Eye Wink Detection using EEG Signals

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Abstract : People who are suffering from a Neuro motor disability are in a condition where they are awake and well aware of their surroundings but are unable to perform any action due to paralysis in the body (with the exception of eye movements and blinking). The people who are suffering from such disorder are not able to speak or not understandable enough so they could not communicate and interact with other people in the word. To help these people to interact better with their surroundings, a machine-learning based methodology for eye wink detection using signals from brain is proposed in this project. A dataset from 50 people was collected using Neurosky Mindwave mobile which provides us various waveforms of EEG signal like Alpha, Beta, Theta and Gamma signals. A model was trained using these features along with Blink Strength to detect the left and right blinks of a person. At the end, replace the mouse click functionality with the left and right eye blinks that will help such people to interact with real world.

***IndexTerms* -** *EEG; Neurosky mind wave mobile 2; pyautogui; Eye wink.*

I. INTRODUCTION

The eyes are directly connected to the brain. For some people, who are suffering from a brain-stem stroke, neuro motor disability or cerebral palsy, the eyes are the option for communication with the world. This requires continuous monitoring and understanding of eye blinks for proper communication with them[1]. It is difficult for a person to understand the meaning of eye blinks. Communication is done solely using the movement of eyes or eyelids. The mouse click functionality can be replaced with the eyes blink or eyelids movement by detection eye blinks of a person using EEG Signals[2].

The electroencephalogram (EEG) signal is a recording of the electrical activity of the brain and is a quite small activity and is measured in microvolts. Brain cells of humans communicate via electrical impulses and all are active at a time even when a person is asleep. This activity is recorded as EEG Waveforms.

The main frequency of EEG human waves are :

1. Delta:It has a frequency of 3 Hz or below. It is highest in amplitude and slowest of all other waveforms. They are generated in deepest meditation and dreamless sleep. It is normal as the dominant rhythm in infants up to one year and in stages 3 and 4 of sleep.
2. Theta:It has a frequency of 3.5 to 7.5 Hz and is classified as quot; slow quot; activity. It is perfectly normal in children up to 13 years and in sleep but abnormal in awake adults.
3. Alpha: It has a frequency of 14Hz. It is seen on both sides of the brain in a symmetrical distribution. It is mostly observed in patients who are alert or anxious and have their eyes open. Beta brainwaves are most prominent during our normal waking state of consciousness and when attention is directed towards some specific tasks of outside world.
4. Beta: It has a frequency of 14Hz. It is seen on both sides of brain in symmetrical distribution. It is mostly observed in patients who are alert or anxious and have their eyes open. Beta brainwaves are most prominent during our normal waking state of consciousness and when attention is directed towards some specific tasks of outside world.
5. Gamma:Gamma waves are fastest of all other brain waves relate to simultaneous processing of information from different brain areas. Gamma brainwaves pass information rapidly and quietly[3].

II. MOTIVATION

People who are suffering from a Neuromotor disability are in a condition where they are awake and well aware of their surroundings but are unable to perform any action due to paralysis in the body (with the exception of eye movements and blinking). The people who are suffering from such disorder are not able to speak or not understandable enough so they could not communicate and interact with other people in the word[1].These people also have a severe movement disorder. Imagine these patients having a fully functional brain trapped within a non-functioning body. This project is dedicated to such person to help them to communicate and perform some action and interact with other people in real world.

III. LITERATURE SURVEY

The first eye tracking was done in 1947 for American Air Force to find out best position for the best control in an aircraft cockpit. The new technique of using a web cam for the problem has been applied and the first tests showed promise for some people who have not had success with control and communication through their high tech solutions[6]. A wide range of methods has been proposed to fore-cast epileptic seizures by classifying seizure and non-seizure EEG signal which employed univariate techniques, eigen spectra of space delay correlation and covariance matrices,Hilbert-Huang transform, and autoregressive modeling and least-squares parameter estimator. An entropy measure was used for the feature extraction and developed an Adaptive Neuro-Fuzzy inference system for the classification of EEG signals into normal and ictal. The aim of their work is to compare the different entropy estimators when applied to EEG data from normal and epileptic subjects. Subsequently, a hybrid system was employed based on decision tree classifier and Fast Fourier Transform (FFT) to improve the accuracy[5]. came up with a cross-correlation and support vector machine. They demonstrated the idea of using cross-correlation for feature extraction in EEG signal recognition. The feature extraction was modified with the use of Wavelet Transform along with Shannon Entropy. It was demonstrated that implicitly selecting features with a genetic programming (GP) algorithm more effectively determined the proper features to discer biomarker and non-biomarker interracial iEEG and fMRI activity than conventional feature selection approaches[9].

3.1Neurosky mindwave

MindWave Mobile 2 is an EEG headset which is the culmination of EEG biosensor technology research of many years and is very easy to control. It is available at affordable price and detects different waveforms of EEG signals such as Alpha, Beta, Theta, Gamma, and Delta. It also measures blink strength of a person along with meditation and attention. It is being used to play various games and is helpful in various research projects to detect and analyze EEG signals[4]. MindWave Mobile 2 was released in 2010 in China and 2011 in the US. This device can be used for both entertainment and educational purpose. It works easily on different platforms such as Android and windows. It is single channel headset and has flexible rubber sensor arms and a rounded forehead sensor tip. It has a T-shaped headband, and wider ear clip to make it comfortable for its users[7].

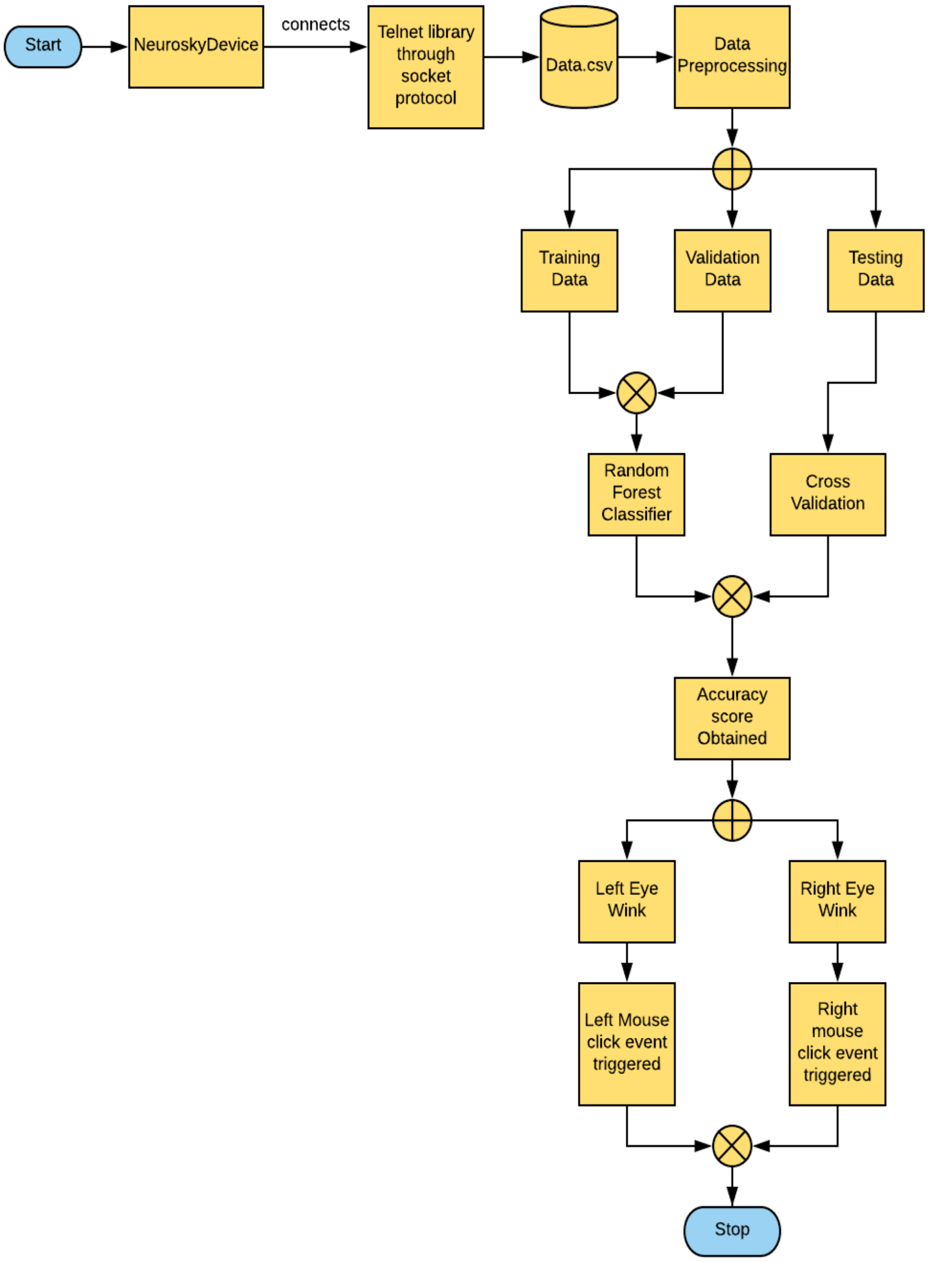
IV. PROPOSED SYSTEM

In this project, we address the problem of eye-blink detection and analysis of left and right human eye winks using EEG signals with help of Neurosky Mindwave Mobile[10]. The purpose of this project is to monitor and understanding of eye blinks for proper communication with a person who is suffering from a brain-stem stroke, Neuromotor disability or cerebral palsy.

The EEG Waveforms are:

Brain Rhythm	Frequency(Hz)	Where it can be found
Delta(δ)	0-4	Deep sleep state
Theta(θ)	4-8	Relaxed state and during light sleep and meditation
Alpha(á)	8-13	Associated with awake state
Mu(μ)	10-12	Open of eye
Beta(β)	14-22	Related to excitement state
Gamma(γ)	22-30	Related to subjective awareness/abnormal state

Flow chart of eye wink detection system :



To build eye wink detector we decided to build a model using Random forest according to our requirement[11]. Steps given below were followed in order to make our project,

1. **Installation of Telnet, Json, Pyautogui and other libraries**

Different libraries were installed for the project such as Telnet and Json were installed and were used for connecting with ThinkGear socket connector and to store the collecting data in CSV format. Pyautogui and some other libraries were installed to perform mouse clicks and for GUI purpose.

2. **Collecting data**

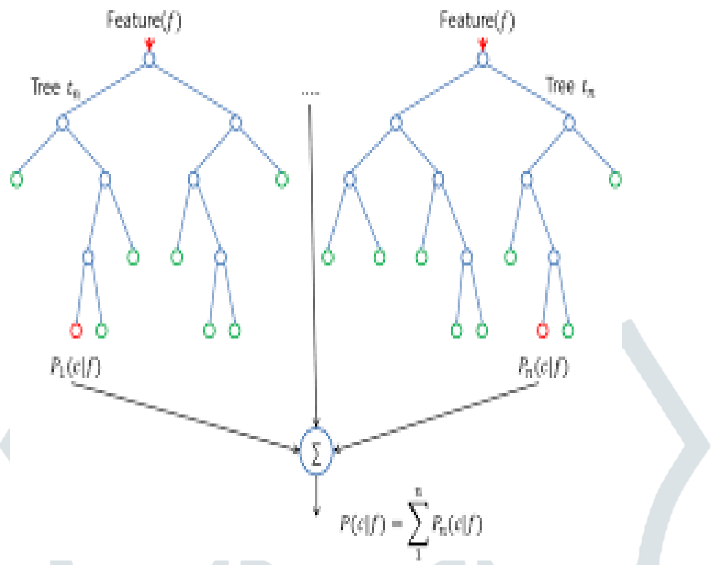
For our project data was collected from 50 different persons with help of Neurosky Mindwave Mobile device and was stored in a file. Different waveforms were recorded from the device like Alpha, Beta, Theta, Delta, Gamma along with the blink strength, meditation and attention. The data after pre-processing was given to the random forest classifier to predict the left and right blinks of a person.

3. **Selecting the Desired Algorithm**

There are many classifiers for classification algorithms likeSVM, KNN, Decision trees, Random forest. We tried our classification problem on various classifiers a narrowed down to random forest classifier because it provides better accuracy than any other model and it is very easy to measure the relative importance of each feature on the prediction.

- **Random Forest Classifier :**

Random forest classifies makes a forest of decision trees and then considers the output from various trees to predict the class of a data input. This algorithm is very flexible and is easy to use[10]. A forest is more robust if it contains a number of trees and then this algorithm predicts decision from every tree and uses the voting method to predict the class of a data input.

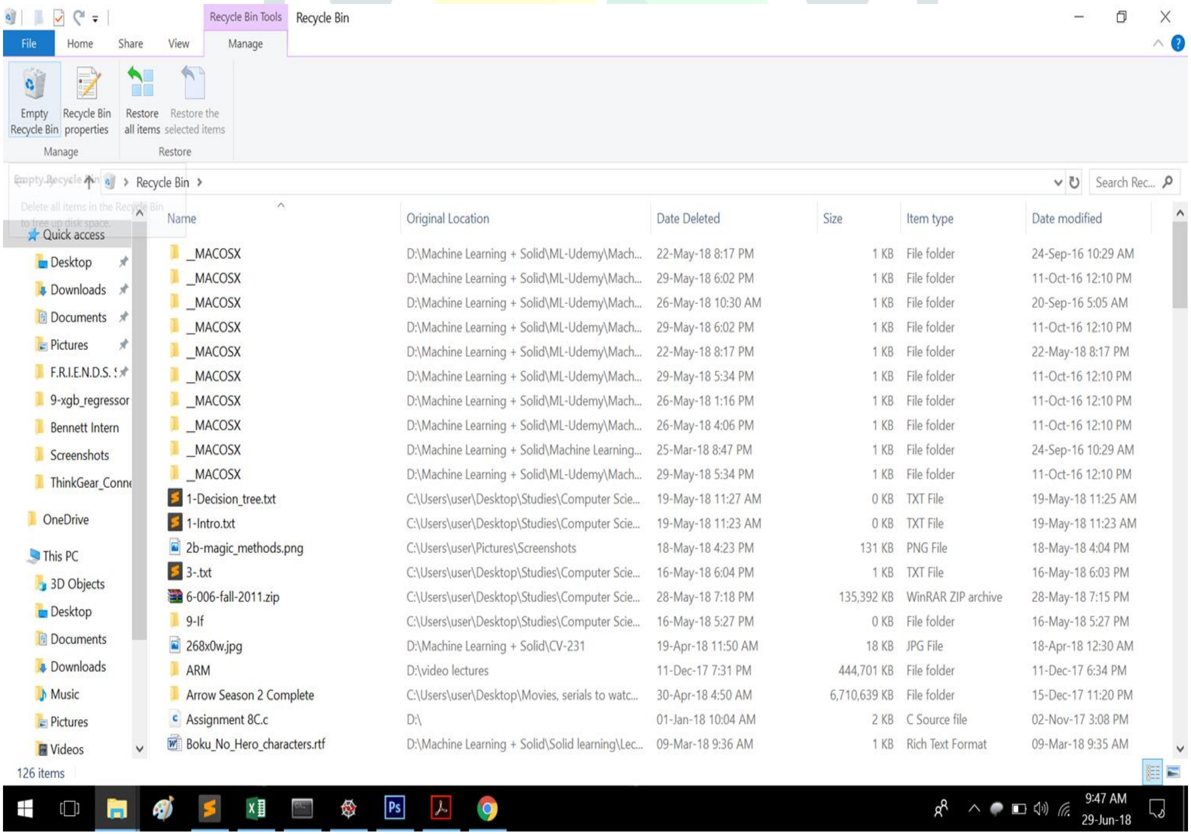


4. Running the model

Finally, the model was trained and it predicts the left and right eye blinks and accordingly left and right mouse clicks were performed.

V. RESULTS

When left eye wink is detected:



When right eye wink is detected:

VI. CONCLUSION

The purpose of this project was to figure out a way such that it could achieve the goal of detecting eye wink and classify it into a right eye or left eye using EEG signals. After the classification problem solved successfully there is an event triggered respective to the eye wink. The device used for this purpose was neurosky mindwave mobile 2, a single channel device. The device gave the feature in the form of EEG waves like delta, theta, gamma, blink strength, attention value etc. which was recorded by the python script converting the data to a data.csv format. The stored data was further pre-processed and trained against various classifiers to obtain a great accuracy score. Furthermore, a real time environment was created to test the wink results by specifying an action to each wink i.e. a left mouse click for left eye wink and vice-versa. The project thus paves the way for further improvements and added functionalities to the projects helping out people on a larger scale. Limitations of this project are more data needed to be collected and this only support python2.7 environment. In the future we can improve the connectivity standard by socket programming and analyzing other features of the EEG and make it supportable on higher versions of python.

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