BRAIN COMPUTER INTERFACE-ASSISTED BRAINWAVE MODULATION FOR INSOMNIA

SAMINATHAN M

OBJECTIVES

- To develop a system that collects brainwave signals from insomnia patients using non-invasive electrodes. Data will be gathered while patients engage with a specially designed application during wakeful states.
- To create an intuitive application that patients use during data collection. It will feature tasks and games that stimulate brain activity, making the system suitable for users with various skill levels.
- To build a model that compares the collected brainwave data to healthy sleep patterns. This will help detect deviations in brain activity associated with insomnia, providing valuable insights.
- To design a system that tracks patient recovery, offering real-time feedback and adjusting treatments based on brainwave pattern analysis. This will help monitor progress and suggest further interventions.

EXISTING SYSTEM

- Current systems for insomnia treatment, such as polysomnography (PSG) or cognitive-behavioral therapy for insomnia (CBT-I), have several limitations. Polysomnography is conducted in clinical settings, requiring patients to sleep in an unfamiliar environment, which can affect results.
- Additionally, these systems rely on expensive, real-time EEG monitoring equipment, making it impractical for widespread or home use.
- In contrast, this project seeks to eliminate the need for real-time EEG equipment by utilizing preprocessed brainwave data. This makes the system more accessible and feasible for use in everyday environments like the home.
- By lowering the cost and increasing ease of access, this system has the potential to be widely adopted, especially in underserved areas where traditional methods are inaccessible.

PROPOSED SYSTEM

The proposed system will consist of the following components:

- **Electrode-Based Brainwave Collection**: Brain signals will be collected via non-invasive electrodes during patient interactions with the system. This will eliminate the need for costly and complex real-time EEG systems.
- **Pattern Analysis and Comparison**: The stored brainwave data will be analyzed and compared with a database of normal brainwave patterns. Any deviations from the norm will be flagged, and the system will provide a detailed report on the patient's brain activity.
- **Recovery Monitoring**: Over time, as the patient continues to use the system, their progress will be tracked. The system will identify improvements in brainwave patterns that indicate recovery from insomnia, providing both the patient and healthcare providers with actionable insights.

SCOPE OF THE PROJECT

- This project aims to develop a non-invasive Brain-Computer Interface (BCI) system to support individuals with insomnia through real-time brainwave monitoring and modulation. Using preprocessed EEG data, the system detects brainwave patterns linked to wakefulness and sleep—specifically reducing beta activity and enhancing alpha and theta waves to promote sleep.
- The solution offers a cost-effective, accessible alternative to traditional BCI setups by eliminating the need for live EEG hardware. It integrates real-time feedback and gamified environments to boost user engagement and rehabilitation adherence.
- The system is adaptable to various needs, including motor recovery and cognitive rehabilitation, and focuses on sleep-related neurofeedback using auditory and visual cues.
- The scope includes EEG signal acquisition, processing, feedback, and UI development, excluding invasive methods and complex medical treatments. Initial testing will involve pilot studies to assess usability and effectiveness.

METHODOLOGY

- Signal Acquisition:

MODULE DESCRIPTION

Electrode-Based Brainwave Collection

- Special non-invasive electrodes are placed on the scalp to detect electrical signals from brain activity. These electrodes function similarly to microphones, capturing the brain's electrical activity during wakeful states and cognitive tasks.

Data Acquisition and Preprocessing

- The collected brainwave signals are cleaned to remove noise, such as muscle movement artifacts or external interference, ensuring the data's integrity. This process includes noise filtering and artifact removal techniques.

Amplifier and Analog-to-Digital Conversion (ADC)

- Since brainwave signals are weak, they are amplified and converted from analog to digital format. This ensures compatibility with computational systems for further processing and analysis.

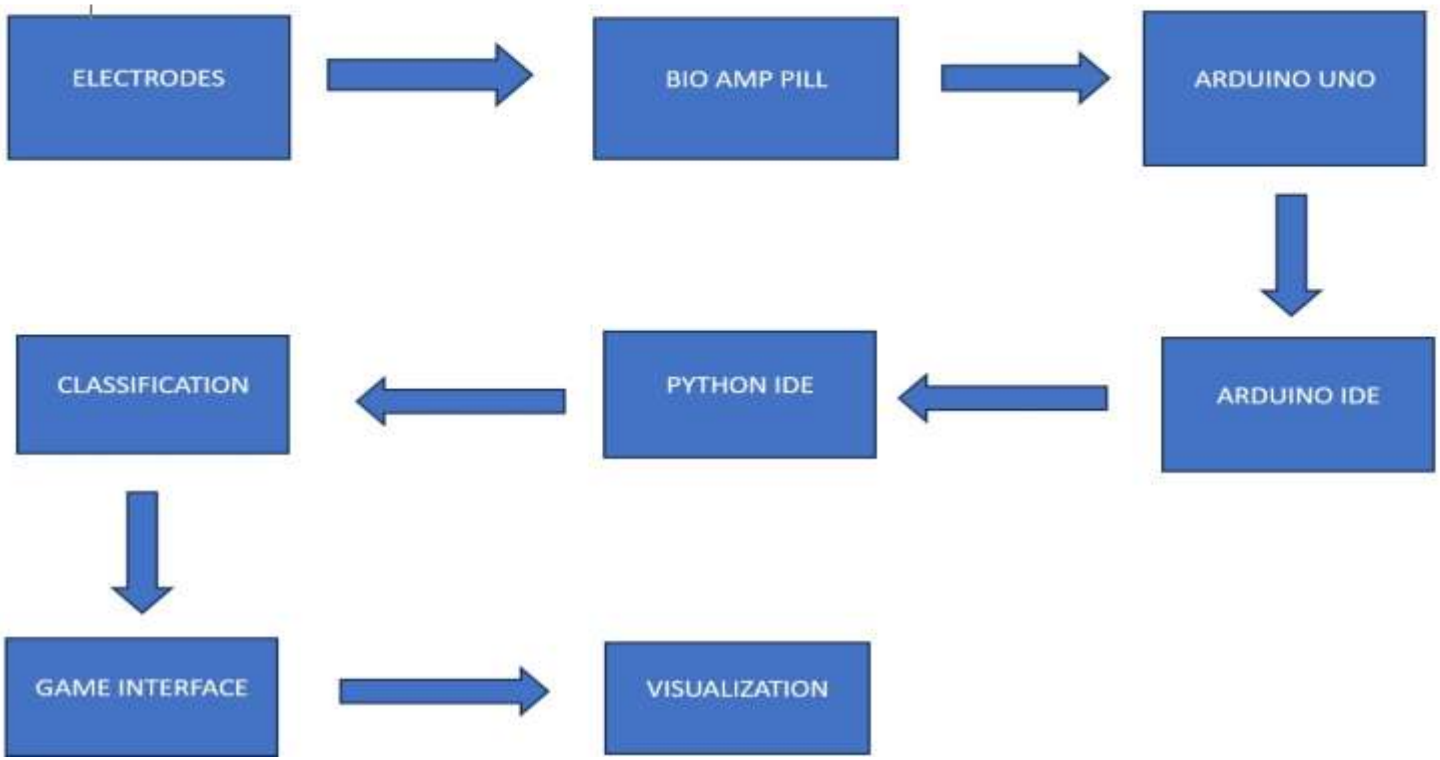
Interactive Application

- A user-friendly application engages patients with tasks and games during data collection. These activities are designed to stimulate brain activity, making the system accessible to users with varying levels of technical expertise.

Pattern Analysis and Feedback

- Collected brainwave data is compared to standard healthy sleep patterns. Deviations are identified and highlighted, providing real-time feedback and detailed reports for healthcare professionals and patients. This feature supports recovery monitoring and treatment adjustments.

MODULE INTERFACE DIAGRAM



Hardware/Software Details

Hardware Details:

ECG Band
BioAmp EXG Pill
Arduino Uno
Electrodes
USB Cable
Connecting Wires with Snap Connectors
Jumper Wires

Software Details:
Vs code
Arduino IDE
Python 3.12

INPUT INFORMATION

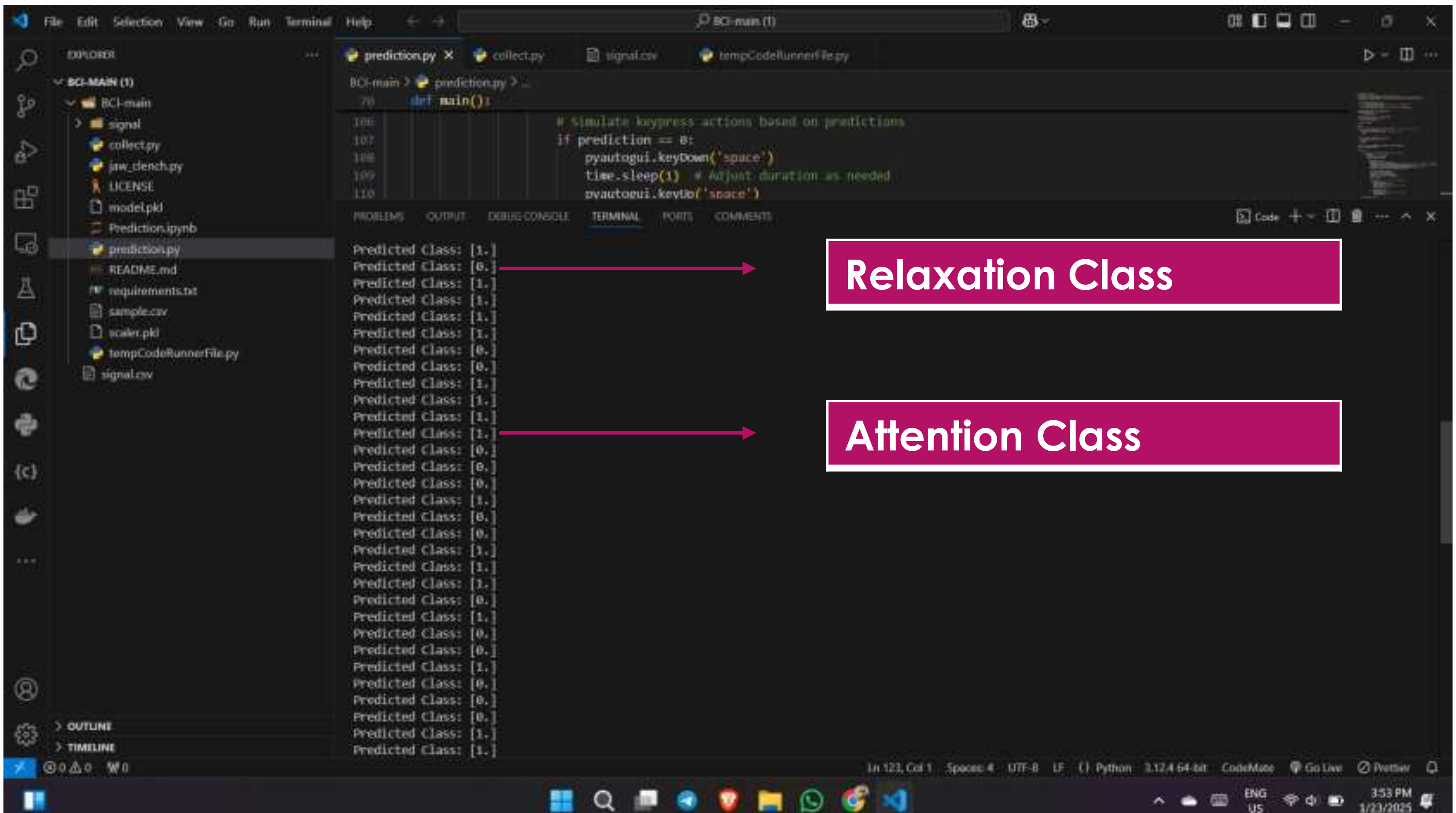
- EEG signals collected using non-invasive electrodes.
- **Data Categories:**

Relaxation Data: Brainwave patterns recorded while the patient is in a calm, relaxed state, often associated with alpha waves (8–13 Hz).

Attention Data: Brainwave patterns recorded while the patient is in a focused or engaged state, typically dominated by beta waves (13–30 Hz).

- These input data is then processed and helps in visualization.

OUTPUT INFORMATION



SYSTEM REQUIREMENTS

Hardware Requirements

- EEG headset with non-invasive electrodes.
- Amplification hardware for signal processing.
- Storage device for data retention.

Software Requirements

- Python for signal processing and machine learning.
- Database for storing collected brainwave data.
- Web or mobile application for user interaction.

WORKING PROCESS

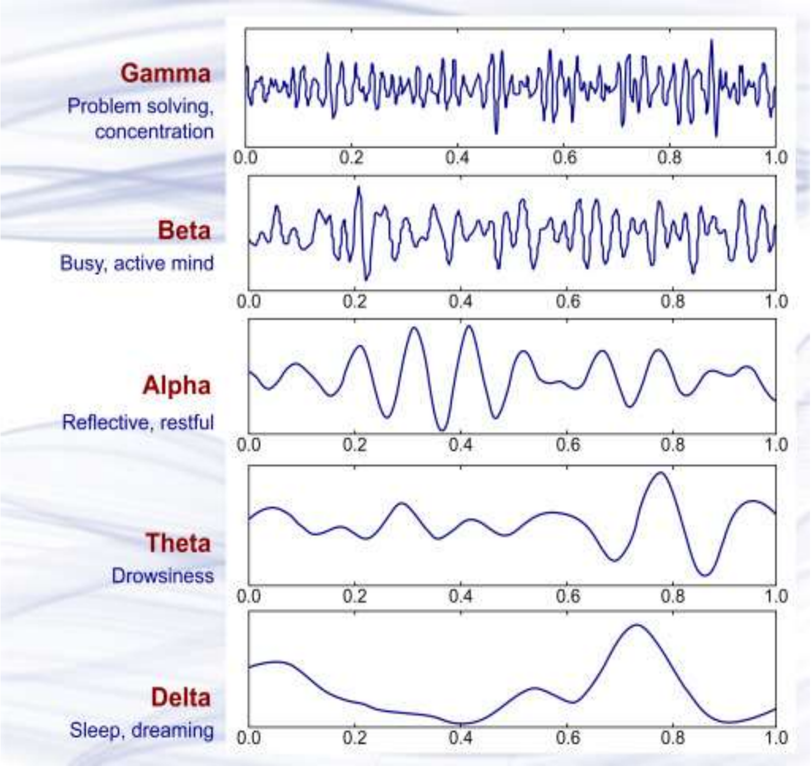
- Real time Data has been collected and tested in project , with the amplification of relaxation and attention signal through electrodes
  Relaxation – 0

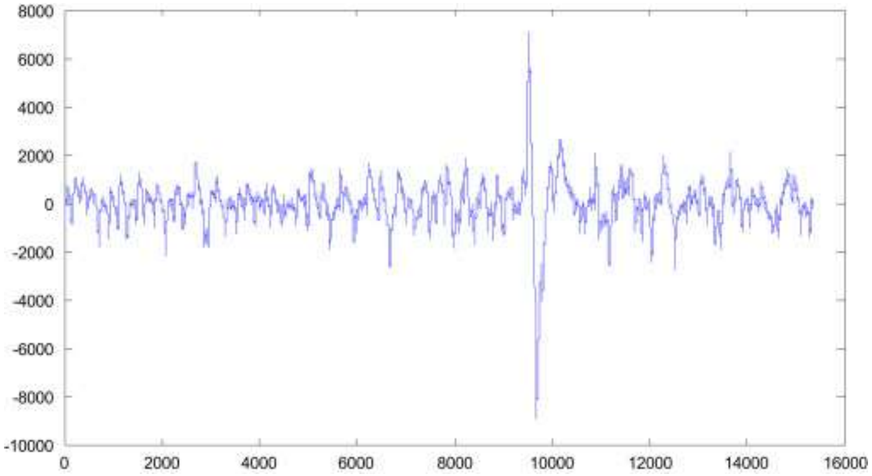
  Attention – 1

- Processed through the Software IDE and output is obtained

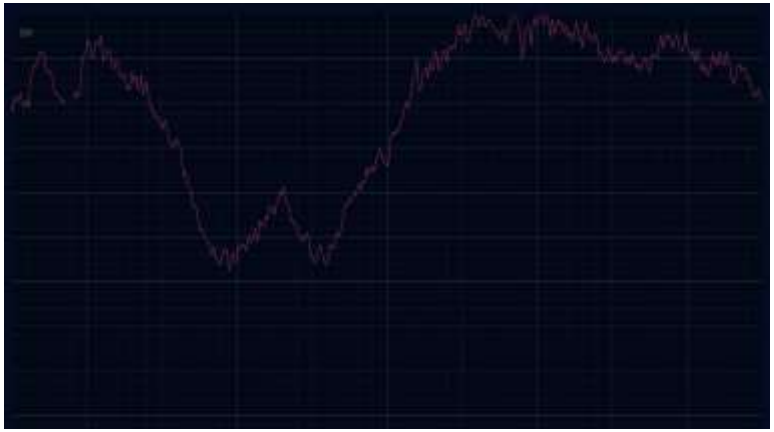
- More real time data needs to be collected and the signal needs to be analyzed for the improvement of the sleep cycle.

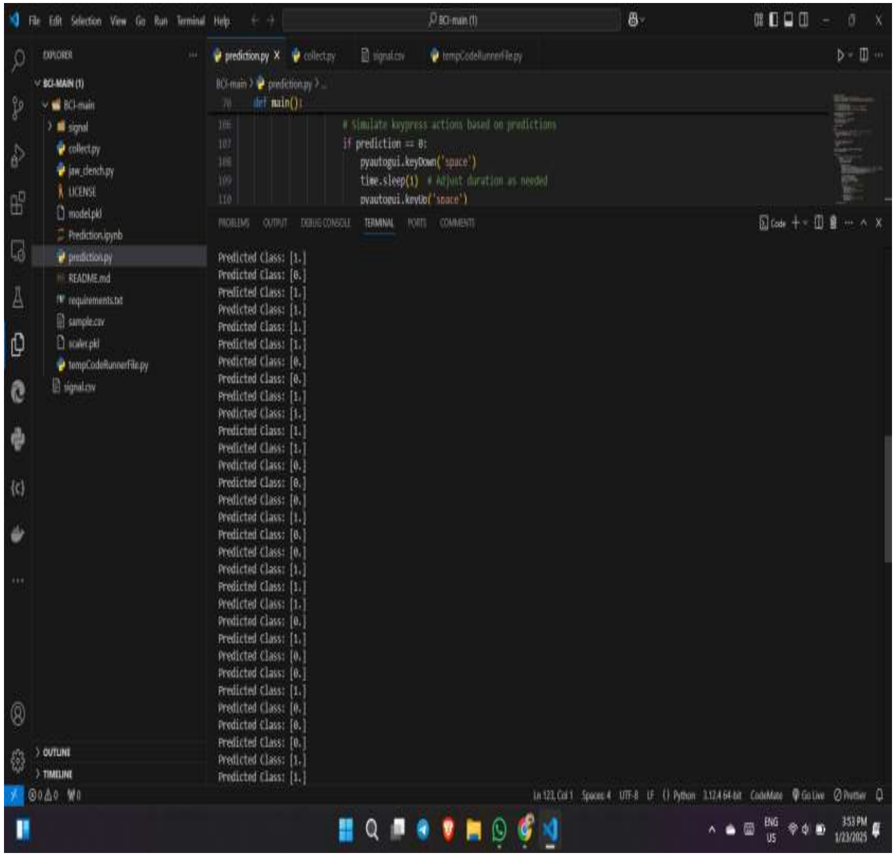
INSOMNIA WAVEFORM





RESULTS





File Edit Selection View Go Run Terminal Help
EXPLORER
BCI-MAIN (1)
BCI-main
signal
collect.py
jaw_clench.py
LICENSE
model.pkl
Prediction.ipynb
prediction.py
README.md
requirements.txt
sample.csv
scaler.pkl
tempCodeRunnerFile.py
signal.csv
# Simulate keypress actions based on predictions
if prediction == 0:
pyautogui.keyDown('space')
time.sleep(1) # Adjust duration as needed
pyautogui.keyUp('space')
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS COMMENTS
Predicted Class: [1.]
Predicted Class: [0.]
OUTLINE
TIMELINE

CONCLUSION

- This project explores a **non-invasive Brain-Computer Interface (BCI)** system to treat **insomnia** by using **real-time EEG monitoring and neurofeedback**. By modulating brainwave patterns—reducing beta activity while enhancing delta and theta rhythms—the system promotes natural sleep without drugs or clinical supervision.
- Built with **non-invasive electrodes, Raspberry Pi, Bluetooth communication, and user-friendly software**, the setup offers a **portable, affordable, and home-based solution**. Literature and pilot studies support its effectiveness in **reducing sleep latency** and **improving sleep quality**.
- Unlike traditional therapies, BCI enables **personalized, long-term brain self-regulation**. Future improvements include integrating **AI for adaptive learning**, enhancing **wearable compatibility**, and refining EEG signal accuracy for **individualized treatment**. This approach represents a **promising and accessible advancement in sleep medicine**.

REFERENCES

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