Emotion Recognition using Mind Wave and Support Vector Machines

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***Abstract*- The Electroencephalogram (EEG) is a complex and aperiodic time series, which is a sum over a very large number of neuronal membrane potentials. The detection of recorded epileptic seizure in EEG (Electroencephalogram) segments is crucial for the localization and classification of epileptic seizures. In this Project we proposed to process the real time EEG signals to detect seizure's in advance using wireless EEG headset. Many algorithms are available to process the benchmark datasets to classify the EEG signals. The overall aim of the project is to design an algorithm that will read signal data from an EEG source and process this data to determine if the person is undergoing an epileptic seizure. The developed program can be ported to the mobile devices in future. This real-time processing of EEG signals helps to find a balance between the performance of the algorithm employed in detecting seizures and the amount of processing required to calculate the presence of seizure. The project also aims to investigate the effect of compression of EEG signal data on the overall effectiveness of the seizure detection algorithm. The EEG signals are obtained from various different persons in real time using the wireless headset All these obtained datasets are classified using the support vector machine and their features are extracted. In the existing algorithms the feature extraction and classification is performed on the benchmark datasets. The proposed idea achieves higher accuracy and has low time complexity than the existing techniques.**

1 INTRODUCTION

1.1 ElectroencephalogramSignals

The electrical nature of the human nervous system has been recognized for more than a century. It is well known that the variation of the surface potential distribution on the scalp reflects functional activities emerging from the underlying brain. This surface potential variation can be recorded by affixing an array of electrodes to the scalp, and measuring the voltage between pairs of these electrodes, which are then filtered, amplified, and recorded. The resulting data is called the Electroencephalogram (EEG). In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp.

1.2 Nature ofElectroencephalogramSignals

EEG reflects correlated synaptic activity caused by post-synaptic potentials of cortical neurons. The ionic currents involved in the generation of fast action potentials may not contribute greatly to the averaged field potentials representing the EEG. More specifically, the scalp electrical potentials that produce EEG are generally thought to be caused by the extra cellular ionic currents caused by dendritic electrical activity, whereas the fields producing magneto encephalographic signals are associated with intracellular ionic currents.

1.3 Epilepsy

Epilepsy is a neurological condition, which affects the nervous system. Epilepsy is also known as a seizure disorder. It is usually diagnosed after a person has had at least two seizures that were not caused by some known medical condition like alcohol withdrawal or extremely low blood sugar. Sometimes, epilepsy can be diagnosed after one seizure, if a person has a condition that places them at high risk for having another. In the figure below,

(a) High-order models are required to distinguish targeted physiological states from background activity.(b) The manifestation of targeted states are different from patient-to-patient.(c) Physiological changes over time (particularly following acute events)

Fig. 2. (a) SVM framework in an EEG-based seizure-detection example. The trainer generates a classifier model from previous observations. Real-time detection

Occurs in two steps: feature extraction and classification.

(b) SVMs form a decision boundary from support vectors, which are sampled from the edge of the data distributions

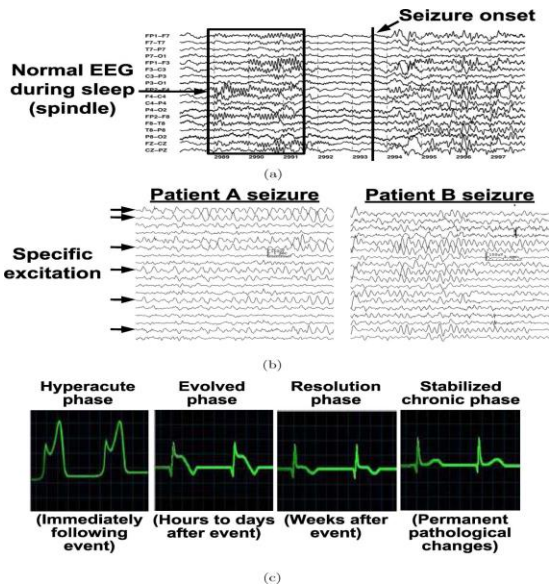


Fig. 1. Challenges with physiological signal analysis.

.2.1 NEURAL NETWORK

In general a biological neural network is composed of a group or groups of chemically connected or functionally associated neurons.

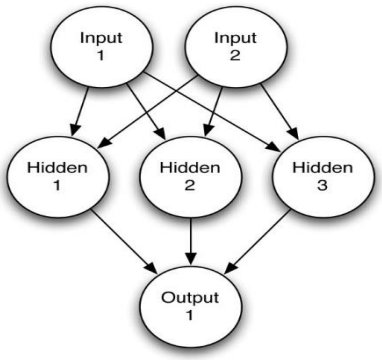


Figure 1. A Basic Neural Network

A single neuron may be connected to many other neurons and the total number of neurons and connections in a network may be extensive.

An artificial neural network (ANN), also called a simulated neural network (SNN) or commonly just neural network (NN) is an interconnected group of artificial neurons that uses a mathematical or computational model for information processing based on a connectionist approach to computation.

2.3 Support Vector Machine

2.3.1 Description

The **Support Vector Machine** proposed by Vapnik has been studied extensively for classification, regression, and density estimation. SVM maps the input patterns into a higher dimensional feature space through some nonlinear mapping chosen a priori. A linear decision surface is then constructed in this high-dimensional-feature space. The SVM is a binary classifier, which can be extended by fusing several of its kind into a Multiclass classifier.

Training the SVM is a quadratic-optimization problem.The SVM is a binary classifier, which can be extended by fusing several of its kind into a Multiclass classifier. SVM's are trained, each of them aimed at separating a different combination of classes. For three classes (A, B, and C) we need three classifiers; one SVM classifies A from B and C, a second SVM classifies B from A and C, and a third SVM classifies C from A and B. The Multiclass-classifier-output code for a pattern is a combination of targets of all the separate SVMs.
Produce results.

3.1 MULTILAYER PERCEPTRON NEURAL NETWORK [MLPNN]

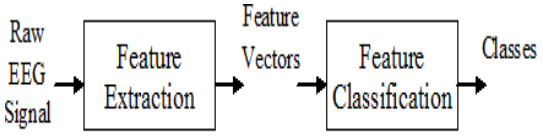
The MLPNNs are the most commonly used neural-network architectures since they have features such as the ability to learn and generalize, smaller training-set requirements fast operation, and ease of implementation.
One major property of these networks is their ability to find nonlinear surfaces separating the underlying patterns, which is generally considered as an improvement on conventional methods.

3.2 Probabilistic Neural Network[PNN]

The PNN was first proposed by Specht. A single PNN is capable of handling Multiclass problems. This is opposite to the so-called one-against-the rest or one-per-class approach taken by some classifiers, such as the SVM, which decompose a Multiclass classification problem into dichotomies and each chotomizer, has to separate a single class from all others.

4 PROJECT DESCRIPTION

This project performs the classification of EEG signal that is extracted using the popular features namely min, max, mean and standard deviation. Here the classification is performed using most popular classifier named Support Vector Machines which uses the hierarchical approach.



The real time EEG signal is given as input to the feature extraction phase where the wavelet decomposition is performed and the signal is divided into five sub bands with the wavelet coefficients namely Mean, Standard Deviation and Variance . The project has been developed with the following phases
Phase 1: Obtaining the real time EEG signals from different persons
Phase 2: Feature Extraction from EEG Signals
Phase 3: Classification of Extracted features

5.2 Real-Time EEG Signal Extraction

The EEG signals are obtained from different persons in real-time using the wireless EEG headset. The real time EEG signals is the raw data obtained. The wireless EEG headset can be connected with either computer or smartphones and the raw data's can be easily recorded.

5.2.1 WIRELESS BIO-SIGNAL ACQUISITION KIT

5.2.1.1 Mind Wave

This Brain-Computer Interface (BCI) device turns your brainwaves into actions, unlocking new worlds of interactivity. The Mind Wave Mobile reports the wearer's mental state in the form of NeuroSky's proprietary Attention and Meditation sense algorithms, along with raw wave and information about the brainwave frequency bands. The NeuroSky Mind Wave Mobile can be used with supported video games, research software, or a number of other applications for an enhanced user experience.

5.2.1.2 Bluetooth Pairing

"Pairing" is when your computer/tablet/phone remembers your Mind Wave Mobile headset, and your Mind Wave Mobile headset allows that computer/tablet/phone to connect to it. Note that this is different from "connecting",

which is when the computer/tablet/phone is actively sending or receiving data and information. **5.3 5.3 Feature *Extraction***

Transforming the input data into the set of features is called feature extraction. The following are the feature extraction techniques used in extracting the composite features of EEG signals. This technique uses wavelet decomposition to separate the input EEG signal into five sub bands namely Alpha, Beta, Gamma, Theta and Delta with the wavelet coefficients like Mean, Standard Deviation and Variance.

5.3.1 Wavelet Transform

Wavelet Transform (WT) is an effective method of time frequency representation of a signal. The attractive feature of WT is that it provides accurate frequency information at low frequencies and accurate time information at high frequencies. This property is important in bio medical applications, because most signals in this field always contain high frequency components with short duration and low frequency components with long time duration.

5.3.2 Discrete Wavelet Transform

In the procedure of multi-resolution decomposition of a signal $x[n]$, each stage consists of two digital filters and two down samplers by 2. The first filter, g [.] is the discrete mother wavelet, high pass in nature, and the second, h[.] is its mirror version, low pass in nature.

$$W(j,k) = \sum_{j} \sum_{k} x(k) 2^{-j/2} \psi(2^{-j} n - k)$$

5.4 Classification

EEG Signal classification is the categorization of Signal for its most effective and efficient use. Here we classify the feature extracted EEG signal using the Multiclass Support Vector Machines classifier extended from the binary classifier named Support Vector Machines [SVM]. This classifier has been described in the literature review of our project.

Proposed Classifier

In this project we had proposed a new classifier named Hierarchical Support Vector Machines [HSVM] extended from the binary classifier Support Vector Machine [SVM] for EEG signal classification.

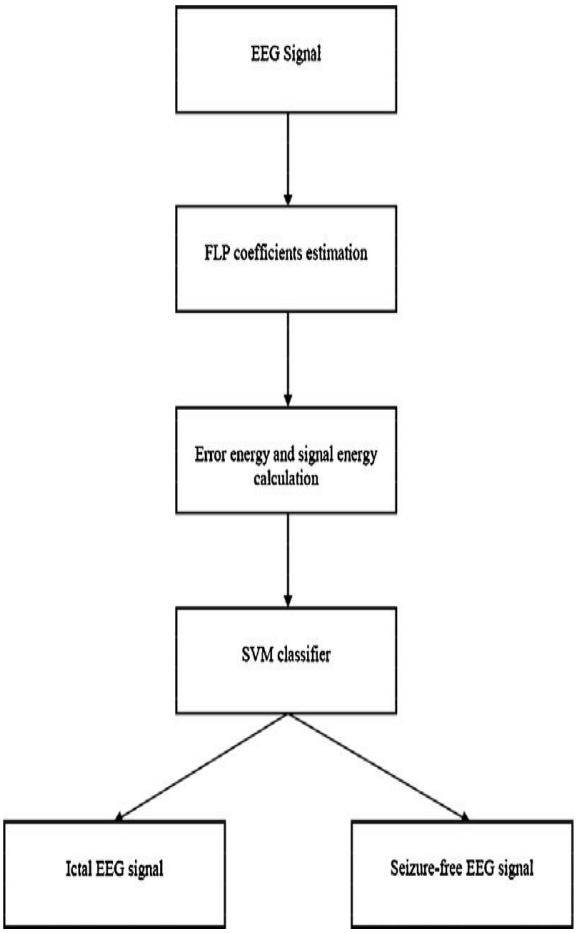


Figure 7. Proposed System

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