INVESTIGATION OF BRAIN STROKE TYPE USING UWB ANTENNA IN THE HUMAN HEAD PHANTOM MODEL

NABILAH ATHIRAH BINTI OTHMAN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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NABILAH ATHIRAH BINTI OTHMAN

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Azahari Bin Salleh
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Alamat Tetap: N0 100 TAMAN DESA CHEMBONG 71300 REMBAU N.SEMBILAN

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DEDICATION

This project is dedicated to myself actually, for being an engineer studentand this is firstly of my project ever for being studying and trying to completethis project. It is also dedicated to my mother and my father, who taught methat even the largest task can be accomplished if it is done one step at atime and be patient. Last but not least, I sincerely thanks to my supervisor Ts. Azahari Bin Salleh and to all my friends for being my great pillars of support throughout my journey of this project.

ABSTRACT

Worldwide, brain stroke is the leading cause of adult disability. Stroke occurs when the blood supply in a part of brain is disturbed as a blood vessel bursts or is blocked by a clot. Due to the limitations of current clinical imaging such as Magnetic Resonance Imaging (MRI) and Computed Tomography Scan (CT Scan),including inflexibility and not smartly system, high-cost medical expenses, bulky and safety issues, the researchers are encouraged to explore alternative and complementary tools to available techniques such as microwave imaging to detect the brain stroke in an earlier stage. In this project, an antipodal Vivaldi UWB antenna is proposed for the brain stroke detection in a microwave imaging system. The antenna provides bandwidth (centered between 1-4GHz) with stable gain and high front to back ratio to get a good image for the brain stroke type investigation and to verify the brain stroke detection in the head model.The effect S_{11} graph was analysed based on different type of substrate for the UWB Vivaldi antenna, return loss result, farfield directivity using FR-4 substratre, with and without head phantom, analysis on normal head phantom with and without tumor also analysis of hemorrhagic and ischemic stroke . This project can be applied as an alternative method for brain stroke type detection, which offers fast detection, no safety issue and a mobile system.

ABSTRAK

Di seluruh dunia, strok otak adalah penyebab utama kecacatan orang dewasa. Strok berlaku apabila bekalan darah di bahagian otak terganggu apabila saluran darah pecah atau disekat oleh bekuan. Oleh kerana batasan pengimejan klinikal semasa seperti Pengimejan Resonans Magnetik (MRI) dan Imbasan Tomografi Berkomputer, termasuk ketidakfleksibelan dan bukan sistem pintar, perbelanjaan perubatan kos tinggi, , para penyelidik digalakkan untuk meneroka alat alternatif dan Dalam projek ini, antena antipodal Vivaldi UWB dicadangkan untuk pengesanan strok otak dalam sistem pengimejan gelombang mikro. Antena menyediakan lebar jalur (berpusat antara 1-4GHz) dengan keuntungan yang stabil dan nisbah depan ke belakang yang tinggi untuk mendapatkan imej yang baik untuk penyiasatan jenis strok otak dan untuk mengesahkan pengesanan strok otak dalam model kepala. Kesan dalam graf S_{11} dianalisis berdasarkan jenis substrat yang berbeza untuk antena UWB Vivaldi, hasil kehilangan pulangan, keterarahan menggunakan substrat FR-4, analisis strok hemorrhagic dan iskemia . Projek ini boleh digunakan sebagai kaedah alternatif untuk pengesanan jenis strok otak, yang menawarkan pengesanan pantas, tiada isu keselamatan dan sistem mudah alih.

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LIST OF SYMBOLS AND ABBREVIATIONS

CT : Computed Tomography

MRI : Magnetic Resonance Imaging

UWB : Ultra-Wideband

CST : Computer Simulation Technology

MWS : Microwave Studio

EM : Electromagnetic

GHz : Gigahertz

BW : Bandwidth

MWI : Microwave Imaging

CHAPTER 1

INTRODUCTION

This chapter gives an outline of the proposed project's goals and objectives. background. The scientific backdrop is offered first, followed by a summary of the difficulties that define the project's objectives. The chapter concludes with an explanation of the thesis' structure.

1.1 Background of Project

The global economic process has changed people's lifestyles throughout the decades, resulting in countless condition cases around the world. Brain stroke is one of the degenerative disorders that doctors and researchers are interested in researching. A stroke is a disruption in the brain's blood flow caused by a blocked or ruptured blood vessel.

Following a brain stroke, the brain is deprived of oxygen and glucose, leading in fast loss of brain functions and, in some cases, death. Strokes are the largest cause of adult disability worldwide and the second biggest cause of mortality [1]. Ischemic stroke and Hemorrhagic stroke are the two types of major brain stroke. Ischemic stroke happens when a blood vessel is blocked or narrowed by a blood clot, preventing oxygen from reaching the brain and causing it to stop working. A hemorrhagic stroke happens when a blood vessel bursts and spills blood into the brain, causing the surrounding tissue to stop working [2].

CT scans, MRIs, X-ray mammography, and ultrasonography are all being used to diagnose brain strokes. Then there are MRI and CT scans, which are very good diagnostic instruments but are also very expensive. Most hospitals, in reality, are unable to purchase reliable diagnostic equipment. Diagnosis equipment is also big, non-portable, and requires a great amount of area to set up. The fundamental disadvantage of the CT scan is that it exposes the patient to excessive radiation (effective dose of roughly 5 mSv), whereas the MRI is more complex and takes a long time to finish [3-4]. As a result, physicians generally rely on medical imaging devices for diagnosis confirmation, such as computed tomography (CT) scans and magnetic resonance imaging (MRI). The importance of CT and MRI scan technologies is highlighted by the complexity of stroke diagnosis. They are not, however, quick, cheap, or portable, and they are not available at rural medical clinics or carried by first-responder paramedical teams. Last but not least by delivering a rapid, cost-effective, and portable detection method, microwave imaging has the potential to improve present diagnostic approaches.

The goal of this project is to present preliminary findings on the efficacy of microwave imaging in the detection of ischemic and hemorrhagic strokes. This is done utilising a CST software-designed anatomically accurate head phantom to forecast scattered electromagnetic fields and infarction, which drastically alter the dielectric characteristics of the affected tissue. Tissues are exposed to very low doses of electromagnetic radiation to explore the brain. Microwave imaging for biomedical applications is gaining a lot of traction these days, as it has the potential to reveal both physiological states and anatomical structures of human tissues. Microwave imaging enables for non-destructive examination of biological tissues due to microwaves' non-ionizing nature, as changes in tissue's dielectric characteristics are often linked to their physiological state. It has been stated that there is a significant difference in dielectric characteristics between fibro glandular tissues and tumour tissues, and that this is a non-ionizing approach that is likely to be quite inexpensive.

The findings of this project will benefit society because they include an analysis of the Antipodal Vivaldi antenna created with CST Studio Suite software based on the design and simulation of the UWB Antipodal Vivaldi antenna for brain imaging applications, as well as an analysis of the designed antenna's capability in detecting buried objects inside the skull phantom. Calculation and modelling were used to investigate the characteristics of Ultra-wideband Antipodal Vivaldi antennas. Next, using CST software, design and model an Ultra-wideband (1GHz - 4GHz) antenna, as well as a comparison antenna with and without a head phantom in simulation for measurements of parameters such as reflection coefficient S_{11}, radiation pattern, directivity, and gain, as well as investigate the characteristics of Hemorrhagic and Ischemic stroke.

1.2 Problem Statement

The existing diagnostic for a head imaging system currently used in our medical field such as MRI & CT scan has created many limitations such as higher cost medical expenses for imaging brain, bulky system, not flexible, not mobile and having safety issues. In addition, X-ray-mammography ionization poses a significant health hazard, and even ionization induces healthy tissue cancels, and MRIs can create a high-resolution image [6].

Moreover, the existing microwave imaging antenna design also has limitations such as non-compact antenna measurements and as an antenna that is not high directivity. Therefore, the frequency operation is not sufficient for head imaging. This problem will affect microwave imaging's efficiency, and thus image quality will become the low-quality image.

To overcome this limitation, we have created a project on microwave head imaging which to develop and provide a flexible platform considering the analysis of brain stroke type classification which made using CST Studio Suite software based on microwave imaging system and Ultra-Wideband (UWB) Antipodal Vivaldi antenna.

1.3 Objective

The primary objectives of this project are:

a) To design and simulate UWB Antipodal Vivaldi antenna for the brain stroke detection.

b) To verify the brain stroke detection based on type (Ishaemic and Haemorrhagic) in the head phantom.

1.4 Scope of project

a) Develop a microwave imaging system that is using UWB antenna for brain stroke detection (Ishaemic and Haemorrhagic).

b) Study the characteristic of brain stroke type (Ishaemic and Haemorrhagic).

c) Simulation of UWB antenna simulation by using CST software.

d) Modelling of head phantom based on dielectric properties.

e) Analysis of parameter including S-parameter, gain, radiation pattern.

f) Compare head phantom with and without brain stroke.

1.5 Significant of project

The outstanding of this project is to provide a flexible and smart microwave head imaging platform to brain stroke types of patients in an affordable price. This project's main advantages are designing a flexible, smart, low-cost and compact microwave head imaging for future medical use.The project is made using cost-effective products which are environmentally friendly too because the frequency of UWB Vivaldi antenna is set 1-4 Ghz to avoid the biological effect of radiation where the CST STUDIO Suite software is used to develop the monostatic Ultrawideband Vivaldi antenna used for object identification in the head phantom with the operational frequency between 2.6 GHz and 3,2 GHz. By referring to the S_{11} graph, the effect of the regular head phantom compared to the effect of the head phantom with different substrate, tumors, the radiation pattern, directivity and gain also the charaasteristic of hemorrhagic and ischemic stroke were analysed for each situation.

1.6 Thesis Organization

Following the general introduction in this chapter, chapter 2 describes the background of this study, followed by literature reviews about research articles related to the study objectives. Information extracted from methodologies, results, and discussions from these research reviews will lay the foundation required to conduct the research and write the thesis. Research methodology is stated in chapter 3, discussing the microwave imaging system for the software components and the development of Antenna simulation using CST software. In contrast, the result for software, results of brain stroke type for designed system and result of simulation had been done by using the Ultra-wideband Antipodal Vivaldi antenna to observe the parameter used in the characterization of an antenna in Chapter 4. Research conclusions, recommendations for future work and some expected social impacts of this research are described in chapter 5.

CHAPTER 2

BACKGROUND STUDY

2.1 Statistic Review

The review aims to provide an overview of current scenarios or brain stroke cases with related fact information.

2.1.1 Overview of Brain stroke

The brain is a critical component of the Central Nervous System (CNS), which is housed within the skull. The brain uses glucose to meet its energy needs in normal circumstances. The brain has no glycogen stores and relies on a constant supply of oxygen and glucose from the blood. In fact, a decrease in blood supply to the brain is the most common cause of injury**.**