EEE 485/585 - Term Project Proposal
Group Members: Ecem Şimşek, Emirhan Koç
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Classification of Epileptic Seizure From Electroencephalogram (EEG) Signals Based on Machine Learning Approaches

Epilepsy is a well-known and prevalent chronic neurological disorder that affects between 60-70 million people worldwide. It is observed more frequently in infants and the elderly, and around 3 million people are affected by this disorder every year. Epileptic seizure is a sudden and abnormal electrical activity in the brain due to extreme discharge of brain nerve cells in the cerebral cortex. As a result of this abnormality, unusual behaviors, repetitive seizures and loss of unconsciousness can be experienced. By considering these effects, timely and correct detection of the seizure is mandatory, and is of great importance in order to decrease the harm, and control the disease. In clinical examinations, epilectic seizures can be detected using various monitoring tools such as electroencephalogram (EEG), magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI). As EEG recording devices are mobile and more economical, they are used widely in the diagnosis of epilepsy. EEG is a non-invasive technique for measuring the brain's electrical activity from multiple locations (channels) in the brain using electrodes over the head. Basically, EEG signals are created by the ionic current resulting from the voltage differences of the nerve cluster in a channel [1], [2], [3], [4]. Thus, the detection of epileptic seizures is an important study and research area that can be investigated by the usage of various machine learning (ML) tools and algorithms.

In this project, we plan to work on a binary classification task that aims to discriminate between brain signals with and without epileptic seizure by recording these signals via the utilization of aforementioned EEG channels. In our work, we use the publicly available "**The Bonn EEG Epilepsy Time Series Dataset**" [5]. In means of its properties, continuous multichannel EEG recordings are collected from each patient; however, after visual inspection for artifacts resulting from muscle activity or eye movement, single-channel EEG signals of 23.6 seconds duration are used for investigation. The continuous EEG signals are sampled with a frequency of 173.61 Hz. Also, a bandpass filter with its cut-off frequencies at 0.53 Hz and 40 Hz is used. After the pre-processing of the raw EEG signals, a dataset of size 500 x 4097 (number of patients x number of samples) is created for the study. This dataset is mainly created for clinical and neurological investigation and research purposes [5]. Furthermore, it is used intensively in ML studies on epilepsy and EEG in recent studies [6], [7], [8], [9]. This is a high volume dataset that consists of EEG records of 500 participants. The dataset consists of 5 sets of conditions that each contains recordings from 100 participants: 2 sets are the EEG recordings obtained from the brain surfaces of the healthy participants with eyes-open and eyes-closed conditions. The other 2 sets are the intracranial EEG recordings (taken from inner regions of the brain) obtained from epilepsy patients placed in both neutral and seizure-stimulating experimental environments during their "seizure-free" condition. The last set also consists of intracranial EEG recordings obtained from the epilepsy patients during their "seizure" condition. By pre-processing and analyzing this dataset by the chosen tools and ML algorithms, our main aim is to perform a differentiation between EEG signals that contain and do not contain the "epileptic seizure" condition. As a side study, we plan to analyze and report the accuracy of the classification results of participants that are epilepsy patients with seizure-free recordings hence exploring the overall accuracy and classification power of our models. Moreover, this will lead us to evaluate both the quality of the datasets, recording environment, and our method's performance.

There are several key challenges that we expect to encounter during our study. First challenge is a common issue in EEG studies. EEG signals represent the potential difference in a brain region and are represented in units of µVs (microvolts). They are severely affected by the noise in the environment and mostly contain noise even when they are bandpass-filtered. Therefore, the further pre-processing of the data may be necessary. Secondly, the problem of feature extraction itself is highly challenging since the data contains 4097 samples without any description and specification in any segments of data. We believe that the feature size of 4097 is huge and redundant for classification and hence it will be extremely computationally costly using our implementation. As a result, it is required to discover useful features from different segments of the signal or artificially produce some additional features using the existing sample features. Hence, performing feature engineering for our dataset will be one of the most challenging yet most important stages towards our previously explained aim of classification.

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