DAYANANDA SAGAR UNIVERSITY

KUDLU GATE, BANGALORE – 560068

Bachelor of Technology
in
COMPUTER SCIENCE AND ENGINEERING

Major Project Phase-II Report

("MACHINE LEARNING BASED DEPRESSION DETECTION USING ELECTROENCEPHALOGRAPHY)

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BANGALORE

(2021-2022)

ABSTRACT

Depression is a disorder that is plaguing today's generation and obstructs people from leading a normal and happy life. It comes with substantial side effects which severely affectthe day to day functioning of humans and has been continuously rising in recent years. Medical professionals employ various methods to detect depression, but the effectiveness of the detection and treatment is a meticulous task that involves continuous monitoring of a patient's behavior and symptoms. With the use of EEG signals to identify depression the accuracy of the level of depression has been vastly improved. But it is still a hassle for doctors to go through hundreds of patients' EEG reports and correctly identify depression. This is where the use of ML based depression analysis comes to the rescue.

The aim of our project is to use a Machine Learning based approach to identify depressionamong people. We will first work with a static dataset and several ML algorithms and build optimized models for depression detection. We will further connect this model to a web app or mobile app and use any music app's API to play appropriate music which may be suitable for the patient's mood. Our final goal is to make the entire implementation real time with the help of EEG headset and determine the patient's mood and play suitable music to pacify his depression. If the patient follows this treatment on a regular basis, we believe it can impact his/her mental health in a positive manner.

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CERTIFICATE

This is to certify that the Phase-II project work titled **"MACHINE LEARNING BASED DEPRESSION DETECTION USING ELECTROENCEPHALOGRAPHY"** is carried out by **Ashmit Dash (ENG18CS0049), Dheeraj NG (ENG18CS0091), Sneha BS (ENG18CS0278), Srinishaa P (ENG18CS0283)** bonafide students of Bachelor of Technology in Computer Science and Engineering at the School of Engineering, Dayananda Sagar University, Bangalore in partial fulfillment for the award of degree in Bachelor of Technology in Computer Science and Engineering, during the year **2021-2022**.

Dr Rajesh TM	**Dr Girisha G S**	**Dr. A Srinivas**
Assistant/Associate/ Professor Dept. of CS&E, School of Engineering Dayananda Sagar University	Chairman CSE School of Engineering Dayananda Sagar University	Dean School of Engineering Dayananda Sagar University
Date:	Date:	Date:

Name of the Examiner	**Signature of Examiner**
1.	
2.	

DECLARATION

We, **Ashmit Dash (ENG18CS0049), Dheeraj NG (ENG18CS0091), Sneha BS (ENG18CS0278), Srinishaa (ENG18CS0283)** are student's of eighth semester B.Tech in **Computer Science and Engineering**, at School of Engineering, **Dayananda Sagar University**, hereby declare that the phase-I project titled **"MACHINE LEARNING BASED DEPRESSION DETECTION USING ELECTROENCEPHALOGRAPHY"**
has been carried out by us and submitted in partial fulfilment for the award of degree in **Bachelor of Technology in Computer Science and Engineering** during the academic year **2021--2022**.

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First, we take this opportunity to express our sincere gratitude to School of Engineering & Technology, Dayananda Sagar University for providing us with a great opportunity to pursue our Bachelor's degree in this institution.

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We would like to thank our guide **Dr Rajesh TM, Associate Professor**, **Dept. of Computer Science and Engineering**, **Dayananda Sagar University**, for sparing his/her valuable time to extend help in every step of our project work, which paved the way for smooth progress and the fruitful culmination of the project.

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We are also grateful to our family and friends who provided us with every requirement throughout the course. We would like to thank one and all who directly or indirectly helped us in the Project work.

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INTRODUCTION

CHAPTER 1 INTRODUCTION

Depression is categorized as a mood disorder. It can be distinguished as feelings of anger, sadness, and loss that interfere with an individual's everyday activities. People experience depression in many ways. It can interfere with our daily work, resulting in lost time and lower productivity. It can cause some chronic health issues and affect relationships. Currently, depression is the world's serious health concern and economic burden worldwide. However, due to the restrictions of current methods for depression diagnosis, a pervasive and objective approach is significant.

The human brain contains millions of neurons that play a serious role in controlling the behavior of the human body involving internal/external motor/sensory stimuli. These neurons will act as information carriers between the human body and the brain. Understanding the cognitive behavior of the brain can be done by analyzing either signals or images from the brain. Human nature can be anticipated with reference to the motor and sensory states such aseye movement, lip movement, remembrance, attention, hand clenching, etc. These states are associated with a particular signal frequency which helps to grasp the functional behavior of complex brain structure. Electroencephalography (EEG) is an effective modality that helps togather brain signals which correspond to various states from the scalp surface area. The brain signals are generally classified as delta, theta, alpha, beta, and gamma based on signal frequencies ranging from 0.1 Hz to more than 100 Hz.

Machine learning techniques can automate clinical EEG analysis. AI and machine learning tools are the perfect accomplices to automate, extend, and improve EEG data analysis. ML techniques can be classified into two types of approaches i.e. feature-based and end-to-end approaches. Certainly, BCI systems like spellers or brain-controlled devices are dependent on decoding pipelines that use different types of machine learning algorithms

1.1 PURPOSE

Depression is one of the major concerns hindering the world at present generation. According to the World Health Organization statistics more than 300 million individuals suffer from depression worldwide and approximately 800,000 people die due to it every year, Depression is hard to diagnose since it depends on how comfortable the patient feels to share feelings with society or doctors due to the social stigma prevailing in human race, hence the majority of patients do not receive optimal treatment.

Machine learning techniques can automate clinical EEG analysis. AI and machine learning tools are the perfect accomplices to automate, extend, and improve EEG data analysis. ML techniques can be classified into two types of approaches i.e., feature-based and end-to-end approaches. Feature learning is a set of techniques that allows a system to automatically discover the representations needed for feature detection or classification from raw data. Feature learning can be either supervised or unsupervised.

The aim of our project is to use a Machine Learning based approach to identify depression among people using EEG and use external APIs to conduct music therapy to patients.

Music therapy is a therapeutic approach that uses the naturally mood lifting properties of music to help people improve their mental health and overall well-being

Music therapy can increase positive feelings, like:

- Calmness
- Euphoria
- Confidence and empowerment
- Emotional intimacy

The uses and benefits of music therapy have been researched for decades. Key findings from clinical studies have shown that music therapy may be helpful for people with depression and anxiety, sleep disorders, and even cancer.

1.2 INTENDED AUDIENCE

Patients suffering from depression, anxiety, tension, fatigue or any other mental ailment. Our approach can be a great help to doctors also since music therapy is available patients who are not in extreme depression can come out of it without any medicines.
People can also be able to treat themselves if they are able to purchase the EEG headset.

1.3 SCOPE OF THE PROJECT

Currently, many studies are utilizing artificial intelligence for the prediction, classification and clustering of real-life problems. Depression is one major problem that has to be solved, So machine learning techniques can be employed to do that as many have social stigma to express their feeling to a doctor.

It can be a great tool to doctors to treat depressed patients and help individuals also to come out of depression.

Can be used for educational as well as commercial purposes.

CHAPTER 2

PROBLEM DEFINITION

CHAPTER 2 PROBLEM DEFINITION

To identify depression using ML based approach using EEG and use external APIs to conduct music therapy to patients.

Our goal is to take input via a web app and suggest appropriate playlist from any music API and determine the patient's mood and play suitable music to pacify his/her depression.

CHAPTER 3
LITERATURE SURVEY

CHAPTER 3 LITERATURE SURVEY

Paper Title	Source	Technology	Results	Inference
A Pervasive Approach to EEG-Based Depression Detection	CAS Center for Excellence in Brain Science and Intelligence Technology, Shanghai Institutes for Biological Sciences, Chinese Academy of Sciences, Shanghai, China	• The MRMR technique • Four classification algorithms, KNN, SVM, CT, and ANN	The results exhibited KNN as the best performance classification method in all datasets,	The results showed that K-Nearest Neighbor (KNN) had the highest accuracy of 79.27%. The result also suggested that the absolute power of the theta wave might be a valid characteristic for discriminating depression.
Decoding attentional orientation from EEGspectra	13th International Conference, HCI International 2009, San Diego, CA, USA, July 19-24, 2009,	EEG and a naïve Bayes classification scheme.	The results of this paper are preliminary and indicate the potential for obtaining an attentional orientation BCI.	EEG signals clearly contain information about attentional orientation that can be used to decode attentional orientation for BCI applications
Analysis of Electroencephalography		EEG Atlas analysis	Accuracy: 93.05%	Types of EEG Signalsand their respective frequencies

Mental Emotional Sentiment Classification with an EEG-based Brain-machine interface	Research Gate April-2019	Ensemble of Random Forest and Decision Tree Muse Headband	Lövheim's three-dimensional emotional model	EEG headband can be effective for classifying a participant's emotional state. There is considerable potential for producing classification algorithms that have practical value for real-world decision support systems
Feature extraction and classification for EEG signals using wavelet transform and machine learning techniques	Australasian College of Physical Scientists and Engineers in Medicine 2015	Discrete wavelet energy along with machine learning algorithms for the classificatio n and the quantitative analysis of spontaneous EEG signals	Accuracy of different ML Algorithms Like SVM , MLP, KNN Naïve bayes	Differences in accuracy of different algorithms

CHAPTER 4

PROJECT DESCRIPTION

CHAPTER 4 PROJECT DESCRIPTION

4.1 DESIGN

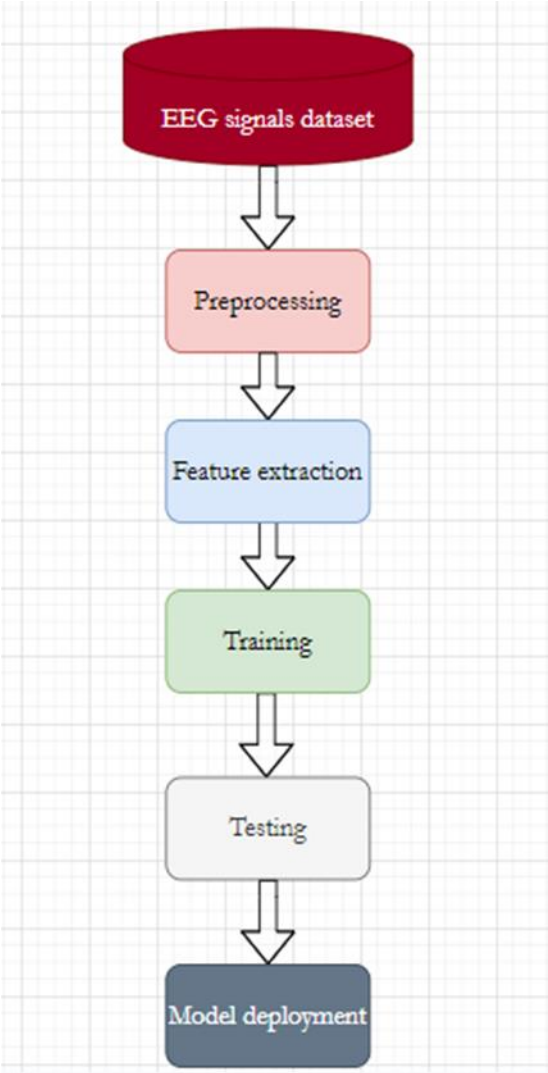

Figure 1 : Design Flow

4.2 MODULES

4.2.1 DATASET ACQUSITION

- We collected the real time data from MODMA, wherein, it's a multi model open dataset for mental disorder analysis.
- For now, the dataset includes data mainly from clinically depressed patients and matching normal controls.
- The patients were carefully diagnosed and selected by professional psychiatrists in hospitals. At this stage, only electroencephalogram (EEG) and speech recording data are made publicly available. The EEG signals were recorded as both in resting state and under stimulation. The EEG dataset includes not only data collected usingtraditional 128-electrodes mounted elastic cap, but also a novel wearable 3-electrode EEG collector for pervasive applications. The speech data were recorded as during interviewing, reading and picture description. Detail descriptions of each sub-datasetwere listed.

4.2.2 DATA PRE-PROCESSING

- For the static data, we did simple preprocessing which includes removal of NULL, NaN values as these values will hinder the models performance so it has to be removed.
- We also performed label mapping, where the label names were mapped with values and replaced.
- The label names were positive, negative and neutral which were replaced with 0, 1and 2.
- The dataset which was obtained from the MODMA website were in the form of EEG signals, from which the values were extracted and stored in a csv file

4.2.3 MODELS

- **RNN**: A **recurrent neural network** (**RNN**) is a class of artificial neuralnetworks where connections between nodes form a directed or undirected graph along a temporal sequence.
- **SVM**: Support Vector Machines is considered to be a classification approach, it butcan be employed in both types of classification and regression problems. It can easily handle multiple continuous and categorical variables. SVM constructs a hyperplane in multidimensional space to separate different classes. SVM generatesoptimal hyperplane in an iterative manner, which is used to minimize an error. Thecore idea of SVM is to find a maximum marginal hyperplane (MMH) that best divides the dataset into classes.
- **Random Forest**: It is an ensemble method (based on the divide-and-conquer approach) of decision trees generated on a randomly split dataset. This collection of decision tree classifiers is also known as the forest. The individual decision trees are generated using an attribute selection indicator such as information gain, gain ratio, and Gini index for each attribute. Each tree depends on an independent random sample.

We have implemented the Random Forest algorithm in final implementation since the accuracy is high (89.74%) and simple to understand.

CHAPTER 5

IMPLEMENTATION

CHAPTER 5 IMPLEMENTATION

5.1 FEATURE EXTRACTION

The live EEG signal obtained from MODMA dataset is converted to CSV file using so machine learning algorithms.

In Feature extraction we have extracted parameters such as

- Hjorth Parameter
- Kurtosis
- Coefficient of Variation
- Skewness
- Wavelet transform features
- Variance
- FFT features
- Shannon Entropy
- Power-Spectral Density

Hjorth Parameter

Hjorth parameters are indicators of statistical properties used in signal processing in the time domain introduced by Bo Hjorth in 1970.[1] The parameters are Activity, Mobility, and Complexity. They are commonly used in the analysis of electroencephalography signals for feature extraction. The parameters are normalised slope descriptors (NSDs) used in EEG

Hjorth Activity

The activity parameter represents the signal power, the variance of a time function. This can indicate the surface of power spectrum in the frequency domain. This is represented by the following equation:

Activity = var(y(t)), Where y(t) represents the signal.

Hjorth Mobility

The mobility parameter represents the mean frequency or the proportion of standard deviation of the power spectrum. This is defined as the square root of variance of the first derivative of the signal y(t) divided by variance of the signal y(t).

$$\text{Mobility} = \sqrt{\frac{\text{var}(\frac{dy(t)}{dt})}{\text{var}(y(t))}}.$$

Hjorth Complexity

The Complexity parameter represents the change in frequency. The parameter compares the signal's similarity to a pure sine wave, where the value converges to 1 if the signal is more similar.

$$\text{Complexity} = \frac{\text{Mobility}(\frac{dy(t)}{dt})}{\text{Mobility}(y(t))}.$$

Skewness

Skewness refers to a distortion or asymmetry that deviates from the symmetrical bell curve, or normal distribution, in a set of data. If the curve is shifted to the left or to the right, it is said to be skewed. Skewness can be quantified as a representation of the extent to which a given distribution varies from a normal distribution. A normal distribution has a skew of zero.

Kurtosis

Like skewness, kurtosis is a statistical measure that is used to describe distribution. Whereas skewness differentiates extreme values in one versus the other tail, kurtosis measures extreme values in either tail. Distributions with large kurtosis exhibit tail data exceeding the tails of the

normal distribution. Distributions with low kurtosis exhibit tail data that are generally less extreme than the tails of the normal distribution.

Coefficient of Variation

The coefficient of variation (CV) is a statistical measure of the dispersion of data points in a data series around the mean. The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from one another.

Wavelet Transform Features

A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. Usually, one can assign a frequency range to each scale component. Each scale component can then be studied with a resolution that matches its scale

FFT Features

FFTs are used to sharpen edges and create effects in static images and are widely used to turn a number series into sine waves and graphs. The FFT quickly performs a discrete Fourier transform (DFT), which is the practical application of Fourier transforms.

Shannon Entropy

The Shannon entropy equation provides a way to estimate the average minimum number of bits needed to encode a string of symbols, based on the frequency of the symbols.

Shannon's entropy equation:

$$H(X) = -\sum_{i=0}^{N-1} p_i \log_2 p_i$$

Power Spectral Density

The power spectrum of a time series describes the distribution of power into frequency components composing that signal. According to Fourier analysis, any physical signal can be decomposed into a number of discrete frequencies, or a spectrum of frequencies over a continuous range. The statistical average of a certain signal or sort of signal (including noise) as analysed in terms of its frequency content, is called its spectrum.

After applying algorithms and extracting the above-mentioned features, A csv file containing this information is passed to the random forest algorithm which later on classifies whether a person is depressed or not

5.2 BACK – END

Random Forest is an ensemble method (based on the divide-and-conquer approach) of decision trees generated on a randomly split dataset. This collection of decision tree classifiers is also known as the forest. The individual decision trees are generated using an attribute selection indicator such as information gain, gain ratio, and Gini index for each attribute. Each tree depends on an independent random sample.

The accuracy obtained by implementing Random Forest is 89.74%

5.2.1 PICKLE MODULE

Python pickle module is used for serializing and de-serializing a Python object structure. Any object in Python can be pickled so that it can be saved on disk. What pickle does is that it “serializes” the object first before writing it to file. Pickling is a way to convert a python object (list, dict, etc.) into a character stream. The idea is that this character stream contains all the information necessary to reconstruct the object in another python script.

5.2.2 NUMPY

NumPy is a Python package. It stands for 'Numerical Python'. It is a library consisting of

multidimensional array objects and a collection of routines for processing of array.

5.2.2 PANDAS

Pandas is an open-source library that is made mainly for working with relational or labeled data both easily and intuitively. It provides various data structures and operations for manipulating numerical data and time series. This library is built on top of the NumPy library. Pandas is fast and it has high performance & productivity for users.

5.3 FRONT-END

The index page consists an option to upload the EEG file and it shows the result and provides music therapy

5.3.1 FLASK

Web Application Framework or simply Web Framework represents a collection of libraries and modules that enables a web application developer to write applications without having to bother about low-level details such as protocols, thread management etc.

Flask is a web application framework written in Python. It is developed by **Armin Ronacher**, who leads an international group of Python enthusiasts named Pocco. Flask is based on the Werkzeug WSGI toolkit and Jinja2 template engine. Both are Pocco projects.

CHAPTER 6

SOURCE CODE

CHAPTER 6 SOURCE CODE

6.1 FRONT-END CODE

Index.html

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="UTF-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>EEG emotion detector</title>
    <link rel="stylesheet" href="static/styles.css">
    <link rel="icon" href="static/favicon.ico">
    <link rel="preconnect" href="https://fonts.googleapis.com">
    <link rel="preconnect" href="https://fonts.gstatic.com" crossorigin>
    <link href="https://fonts.googleapis.com/css2?family=Special+Elite&display=swap"
rel="stylesheet">
    <link rel="preconnect" href="https://fonts.googleapis.com">
    <link rel="preconnect" href="https://fonts.gstatic.com" crossorigin>
    <link href="https://fonts.googleapis.com/css2?family=Song+Myung&display=swap"
rel="stylesheet">
</head>

<body>
    <div class="home">
        <h1>EEG emotion detector</h1>
        <p>
            Currently, depression is the world’s serious health concern and economic burden
worldwide. However, due to
            the restrictions of current methods for depression diagnosis, a pervasive and objective
approach is
            significant.<br>
            The aim of our project is to use a Machine Learning based approach to identify
```

depression among people. We

will first work with a static dataset and several ML algorithms and build optimised models for depression

detection. We will further connect this model to a web app and use spotify music playlists to play

appropriate music which may be suitable for the patient's mood. Our final goal is to make the entire

implementation real time with the help of EEG headset and determine the patient's mood and play suitable

music to pacify his depression. If the patient follows this treatment on a regular basis, we believe it can

impact his/her mental health in a positive manner.

</p>

<form method="POST" , action="{{url_for('predict')}}" enctype="multipart/form-data">

<label for="files">Insert eeg file here:</label>

<input type="file" id="files" name="file">

<input type="submit" class="submit">

</form>

{%if data != None%}

<h2>Your mental state is determined to be {{data}} by our model. </h2>

{%if data == 'NEGATIVE'%}

<h3>Here's a playlist that will get you motivated and ready to rock the world in no time!</h3>

*
*

* *

<iframe style="border-radius:12px"

src="https://open.spotify.com/embed/playlist/37i9dQZF1DXdxcBWuJkbcy?utm_source=generator" width="80%"

height="380" frameBorder="0" allowfullscreen=""

allow="autoplay; clipboard-write; encrypted-media; fullscreen; picture-in-picture"></iframe>

* *

{%endif%}

{%if data == 'POSITIVE'%}

<h3>Here's a happy playlist for a happy person like you!</h3>

```
<br>
<div style="text-align: center;">
  <iframe style="border-radius:12px"

src="https://open.spotify.com/embed/playlist/0jrlHA5UmxRxJjoykf7qRY?utm_source=generator
" width="80%"
      height="380" frameBorder="0" allowfullscreen=""
      allow="autoplay; clipboard-write; encrypted-media; fullscreen; picture-in-
picture"></iframe>
</div>
{%endif%}
{%if data == 'NEUTRAL'%}
<h3>You are fine, but this playlist will make you feel great!</h3>
<br>
<div style="text-align: center;">
  <iframe style="border-radius:12px"

src="https://open.spotify.com/embed/playlist/42EL4koTAevxJ4R8IT8OHJ?utm_source=generat
or" width="80%"
      height="380" frameBorder="0" allowfullscreen=""
      allow="autoplay; clipboard-write; encrypted-media; fullscreen; picture-in-
picture"></iframe>
</div>
{%endif%}
{%endif%}
  </div>
</body>
</html>
```

6.2 BACK-END CODE

App.py

```
from flask import Flask, render_template, request
import pickle
import numpy as np
import pandas as pd
import models.eeg_rndforest

app = Flask(__name__)
model = pickle.load(open('eeg.pkl', 'rb'))

@app.route('/')
def index():
    return render_template('index.html', data = None)

@app.route('/predict', methods=['POST'])
def predict():
    if request.method == 'POST':
        # FileStorage object wrapper
        file = request.files["file"]
        if file:
            df = pd.read_csv(file)

    label_mapping = {'NEGATIVE': 0, 'NEUTRAL': 1, 'POSITIVE': 2}
```

```
    label_unmapping = {0 :'NEGATIVE', 1: 'NEUTRAL', 2 :'POSITIVE'}
    df['label'] = df['label'].replace(label_mapping)

    y = df['label'].copy()
    X = df.drop('label', axis=1).copy()
    predictions = model.predict(X)
    print(type(predictions))

    for p in predictions:
        print(label_unmapping.get(p))

    pred = label_unmapping.get(predictions[3])

    return render_template('index.html', data = pred)

if __name__ == "__main__":
    app.run(debug=True)
```

6.3 CODE REPOSITORY

HTTPS://GITHUB.COM/SRINISHAA/EEG-PROJECT

CHAPTER 7

RESULTS

CHAPTER 7 RESULTS

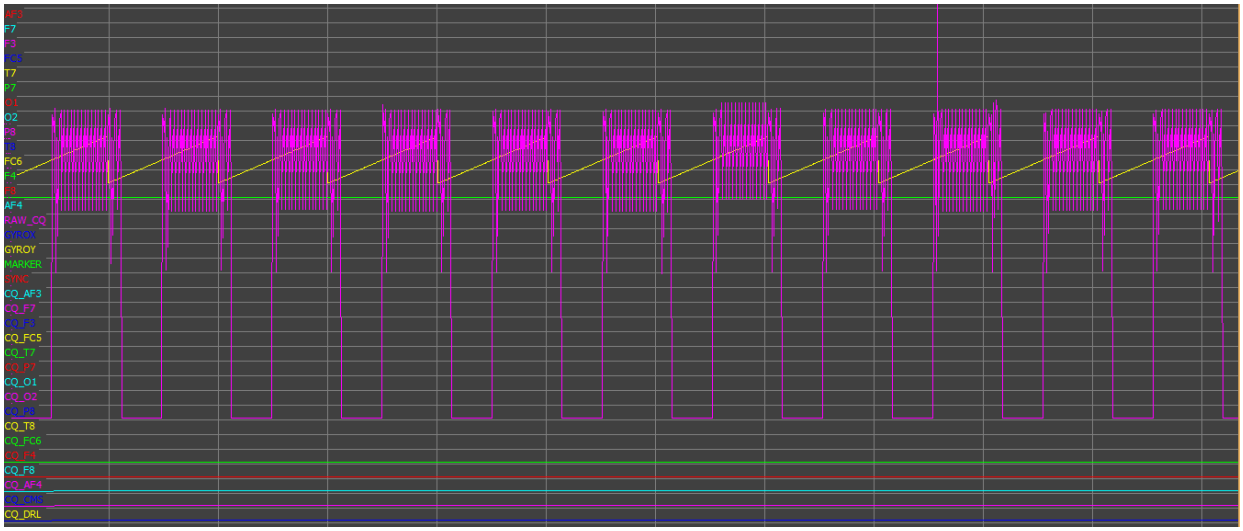

Figure 2: EEG Signal from Modma Data set

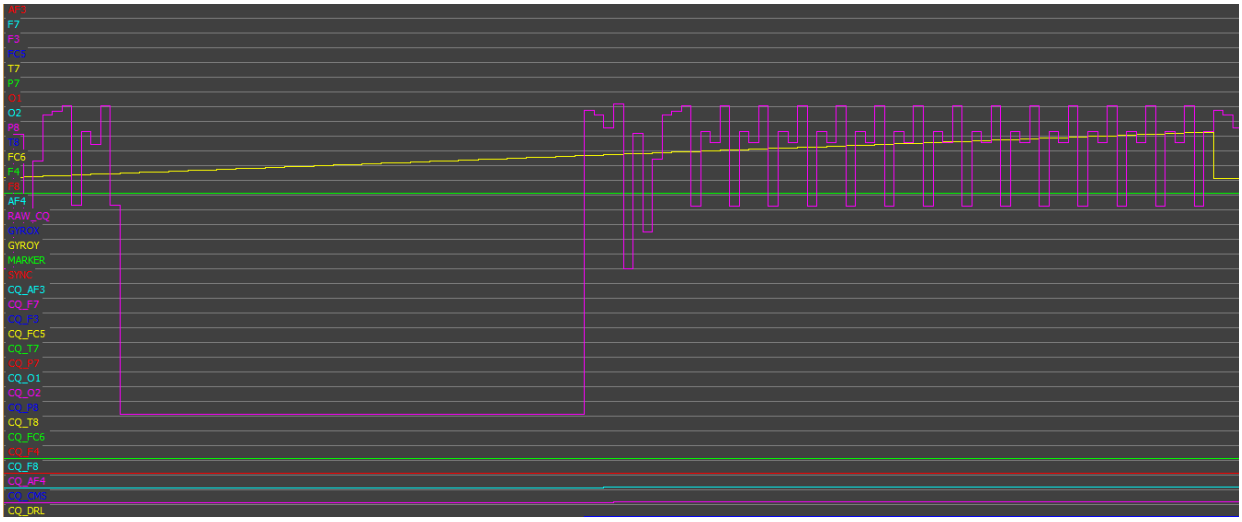

Figure 3: Zoomed in EEG data for better View

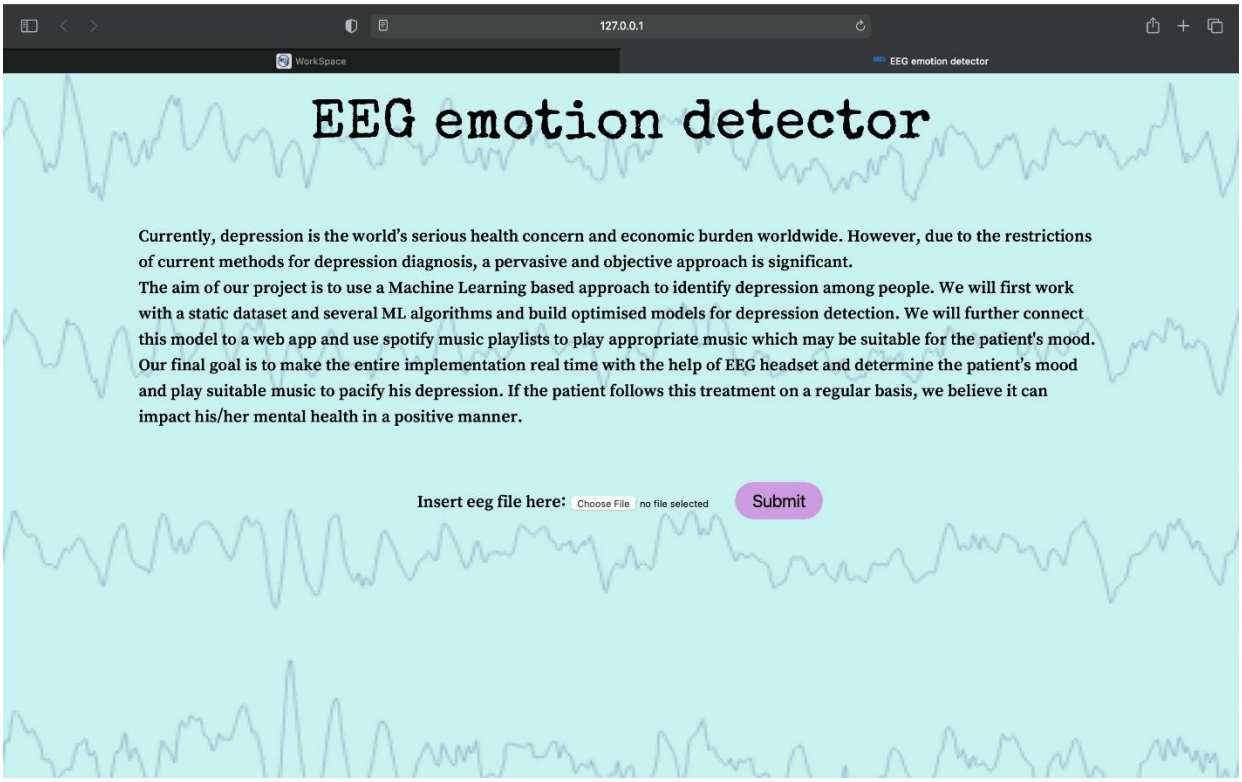

Figure 4: Front Page

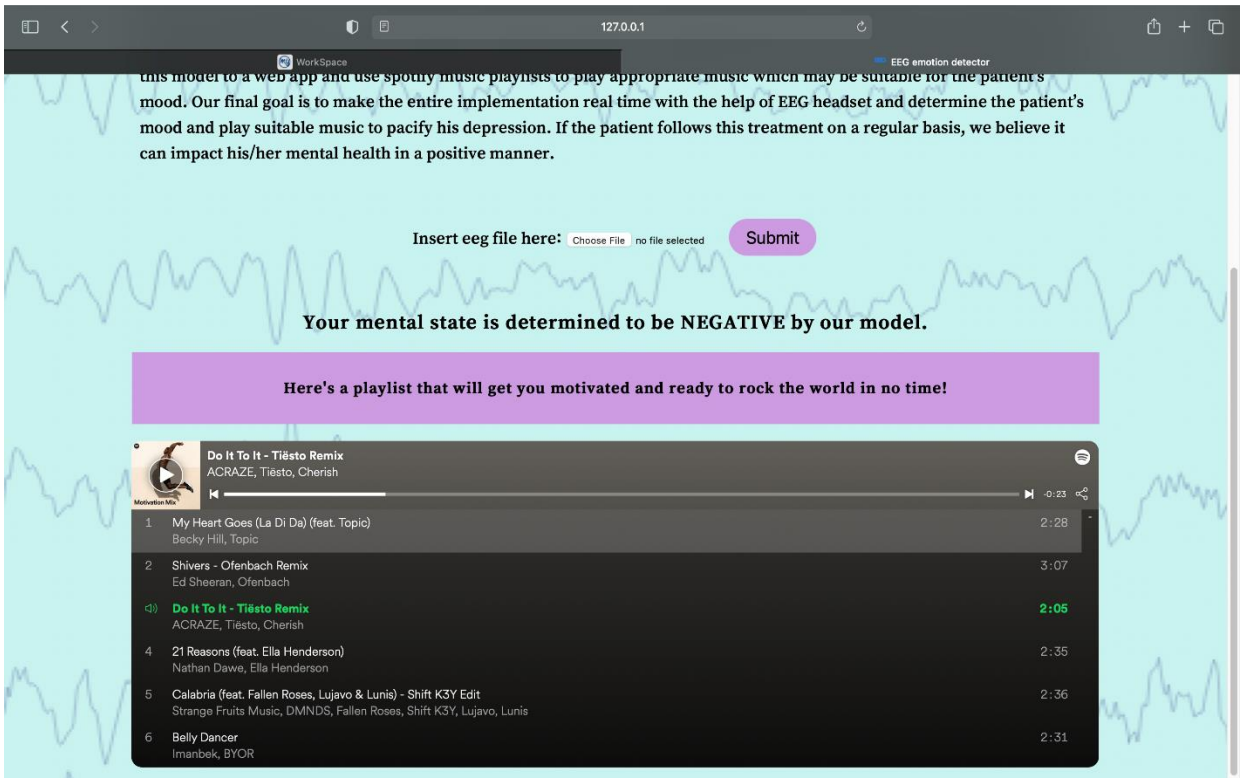

Figure 5: Final Output with Music Therapy

CHAPTER 8

SUMMARY

CHAPTER 8 SUMMARY

Depression has been plaquing in the society and causing lot of problems, people don't open up and speak about their depression so some measure has to be incorporated to solve this problem.

One such solution is machine learning approach where the patients don't have to worry about anyone judging them and can take the mental assessment of themselves.

In our project we have developed such a model where in it takes the EEG signal as an input and classifies whether a person is depressed or not, and it also provides a music therapy.

Here we have extracted the features from the EEG signal and tried using many classification algorithms such as LDA, SVM, RNN and Random Forest, from the accuracies obtained Random Forest had the highest accuracy so we have used it as a classifier.

Flask is a micro web framework in python we have made use of it to develop the front-end part.

REPORT LINK :-

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