**Project Title: EEG-Based Cognitive Load Assessment**

**Introduction**

* A brain–computer interface (BCI) enables control of devices using brain activity alone.
* EEG (Electroencephalography) is a widely used method for capturing electrical activity in the brain.
* This project assesses **cognitive load** based on EEG signal band analysis.

**Objective (You should define it as):**

To classify mental states (like high, medium, low cognitive load) using EEG signals by analyzing power in alpha, beta, and theta bands.

**Tools used:**

You are using:

* Python for programming
* MNE for EEG data loading and preprocessing
* Scipy for PSD and integration
* Matplotlib for plotting
* Welch’s Method for band power estimation

**Processing Pipeline**

1. **Read EDF files**
2. **Extract EEG channels of interest**
3. **Compute power spectral density**
4. **Calculate mean Alpha, Beta, Theta power**
5. **Classify load based on threshold**
6. **Visualize using Matplotlib**

**Highlights:**

* Use of **physiological brain signals (EEG)** for classifying **cognitive states**
* Based on **scientific formula**: θ / (α + β)
* Works with **real EEG data (BCI2000 dataset)**
* Supports **multiple subjects and trials**
* Fully automated: no manual band calculations
* Generates **visual plots** comparing alpha, beta, and theta

**Possible Applications:**

* Adaptive learning systems that adjust difficulty based on mental state
* Driver fatigue or overload detection systems
* Mental workload monitoring in critical environments (e.g., air traffic control)
* Stress/burnout monitoring in workplaces
* Mindfulness or meditation state tracking

**Input-Output**

| **Aspect** | **Description** |
| --- | --- |
| **Input** | Raw EEG .edf files from PhysioNet (e.g., S001R01.edf to S001R14.edf) |
| **Preprocessing** | Extracting channels, computing PSD, integrating over α, β, θ bands |
| **Output (Terminal)** | Alpha, Beta, Theta values per file with classification (High/Medium/Low) |
| **Output (Plot)** | Visual trend comparison across files and subjects |

**Dataset Details:**

| **Item** | **Description** |
| --- | --- |
| **Source** | PhysioNet: EEG Motor Movement/Imagery Dataset (BCI2000) |
| **Size** | ~1.9 GB (for Subject S001) |
| **Format** | .edf (European Data Format) |
| **Channels** | 64-channel EEG |
| **Sampling Frequency** | 160 Hz |
| **Band Info** | Uses α (8–13 Hz), β (13–30 Hz), θ (4–8 Hz) |
| **Events** | Optional use of T0, T1, T2 annotations (for mental task segmentation) |

**Results Format**

File Alpha Beta Theta Load

S001R01.edf 105.4 110.6 120.1 Medium

S001R02.edf 450.0 230.1 160.0 Low

S001R03.edf 130.2 210.0 290.3 High

**Conclusion**

* EEG signals provide a practical way to assess real-time cognitive states.
* Cognitive load estimation can support adaptive systems in education, workload management, etc.
* Future work can involve machine learning classification models using more complex features.

**Why This is a Valid Project (Academically):**

* You solve a **real physiological signal classification** problem.
* You use **open-access medical data** in a reproducible way.
* You apply a **well-known psychological EEG theory** (theta over alpha+beta).
* You show **analysis, automation, and visualization**.
* Fits well in BCI coursework or cognitive neuroscience projects.

**Can Enhance by Adding:**

* Saving output as .csv or .xlsx
* Optional GUI (using Tkinter, PyQt)
* Optional Machine Learning classifier: SVM or Decision Tree on (α, β, θ)
* Real-time EEG input simulation using synthetic signals