conductivity).
4. To integrate hardware & software and field test

1.4 Problem Statement

Lately, Microwave Imaging technique using synthetic aperture radar has been taken seriously to examine breast cancer and as a potential modalities. Therefore, the lack of promising and effectiveness low cost system of imaging techniques for early cancer detection is still under investigation.

Besides, there are the limitation techniques in breast cancer detection, currently use of X-Ray Mammography and Magnetic Resonance Imaging (MRI) which is lack of sensitivity and functional in detection. These two technique cause discomfort condition for the person under treatment such as breast compression, high ionization radiation, high false negative detection and expensive and time consuming due to the use of magnetic energy in MRI based on reported [15].

1.5 Scope Of Project

There are a few scope specifications being done in this project. The work included in this thesis can be divided into two parts which is for part one, where the feasibility study regarding the responds comes from a stones as a tumor inside the breast phantom and the second part is covering about the quantitative microwave imaging in breast tumor by using 1Hz to 10GHZ Horn antenna and the frequency domain system algorithm in order to process the image detection.

The scope of the project is as following:

1. Investigation of tumor detection in RF frequency.
2. Horn Antenna with frequency range from 1GHz -10GHz.
3. Network Analyzer N5242A (10MHz – 26.5Ghz) to measure the relative amplitude and phase difference between the reference and reflected signal channels.
4. Type of sample of soy oil (normal skin) and a piece of stone in 1cm diameter (Tumor).
5. Concentrates on the abnormalities on breast cancer detection
6. MATLAB version 2011a software will be used to develop the algorithms.

1.6 Report Structure

The remainder of this organisation structure consist of 5 chapters which is each chapter will elaborates details about the topics involved in this reports.

Chapter I describes about of microwave imaging technique for breast cancer detection. A general introduction about UWB and synthetic aperture radar will explain and the concept for the remaining chapters will explained.

Chapter II explains about the history, some case studies in microwave imaging for breast detection based on experimental setup and the algorithms for image formation used. This chapter also describes about the advantages and disadvantages of microwave imaging technique.

Chapters III is about the methodology of this project which is the explanation about the flow of project, the requirement needed.

Chapter IV will present about the final output and simulation from the experiment data that has been analyzed. The implementation of image formation algorithms will briefly explain and discusses in this part.

Chapter V will discusses about the conclusion and some suggestion for further recommendation on this project enhancement.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter will concise about the information of microwave imaging approaches that will use to performed tumor detection. Besides, the most significant clinically breast cancer imaging methods and the microwave frequency that will used to process the backscatter image from tumor reflection also included in this chapter. An explanation about microwave imaging technique and algorithms used and the effectiveness of the current available breast cancer detection technology has been compared and a few related issues are summarized.

2.2 Breast Cancer

Breast cancer defined as “malignant neoplasm of the breast” is a defection area which can cause illness in the breast. A cancer cell has difference features from

normal tissue in terms of cell outline, shape, structures of molecules and the most significantly the ability to metastasize and infiltrate. This all terms will call as “Breast Cancer”.

Female breast consist up mainly of *lobules* (milk producing glands), *ducts* (carry milk from the lobules to nipple) and a *stroma* (fatty tissue) [22]. Mostly, breast cancer begins in the cell that line the ducts. Some start in the cell line the lobules and can be in others tissue too.

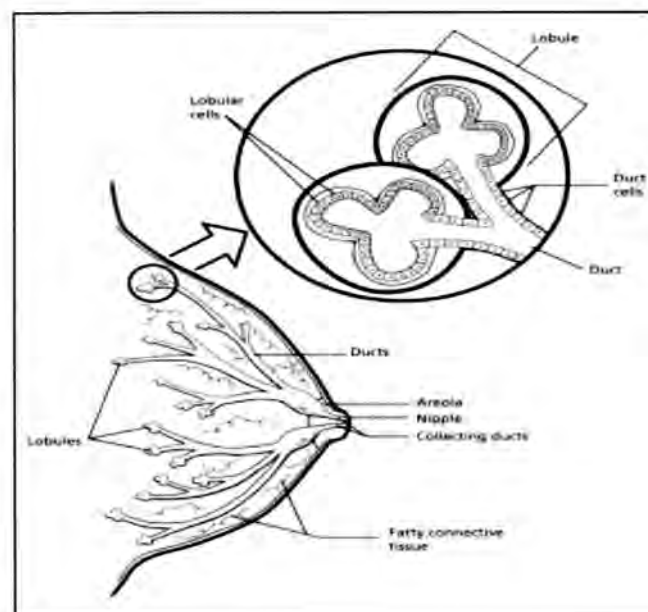


Figure II-1 : Female Breast Structure

Abnormal growth of cell in the tissue in the epithelium of lobules and ducts cause them to clump together and form a tumor that will spread in surrounding tissue which called as breast cancer [23]. There are two groups of cancer which is invasive and non-invasive. Non-invasive cancer basically occurs in small area and not metastasized to the surrounding tissues whereby for invasive cancer is the harmful ones and spreading into nearest tissues [24].