GR-307

EEG classification using Neural Network – An Application of Machine Learning in Classification of attention deficiency, to measure the effect of ChakraMarmaKosha Meditation-II

Abstract

Stress reduces attention span and is a common problem that impacts students' academic performance as well as their self-efficacy in handling challenging situations. Meditation techniques have been proven to help manage stress levels. In the previous research, the author used Heart Coherence as the metric to show the impact of ChakraMarkaKosha Meditation (CM), a meditation on human energy centers, on reducing the stress level. In this research we apply a new version of CM which is CM-II as a guided psychotherapy and cognitive therapy meditation, to analyze its impact on reducing attention deficiency among students. This study uses Electroencephalography (EEG) data as a metric to analyze electrical activities of the brain that contribute to attention deficiency. We use a neural network as a machine learning classifying algorithm to analyze the EEG data to measure the impact of CM-II on students' attention deficiency.

Introduction

Attention is one of the cognitive skills that involve concentration, problem-solving, judgment, and language. Attention-Deficit Hyperactivity Disorder (ADHD) is a neuro-developmental disorder that is characterized by hyperactivity and inattentiveness. As EEG can help in detecting signals that contribute to ADHD, we use a public EEG dataset of 60 ADHD and non-ADHD participants to train our developed machine learning classifier. Multi-layer Perceptron (MLP), a feedforward artificial neural network, is a fully connected multi-layer neural network that we use in the classification of ADHD in each dataset.

Our contributions:

- Visualizing the EEG data to see ADHD and non-ADHD brain scans using the MNE library in Python (Fig. 1, Fig.3).
- Extracting Alpha (α), Beta (β), and Theta (θ) band features (Fig. 4)
- Applying Multi-layer Perceptron (MLP) in the classification of ADHD. Obtaining 69.2% accuracy in detecting attention deficiency.
- Additional metrics to be designed in the next phase to measure the change in attention span after meditation.

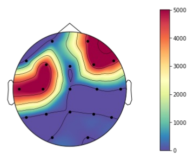


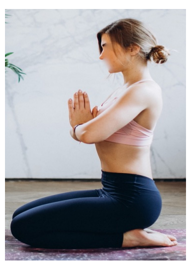
Fig 1. Brain scan with ADHD

Research Question(s)

- Can a machine learning algorithm detect accurately attention deficiency through spectral analysis of EEG data? (Phase 1)
- Does ChakraMarkaKosha Meditation II improve attention and increases students' self-efficacy? (Phase 2)

ChakraMarmaKosha II Meditation

CM-II is a sequel of CM in which the script focuses on improving an individual's attention and self-efficacy. It guides the user through their emotional memories and releases past painful emotions associated with trauma. For instance, individuals with acute stress disorder may have significant psychological issues and distress that could have arisen from past stored emotions. In addition, they may also have distorted cognitions formed from convictions during trauma that keep them under stress. CM-II addresses these issues by guiding the listener through past emotional release and cognitive restructuring. The hypothesis is that CM-II improves attention, and increases students' problem-solving skills, and self-efficacy. CM-II's effect will be measured primarily by live EEG data in phase II of the research.



Machine Learning

In this project, the dataset from Mohammadi et al. is used to train the developed ML classifier using a Convolutional Neural Network (CNN). CNN is a deep learning technique that usually consists of four layers: an input layer, a pooling layer, a fully connected layer, and an output layer. CNN Multi-Layer Perceptron (MLP) (Fig. 2) which has forward-feed and back-propagation learning methods is chosen here because it has been found that its accuracy is very high for ADHD data classification compared to other classifiers such as SVM. CNN was chosen because when compared to K-nearest Neighbors (69%), Support Vector Machines (72%), and Random Forest (74%) was found to have the highest accuracy (84%) on a similar dataset.

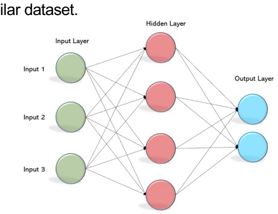


Fig 2. MLP Neural Network

In this study, a 6-layer MLP model was coded and trained using TensorFlow library. These techniques utilized for classification and spectral analysis were developed in Python. After training and testing, the model was evaluated for its accuracy. This model will be used in the next phase to determine the effect of CM-II on attention improvement through live EEG data and self-efficacy analysis.

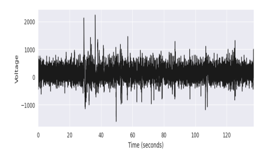


Fig 3. EEG raw data

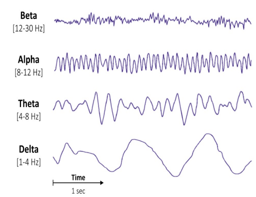


Fig 4. Frequency band waves

Methodology

To achieve classification for inattention by EEG, the following steps were followed:

Data visualization: Visualized the EEG data to see ADHD and non-ADHD brain scans using MNE in Python. Visualized EEG waves using matplotlib. (samples in Fig. 1 and Fig. 3)

Feature selection and extraction: Estimated power spectral density using Welch's method. Computed the absolute power by approximating the area under the curve. Band powers of Alpha (α), Beta (β), Gamma (γ), Delta (δ), and Theta (θ) bands (Fig. 4) were extracted as they help in the identification of ADHD. And a spectral analysis was done on theta/beta ratio (TBR) - an index of inattention. As theta activity increases and beta activity in the brain dramatically reduces in ADHD, Theta to Beta ratio is a good indication of ADHD.

Development and training of an ML classifier: Absolute band values were calculated and fed as input to the ML model. A new dataset was created from frequency bands using the TensorFlow library. Then a neural network model was made using TensorFlow and Keras libraries. The model was then optimized, and the loss function was estimated using Stochastic Gradient descent. Thereafter, the model was trained with a batch size of 32 and 200 epochs.

Model Evaluation: Then this model was tested using the partitioned test data set and accuracy were calculated. A confusion matrix also was created from sklearn library functions to visualize the performance of the classification.

Research Phase 1: ML model creation.

In the first phase of this research, an existing raw EEG dataset was imported into the Python ML model (Fig. 5). From the raw EEG data, power spectral density using Welch's method, absolute power was calculated for each α,β,γ,δ,θ bands. A new dataset with powers formed input to the ML model. The dataset was partitioned into test/train data. Then the MLP neural networks sequential model was implemented using Keras and Tensorflow Python libraries. This model was optimized using Stochastic Gradient descent (SGD). After training, a test set was given as input to determine its accuracy. As a result, the model produced 69% accuracy in detecting a person with ADHD.

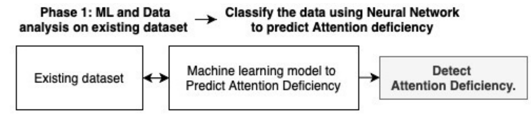


Fig 5. Phase 1: Machine Learning

Research Phase 2: Data collection and running the experiment

In the next phase, the study will continue to improve the model's accuracy and stability. Then, an experiment will be conducted on 10-15 participants to analyze their live EEG scans to measure their attention deficiency as well as its improvement after CM-II meditation (Fig. 6). In addition to EEG, a self-efficacy standard test, and heart coherence measurements will be included as metrics.

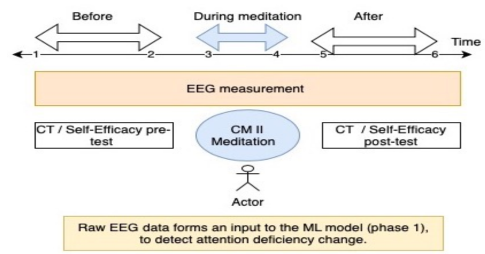


Fig 6. Phase 2: Experimental Phase

Conclusions

The goal of this study is to 1) use neural network classification ML algorithm to detect attention deficiency by using EEG dataset, and 2) analyze the impact of CM-II on individuals with attention deficiency. For goal 1, we used Multi-layer Perceptron (MLP) on bandwidths of α,β,δ,θ bands obtained from 19 channels of raw EEG dataset. The algorithm produces an accuracy of 69%. Given the accuracy could be improved, in the next phase of this research, we will run the study on live EEG data and will improve the model for higher accuracy. For goal 2, we will analyze the impact of CM-II on participants' attention spans.

References

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