DISCRETIZATION OF FLAT ELECTROENCEPHALOGRAPHY (EEG) USING A PROBABILITY DISTRIBUTION FOR FUZZY TOPOGRAPHIC TOPOLOGICAL MAPPING (FTTM) APPLICATION

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I dedicated this Master thesis to my beloved parents Mohd Hussain Bin Ismail and Noriah Binti Nawan and my reliable siblings.

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ABSTRACT

The abnormality of the electrical activity in the brain during an epileptic seizure can be measured by using Electroencephalography (EEG) and Magnetoencephalography (MEG). Flat EEG is EEG data accurately translated to a two-dimensional plane. The probability of the Flat EEG signal centroid relocating to a different location of the brain after a time interval can be represented in matrix form. Then, the aim of this study is to discretize the Flat EEG plane for FTTM model application into the centered cells represented by matrices. This study also attempts to construct an algorithm for populating a matrix with probabilities that a Flat EEG centroid moves to another location. These objectives lead to the construction of a program for generating the matrix of probabilities, given a Flat EEG centroid and a vector representing the change of its location. Additionally, this study contributed to the programming techniques for generating Flat EEG matrix data. The Flat EEG plane containing signal centroids was discretized into centered cells and mapped to the entry of a matrix. The matrix of probabilities that a signal centroid moves to another location was constructed. Apart from that, an algorithm for populating the matrix of probabilities was also constructed. A program to generate the matrix of probabilities was constructed based on the algorithm for populating the matrix of probabilities. After that, the program for generating matrix of probabilities was implemented by computer programming using the Microsoft Visual Studio 2010 software. Thus, matrices of probabilities of size 5×5 and 15×15 were generated for time $t = 0$ to $t = 1$ with varying values of parameter for probability distribution, r. The matrix of larger size was also more precise which means the details were finer than the smaller sized matrix. Therefore, the constructed program for generating matrix of probabilities was able to describe the movement of the signal centroid to another location after the present time. The potential for added slices of Flat EEG data for another time was recommended for the future work of this study.

ABSTRAK

Aktiviti elektrik tidak normal di dalam otak semasa sawan epilepsi boleh diukur menggunakan Electroencephalography (EEG) dan Magnetoencephalography (MEG). EEG Datar ialah data EEG yang diterjemahkan dengan tepat kepada satah dua dimensi. Kebarangkalian isyarat sentroid EEG Datar berpindah ke lokasi yang berbeza pada otak selepas sesuatu selang masa boleh diwakili dalam bentuk matriks. Oleh itu, tujuan kajian ini ialah untuk mendiskretkan satah EEG Datar untuk aplikasi model FTTM ke dalam sel-sel berpusat diwakili oleh matriks. Kajian ini juga bertujuan membina algoritma untuk mengisi matriks dengan kebarangkalian bahawa sentroid EEG Datar bergerak ke lokasi lain. Objektif tersebut membawa kepada pembinaan program untuk menjana matriks kebarangkalian, apabila diberi sentroid EEG Datar dan vektor yang mewakili perubahan lokasi. Selain itu, kajian ini menyumbang kepada teknik-teknik pengaturcaraan untuk menjana data matriks EEG Datar. Satah EEG Datar yang mengandungi sentroid isyarat telah didiskretkan ke dalam sel-sel berpusat dan dipetakan kepada elemen matriks. Matriks kebarangkalian bahawa sentroid isyarat bergerak ke lokasi yang lain dibina seterusnya. Selain itu, algoritma untuk memenuhi matriks kebarangkalian juga ditakrifkan. Program untuk menjana matriks kebarangkalian telah dibina berdasarkan algoritma pengisian matriks kebarangkalian. Selepas itu, program menjana matriks kebarangkalian telah dilaksanakan melalui pengaturcaraan komputer dengan menggunakan perisian Microsoft Visual Studio 2010. Oleh itu, matriks kebarangkalian yang bersaiz 5×5 dan 15×15 dihasilkan dan diolah dari masa $t = 0$ hingga $t = 1$ dengan nilai-nilai berbeza bagi parameter taburan kebarangkalian, r. Matriks yang bersaiz lebih besar juga lebih tepat yang bermaksud butiran adalah lebih halus daripada matriks yang bersaiz lebih kecil. Maka, program yang dibina untuk menjana matriks kebarangkalian dapat menggambarkan pergerakan sentroid isyarat ke lokasi lain selepas sesuatu masa kini. Potensi untuk tambahan kepingan data EEG Datar untuk rekod masa-masa yang lain dicadangkan sebagai kajian selanjutnya.

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LIST OF ABBREVIATIONS

FTTM	-	Fuzzy Topographic Topological Mapping
EEG	-	Electroencephalography
MEG	-	Magnetoencephalography

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The human brain is the main organ of the human central nervous system. The central nervous system is very important because it integrates information it receives from all parts of the bodies and controls all activities of the body. An electrophysiological monitoring method called Electroencephalography (EEG) is to record the electrical activity in the brain. EEG is used to diagnose sleep disorders, coma, encephalopathies, brain death and most often to diagnose epilepsy which is a problem with the brain's electrical system. The abnormality of the electrical activity in the brain can be measured by using Magnetoencephalogram (MEG) and EEG which measure magnetic field and electrical potential respectively during an epileptic seizure (Ahmad, 2009).

The measurement of the electrical activity in the brain by using MEG and EEG is called bio-electromagnetic inverse problem which was to detect pointers dipolar current sources located in the brain (Ahmad, 2009). There is a need to develop a mathematical modelling for solving this problem. Then, a novel method called Fuzzy Topographic Topological Mapping (FTTM) has been introduced to solve neuromagnetic inverse problem (Ahmad et al., 2000). The neuromagnetic inverse problem was the process to determine the location, direction, and magnitude of unbounded single current sources by using the magnetic field readings (Ahmad et al., 2005). The designation of FTTM version 1 (FTTM1) was presented the 3-D view of an unbounded single current source and FTTM version 2 (FTTM2) was presented the 3-D view of bounded multi-current sources (Jamaian, 2009).

Fuzzy clustering is a form of clustering in which each data point can belong to more than one cluster or partition. In the process of applying FTTM2, two different algorithms were applied to the data which were fuzzy c-means (FCM) to determine the region and approximate the number of the current sources whereas seed-based region growing (SBRG) to confirm the available number of current sources in the system automation (Zarina, 2006). This process results in the position of the centroids in the partitions with the high electrical activity within the brain. The continuous spaces of the Flat EEG signal data are discretized and the probability of the location of current source produced by Flat EEG signals in the region is represented in form of matrix. Therefore, this study proposes to construct a program for generating the matrix of the probability of the Flat EEG signal centroid moves to another location after the present time.

1.2 Problem Statement

The mathematical modeling of Flat EEG signals named FTTM used for solving the inverse neuromagnetic problem which was the process to determine the location, direction, and magnitude current sources by using the magnetic field readings. The main problem of this study is the lack of computer application for modeling location of Flat EEG signal centroids. The probability of a Flat EEG signal centroid relocating to a different location of the brain after a time interval can be represented in transition matrix. Then, there is a need to discretize Flat EEG's continuous spaces where the current source lies for computer implementation of a program for generating the matrix of probabilities. Some representation of probability cloud may be used as weightage values during interpolation of signals between discrete time slices of Flat EEG data.

1.3 Objective of the Study

The objectives of this research are:

1. To discretize the Flat EEG plane for FTTM model computer application via centered cells represented by matrices.
2. To construct an algorithm for populating a matrix with probabilities that a Flat EEG centroid moves to a particular location after a time interval.
3. To construct a program to generate a matrix of probabilities for the system after the time interval, given a Flat EEG centroid and a vector representing the change of its location.

1.4 Scope of the Study

This study develops a program for generating the matrix of probabilities of the Flat EEG signals moving to another location after the present time. The computer software Microsoft Visual Studio 2010 was used to implement the program for generating the matrix of probabilities. The efficiency of the program in this study was showed by comparing the running time for the program to generate the matrix of probabilities different matrix sizes.

1.5 Significance of the Study

This study will give the understanding on how the FTTM model can determine the location of the current source produced by EEG signals and the effectiveness of the program for generating the matrix of probabilities of the signal centroid moves to another location after the present time. The findings of this study will contribute to defining a discretization of Flat EEG space for digital image processing. Next, this study will also contribute to expanding algorithms for describing digital/discrete two-dimensional probability clouds. Finally, this study will contribute the programming techniques for generating Flat EEG matrix data.

1.6 Thesis Outline

The outlining of the five chapters in this thesis is performed as a flowchart in Figure 1.1. This thesis begins with Chapter 1, introducing the background of the study. Then, in Chapter 2 the literature survey on Flat EEG and mathematical modeling of FTTM. Followed by Chapter 3 of methodology that will discuss the Flat EEG plane and matrix of probabilities. After that, Chapter 4 of implementation will present the output of the matrix of probabilities. Finally, Chapter 5 for the conclusion and recommendations.

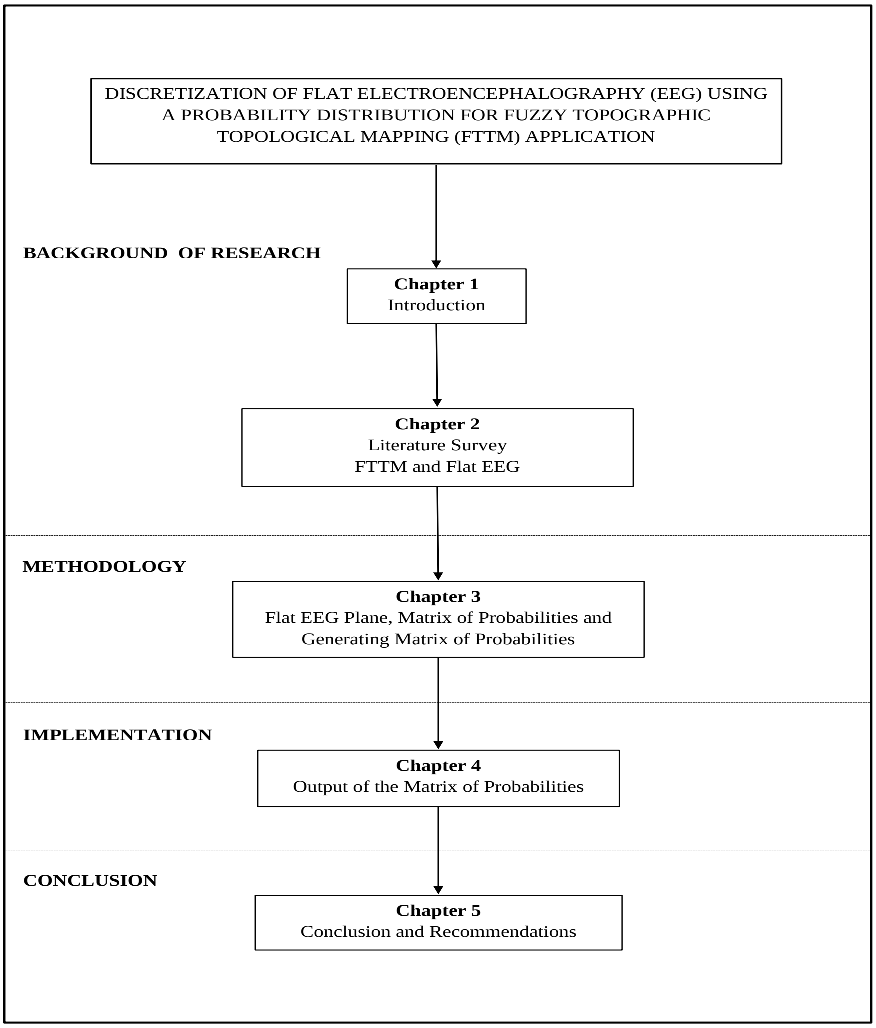

Figure 1.1: Thesis outline

1.7 Context of Research

The Figure 1.2 shows the relationship between this study and the previous study in the same fields.

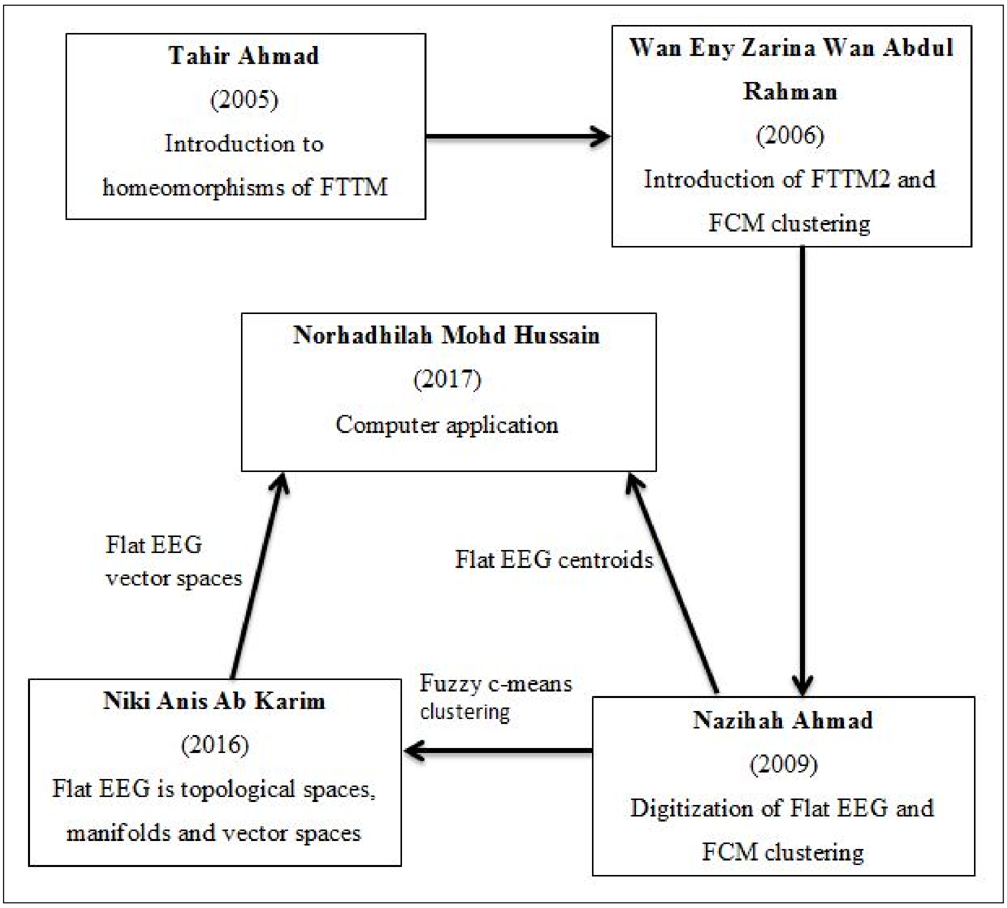

Figure 1.2: Context of research

The topic of FTTM started by Tahir Ahmad (2005). Then, Wan Eny Zarina Wan Abdul Rahman (2006) was introduced the FTTM2 and clustering algorithm. Followed by Nazihah Ahmad (2009), digitized Flat EEG and clustering. Finally, Niki Anis Ab Karim (2016) showed that Flat EEG were topological spaces, manifold, and vector. Also, my study contributing in the computer application for modeling the location of Flat EEG signal centroids.

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