CHAPTER I
INTRODUCTION

1.1 Background

Epileptic disorders are challenging to detect because the signals produce tend to be repetitive, making it difficult to distinguish between normal patterns and those specifically indicating a disorder. Disorders experienced by people with epilepsy include heterogeneous, multifaceted with recurring seizures (2 or more times), where involuntary movements occur that involve part of the body or the whole body, and are often accompanied by loss of consciousness and control of digestive tract function [1]. Epilepsy is a neurological condition that does not recognize race, age, social class or nationality with a disease characteristic that is not transmitted to people around it [2]. Epilepsy has a detrimental effect on a person's social and psychological well being. These effects include social isolation, stigmatization, or disability which can lead to low learning achievement and poor job opportunities. The stigma associated with epilepsy is fear of seizures, injury, death, shame, loss of job, educational opportunities, or not being allowed to marry [3].

Efforts to detect epilepsy can be made by following technological developments. Electroencephalography (EEG) is a supporting examination available, relatively cheap, and widely used to detect and monitor electrical activity [4]. Another function of the EEG is to provide information in the form of classification, diagnosis and therapy on brain conditions because the signals in the brain are not easily seen and are complex [5]. The discovery of various patterns in EEG signals can use artificial intelligence techniques with machine learning schemes that can be utilized effectively [6].

However, for long EEG recording, the visual interpretation becomes an expensive, intensive and tedious error-prone exercise and the result can vary from different neurophysiologists in the same recording [4]. Thus, there is an ever-increasing need for developing an effective method for automatic seizure classification in order to prevent the possibility of any missing information so as to give a proper diagnosis and possible treatment plan for epilepsy. There are several factors which affect a classifier's behavior, such as the dimensionality of the feature space, the number of available patterns to learn from, imbalanced class labels and so on. However, to develop an efficient method, the main challenges are designing an appropriate feature extraction method and selecting the most prominent features because the quality of feature set plays an important role on the classification accuracy.

The significant disadvantages of Empirical Mode Decomposition (EMD) are that it is not recursive and does not allow backward error correction. To solve these problems, a new method called variational mode decomposition (VMD) has been presented. The VMD method is an internal and variable method that simultaneously and adaptively determines the frequency band of each mode. With this method, an error that will occur while calculating the modes can be compensated quickly [7]. VMD was formulated to overcome the noise in the input signal by selecting the appropriate mode and performing error balancing correctly through adaptive band calculations. The updating of modes in the Fourier domain using Fourier Transform (FT) directly to the VMD method makes optimization fast and easy [8] . In addition, a variety of methods like, mean, covariance, correlation, entropy features are widely used to extract the features from EEG signals [9].

Several previous studies have been carried out using different classification methods including using the Hurst exponent, Discrete Wavelet Transform level 5 feature extraction with the K-nearest neighbor algorithm and Support Vector Machine which produces an average accuracy of 99% and 93% in open and closed eye conditions [10]. The classification process in epilepsy can be assisted by a type of machine learning in the form of a Support Vector Machine (SVM). SVM is the most popular algorithm as an EEG signal classification method because of its good classification performance and the ability to generalize based on energy, entropy, standard deviation used as its features [11]. Performed different feature extraction methods (Spectral features, wavelet features, complexity features) from EEG signals to diagnose AD in their study. As a result of classifying the obtained features with the help of the SVM algorithm, the classification success rate was 86% for Spectral features, 88% for wavelet features, and 96% for complexity features, respectively [12].

In this study, statistical features are extracted from EEG signals using an enhanced VMD method, which adaptively decomposes complex, multi-component signals to capture subtle signal variations essential for seizure classification. Each decompose signal will be extracted using cross correlation for optimized features. IMFs will reduction using cross correlation to get the most relevance with original signals. Classifiers are subsequently used in a SVM, which effectively distinguishes between various EEG states, normal, inter-ictal, and ictal, ensuring efficient and accurate seizure identification.

1.2 Problem Identification

Epileptic seizures are unpredictable and often difficult to diagnose accurately using manual EEG analysis due to the complex and non-linear nature of EEG signals. Traditional

EEG analysis for detecting seizures involves visual inspection by clinicians, which is time-consuming, prone to human error, and requires significant expertise. The inherent complexity of EEG signals, characterized by non-stationarity and noise, further complicates the diagnostic process. This challenge necessitates a systematic and efficient approach to classify epileptic seizures with better accuracy. The main problem is decomposition return many IMFs each band then should running on feature extraction process. It will impact for feature dimensional data.

1.3 Objective

The primary objective of this research is to develop an automated seizure classification system using artificial intelligence and machine learning to reduce the reliance on manual EEG analysis and minimize human error. To address the complex, non-linear characteristics of EEG signals, the system will utilize VMD for efficient feature extraction, breaking down the signals into meaningful IMFs components. The selected IMFs using cross correlation will reduce number of features then be classified using a SVM algorithm, chosen for most relevance data, with the aim of achieving high diagnostic accuracy. Finally, the proposed model will be rigorously evaluated using metrics such as accuracy, sensitivity, and specificity to ensure it meets the desired balance between computational efficiency and diagnostic performance.

1.4 Research Method

The raw EEG signals typically contain noise and artifacts that can interferences with accurate analysis. To address this, preprocessing steps such as wavelet denoising will be applied to remove unwanted noise and enhance the quality of the signals before further processing. The core of the feature extraction process involves decomposing the preprocessed EEG signals using VMD. This method breaks down the EEG signals into a set of Intrinsic Mode Functions (IMFs), each representing different frequency sub-bands. By decomposing the signals in this way, VMD simplifies the analysis by isolating different frequency components, making it easier to extract meaningful features. From each of these sub-bands, features such as entropy, curve, and spectral power will be derived, capturing both time-domain and frequency-domain characteristics. By following this systematic approach, the study aims to develop a robust and efficient automated seizure classification system that can aid clinicians in diagnosing epilepsy more accurately and with reduced computational burden.

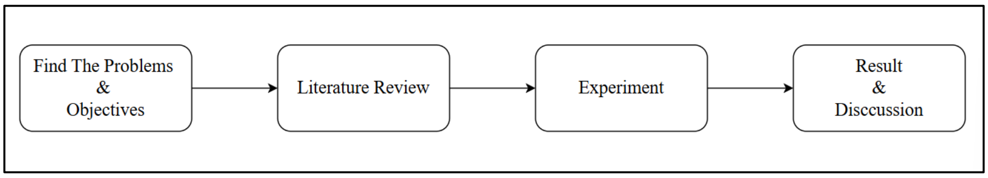

Figure 1. 1 Research Method.

The figures 1.1 presents the background of the research, emphasizing the importance of automated seizure detection using EEG signal analysis and artificial intelligence. It provides the problem statement, highlighting the challenges faced in manual analysis of complex EEG signals, and sets the boundaries of the study by defining the scope and limitations. This chapter also elaborates on the objectives and potential benefits of the research, aiming to enhance diagnostic accuracy and efficiency. Finally, it concludes with an overview of the thesis structure, offering a roadmap of the subsequent chapters. Then a comprehensive review of relevant literature, including previous studies on seizure detection using EEG signal analysis and machine learning approaches. It discusses the theoretical concepts and techniques employed in this research, including all alogrithm such as VMD and SVM.

Experimental simulation scheme as technical. In the preprocessing stage, noise reduction techniques such as wavelet denoising are applied to the raw EEG signals, enhancing the signal quality before further analysis. The next step involves VMD, a method employed to break down the EEG signals into IMF's that represent distinct frequency components. Following this, key features are extracted from the VMD components, including metrics like entropy, spectral power, and signal curvature, to capture essential time-domain and frequency-domain characteristics. Machine learning models are trained using these selected features to classify the EEG signals as indicative of a seizure or non-seizure. Finally, the performance of the classification models is evaluated using metrics such as accuracy, sensitivity, and specificity, providing a comprehensive assessment of the system's effectiveness.

The analysis of the results obtained from the implementation of the proposed system. It provides a detailed evaluation of the feature extraction process, the effectiveness of selected IMF on VMD, and the performance of the classification models. Comparative analysis is conducted between the SVM and other classifiers, examining their accuracy and efficiency.

1.5 Hypotheses

The hypotheses related to the proposed method for epilepsy seizure classification can be summarized as follows. Firstly, this research hypothesizes that the application of VMD using cross corelation will yield a more accurate extraction of relevant features from EEG signals compared to traditional methods. This enhanced feature extraction capability is expected to facilitate improved differentiation between seizure and non-seizure states. Secondly, this research proposes that utilizing SVM with an RBF kernel will achieve higher classification accuracy for seizure classification than conventional classifiers, such as Decision Trees or K-Nearest Neighbors. This is due to SVM's ability to effectively manage the high-dimensional and non-linear nature of EEG data. This research, expect that the systematic approach of combining adaptive feature extraction and robust classification result in a superior diagnostic tool for epilepsy.