AN ELECTROMAGNETIC FIELD EFFECT ON A HUMAN CELL

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ABSTRACT

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(Keywords: electromagnetics, Human Skin Cell, FDTD, Mazwell equation)

Electromagnetic radiation (EM radiation or EMR) is a form of energy emitted and absorbed by charged particles which exhibits wave-like behaviour as it travels through space. EMR has both electric and magnetic field components. The effect of EMR upon biological systems depends both upon the radiation's power and frequency. It is difficult to verify the effect of electromagnetic wave on human cell experimentally. Some of mathematical models which available today still can't be proved in order to relate them with electromagnetic wave on human being. The Finite Different Time Domain was used as numerical method to represent the wave equation of interaction among electromagnetic waves and human cell. The interaction was representing the contour color in the MATLAB. The purpose of this project is to analyze the interaction and effect on human cell when exposed to electromagnetic wave. Other than that is to develop an accurate simulation using FDTD method and MATLAB for studying the wave propagation properties. The outcome of this project will give an understanding about propagation of electromagnetic wave in human skin cell The Maxwell equations will be used as the basis of the modeling in this project with the aid of numerical method approaches specifically Finite Difference Time Domain (FDTD) techniques.

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ABSTRAK

Sinaran elektromagnet (EM radiasi atau EMR) adalah satu bentuk tenaga yang dipancarkan dan diserap oleh zarah bercas yang mempamerkan tingkah laku seperti gelombang kerana ia bergerak melalui ruang. EMR mempunyai kedua-dua komponen medan elektrik dan magnet. Kesan EMR kepada sistem biologi bergantung kepada kedua-dua kuasa sinaran dan frekuensi. Ia adalah sukar untuk mengesahkan kesan gelombang elektromagnet pada sel manusia yang diujikaji. Beberapa model matematik yang ada hari ini masih tidak dapat dibuktikan dalam usaha untuk mengaitkan mereka dengan gelombang elektromagnet pada manusia. Finite Difference Time Domain yang berbeza telah digunakan sebagai kaedah berangka untuk mewakili persamaan gelombang interaksi antara gelombang elektromagnet dan sel manusia. Interaksi mewakili warna kontur dalam MATLAB. Tujuan projek ini adalah untuk menganalisis interaksi dan kesan ke atas sel manusia apabila terdedah kepada gelombang elektromagnet. Selain daripada itu adalah untuk mendapatkan simulasi tepat dengan menggunakan kaedah FDTD dan MATLAB untuk mengkaji ciri-ciri penyebaran gelombang. Hasil daripada projek ini akan memberi kefahaman tentang penyebaran gelombang elektromagnet di dalam sel kulit manusia melalui Persamaan Maxwell yang digunakan sebagai asas model dalam projek ini dengan bantuan kaedah berangka pendekatan khusus Finite Difference Time Domain (FDTD) teknik.

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LIST OF SYMBOLS

b	-	Normalized propagation constant
c	-	Speed of light; Phase velocity [m/s]
B	-	Magnetic flux-density complex amplitude [Wb/m^2]
d	-	Differential
div	-	Divergence
D	-	Electric flux density [C/m^2]
E	-	Electric field [V/m]
F	-	Force [$kgms^{-2}$]
H	-	Magnetic-field complex amplitude [A/m]
H	-	Magnetic field [A/m]
j	-	$(-1)^{1/2}$ integer
J	-	Electric current density [A/m^2]
k_0	-	Free space propagation constant [rad/m]
l	-	length [m]
m	-	number of modes
M	-	Magnetization density [A/m]
n	-	Refractive index
ρ	-	Electric polarization density [C/m^2]
Q	-	Electric charge [C]
T	-	Time [s]

TE	-	Transverse electric wave
TM	-	Transverse magnetic wave
TEM	-	Transverse electromagnetic wave
φ	-	Total internal reflection phase shift [rad]
V	-	Voltage [V]
β	-	Propagation constant [rad/m]
ε	-	Electric permittivity of medium [F/m]
ε_0	-	Electric permittivity of a free space [F/m]
ε_r	-	Relative dielectric constant of the material[F/m]
θ	-	Angle
θ_c	-	Critical angle
λ	-	Wavelength [m]
λ_0	-	Free space wavelength [m]
μ	-	Magnetic permeability [H/m]
μ_0	-	Magnetic permeability of free space [H/m]
Φ	-	Angle in a cylindrical coordinate system
ω	-	Angular frequency [rad/s]
∂	-	Partial differential
∇	-	Gradient operator
$\nabla .$	-	Divergence operator
∇ x	-	Curl operator
∇_2	-	Laplacian operator

σ - Conductivity

σ_{eff} - Conductivity effective

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, more electrical and electronic equipment produced and each device will emit electromagnetic waves intentionally or unintentionally. It threatens the world during the 24 hours when using a mobile phone, computer, electrical items and equipment that emits waves. Long exposures to low-power electromagnetic waves have the potential to effect human health. The impact will not appear immediately because these may affect human cells in the future if exposed for too long. When radiation enters human cell, the component of the cell will react through kinetic energy.

Three phenomena can be considered as the effects of the interaction of electromagnetic radiation with biological tissues such as the EM wave's penetration into the living system and their propagation into it. Besides that, the possible secondary effects induced by the primary interaction and the primary interaction of the waves with biological tissues [3].

The purpose of this project is to analyze the interaction and effect on human cell when exposed to electromagnetic wave and how we can prove it experimentally. Some of mathematical models which available today still can't be proved in order to relate them with electromagnetic wave on human being. Matlab and GUI is used to assist the understanding on how electromagnetic wave effecting human cell. The Maxwell equation will be used as the basic of the modelling in this project with the aid of numerical method approaches especially Finite Difference Time Domain technique.

1.2 Objective

i. To analyze the interaction and effect on human cell when exposed to electromagnetic wave.
ii. To develop an accurate simulation using FDTD method and MATLAB for studying the wave propagation properties. . The numerical method used is the finite-difference time-domain (FDTD) because it has successfully applied in various engineering fields.

1.3 Problem Statement

It is difficult to verify the effect of electromagnetic wave on human cell experimentally. Some of mathematical models which available today still can't be proved in order to relate them with electromagnetic wave on human being. Matlab and GUI are used to assist the understanding on how electromagnetic wave effecting human cell. In addition, MATLAB and GUI handle all the parameters of the FDTD simulation and computes theoretical values of characteristics parameters of the wave propagation in different mediums.

1.4 Scope of Work

The project has three main scopes:

1. Understand the concept of human cell, interaction in a single cell and effect when exposed to electromagnetic wave.
2. Understand the Finite Difference Time Domain Method (FDTD) to develop the Maxwell equation.
3. Understand Matlab and GUI to develop simulation program for studying the wave propagation properties.

1.5 Importance and Motivation of Work

1. Increase the number of study done
2. To prove that electromagnetic waves effect human cell mathematically.
3. To develops public information to raise the level of understanding about potential health risks of radiation.
4. Once the cells are damaged, it can cause many diseases such as skin cancer and it is very dangerous to humans.

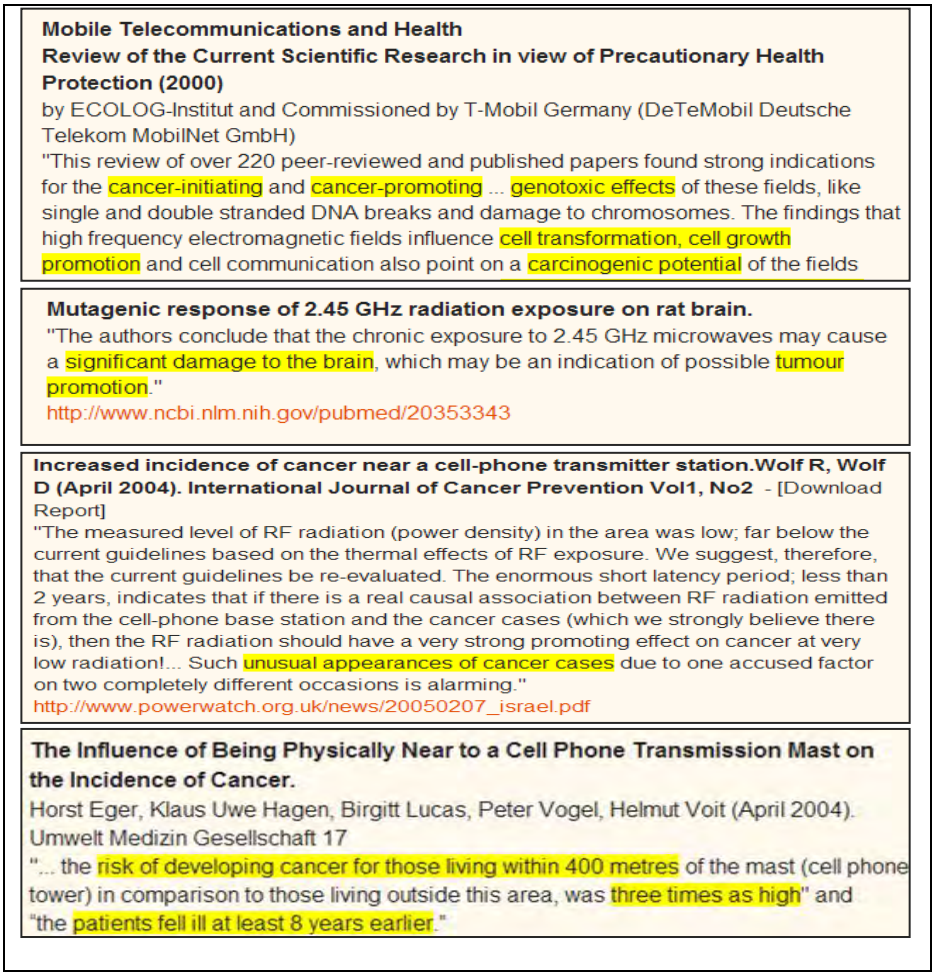

Figure 1.0: Importance and Motivation of work

1.6 Methodology

Implementations and works of the project are summarized into the project flow and flow chart shown below in Figure 1.1 and Figure 1.2. It shows the details of the work of the project that had been implemented in the first and second semester.

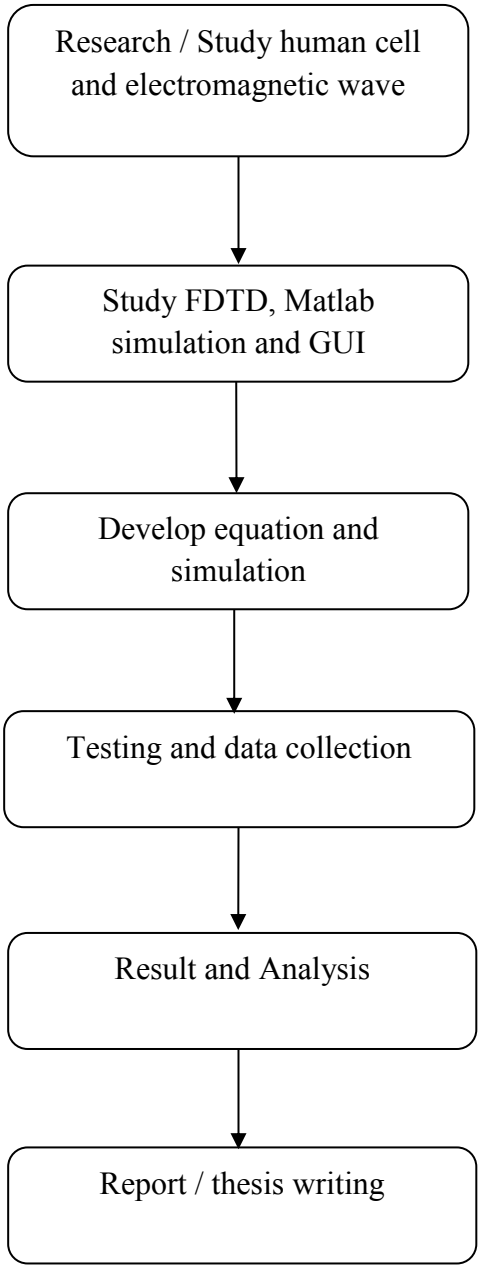

Figure 1.1: Overview of Project Flow

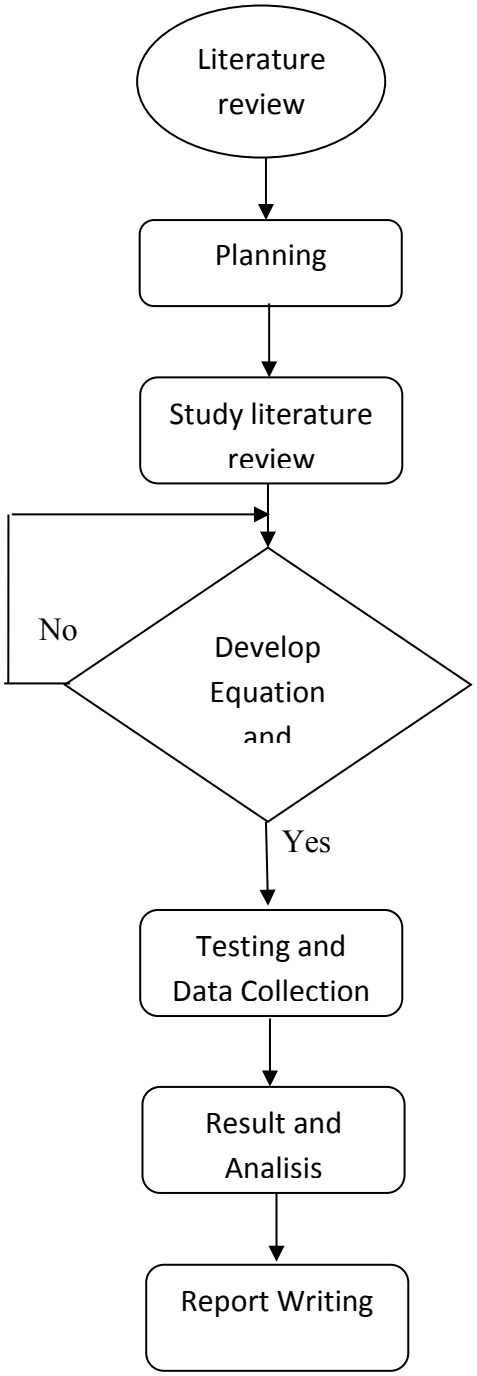

Figure 1.2: Flow Chart of Project

NO	ACTIVITY	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	W11	W12
01	Literature review												
02	Modeling of Maxwell equation												
03	Modeling of FDTD behaviour												
04	Study human cell and interaction in cell												
05	Study Matlab simulation and GUI												
06	Modeling coding of cell												
07	Test and run												
08	Publis paper and make a report												

Table 1.1: Gantt chart for Project

1.7 Structure of the report:

This report represented by 3 chapters.

Chapter 1: This chapter discuss about the brief overview about the project such as project background, objective, and scope of work, problem statement and methodology.

Chapter 2: This chapter discuss about the information that have in project. This chapter discusses more about literature review for the interaction in cell when expose to electromagnetic wave. The structure of human cell also will be discussed in this chapter and its function within electromagnetic propagation. Beside that the behaviour and structure of three layers also be mentioned.

Chapter 3: This chapter discuss about the methodology of the project. Mathematical analysis will be present in this chapter. Then, the interactions

have been analyzed using the numerical method based on finite difference time domain approach. The assumption is considered to design the interaction of electromagnetic wave with human cell. To obtain the result, we discuss the parameters of relative permittivity and conductivity at different frequency.

Chapter 4: In this chapter, we focused on Matlab development which it shows how mathematical equation was apply in Matlab file. The value of attenuation and skin depth are calculated using formula. The relationships between them are discussed. The result will be compared with others references.

Chapter 5: Conclusion and future work will be discuses in this chapter. The overall project will be summarized to conclude this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Human cell

All living things are made up of basic unit called cells. Cells are the building blocks of all living organisms. All cells share certain general characteristics. The living component of a cell is called the protoplasm. It consists of the cytoplasm and the nucleus. The nucleus content is known as the nucleoplasm. The part of the protoplasm surrounding the nucleus is called the cytoplasm. The protoplasm is surrounded by a thin membrane known as the plasma membrane. Cytoplasm contains a variety of tiny structures called organelles. Organelles are cellular components that perform specific functions within the cell. Many of these organelles are enclosed by their own membranes which help maintain the chemical environments inside the organelles [2].

2.2 The structure of the plasma membrane

Plasma membrane is a semi-permeable cell membrane that allows movement of water and certain substances in and out of the cell. According to the fluid mosaic model [2], plasma membranes are composed mainly of protein and phospholipids. At the plasma membrane, phospholipids are arranged in a double layer, called the phospholipids bilayer that surrounds a cell.

A membrane is said to be impermeable if it prevents the passage or movement of all substances. The plasma membrane is partially permeable or semi-permeable. This means that certain substances can move across the plasma membrane freely while others cannot. Membranes that envelop organelles such as mitochondria, chloroplast and the nucleus are semi-permeable, that is, they allow only certain substances to enter or leave the organelles [4].

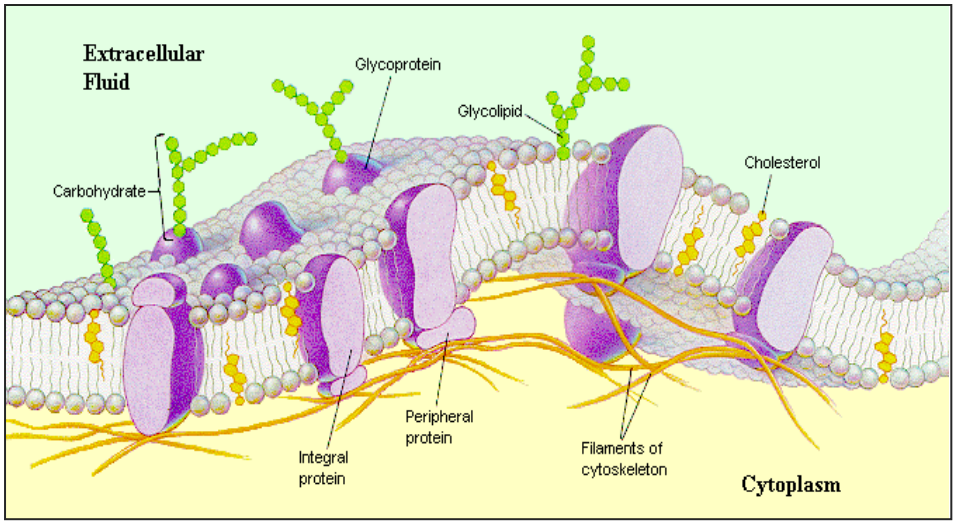

Figure 2.1: Structure of Plasma Membrane

2.3 Human skin cell structure and size

General Medical Sciences (NIGMS) USA was done their research about Human skin cell sizes at 2008. The size was reported as shown in table 2.1. This size is very important in this project because this size will be used as cell size when modelling the structure of cell in MATLAB software.

Cell portion	Actual size average
Cell diameter	40 micrometer
Nucleus diameter	3 micrometer
Membrane diameter	4 micrometer
Substances in cell	20-30 micrometer

Table 2.1 Human Skin Cell size from NIGMS

2.4 Cell membrane effect

The biological action of non ionizing electromagnetic radiation of low intensity on molecular and super electromagnetic fields induce the processes of the electric charge carrying across cell membrane that brings the additional electric potential on cellular membrane. The microwave radiation causes the significant changes of different type of cell membrane characteristics, basically, via lipid membranes it induce increase of membrane permeability for sodium, potassium and chlorine ions and inhibit the active transport of these ions [9].