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University of South Bohemia
Faculty of Science
Artificial Intelligence and Data Science, M.Sc.

ADHD Detection with EEG Signals

Submitted for the course **Information Theory and Feature Engineering**
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Declaration

I declare that I have written this report by myself and have only used the sources and aids mentioned, and that I have marked direct and indirect citations as such. This report has not been submitted prior for any other examination.

I agree that the results of this study work / report may be used free of charge for research and lecturing purposes.

Contents

List of Abbreviations

ADAS	Advanced Driver Assistance Systems
ADC	Analog-to-Digital Converter
AMCW	Amplitude Modulated Continuous Wave
CAN	Controller Area Network

1 Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental condition that affects individuals across the lifespan. According to Furman [1], ADHD is not a single disease entity but rather a constellation of symptoms representing a final common behavioral pathway for a range of emotional, psychological, and learning difficulties.

Although the behavioral manifestations of ADHD are well-documented, its neurophysiological underpinnings remain an active area of research. Electroencephalography (EEG) has been widely used to study ADHD, as it provides a non-invasive measure of brain electrical activity. Previous studies have identified characteristic EEG patterns in individuals with ADHD, particularly abnormalities in the frontal and central regions, often reflected as altered spectral power or atypical signal complexity.

This study aims to investigate differences in EEG activity between healthy individuals and those diagnosed with ADHD, using the dataset provided by Sadeghi Bajestani *et al.* [2]. Specifically, the project focuses on (1) comparing the statistical and informational properties of EEG signals across both groups, (2) engineering features inspired by information theory—such as entropy and mutual information—to quantify signal complexity and connectivity, and (3) building a predictive model capable of distinguishing ADHD from healthy controls based on these features. This work bridges the domains of signal processing, feature engineering, and information theory to improve understanding and potential classification of ADHD-related brain activity.

2 Data Description

The dataset [2] comprises EEG recordings from a total of 79 adult participants, including 42 healthy controls and 37 individuals diagnosed with ADHD (age range: 20-68 years; male/female ratio: 56/23). EEG signals were recorded under four different experimental conditions: (1) resting state with eyes open, (2) resting state with eyes closed, (3) a cognitive challenge task, and (4) an auditory condition involving listening to an "omni harmonic" sound stimulus.

Recordings were obtained from five scalp locations—O1, F3, F4, Cz, and Fz—using a sampling rate of 256 Hz. These regions encompass occipital and frontal areas known to play critical roles in attentional control and cognitive processing. The dataset is organized by participant group and gender, with each subject's data stored as MATLAB `.mat` files. One recording (from the ADHD female group) was reported to be corrupted and is therefore excluded from analysis.

The diversity of conditions and electrode sites allows for a comprehensive comparison of neural dynamics across both spatial (channel-based) and functional (task-based) dimensions. This structure also facilitates the extraction of time-domain, frequency-domain, and information-theoretic features for subsequent modeling and classification.

3 Data Description

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File organization and structure. The data are provided as four MATLAB `.mat` files, corresponding to the experimental groups:

- `FC.mat` – female control group
- `MC.mat` – male control group
- `FADHD.mat` – female ADHD group
- `MADHD.mat` – male ADHD group

Each file contains a 1×11 cell array, where each cell represents one experimental task or condition. Within each cell, the data are stored as a three-dimensional matrix with dimensions `[subjects × samples × channels]`. For instance, a typical entry of size 13×7680×2 indicates 13 participants, 7680 time samples (corresponding to 30 seconds of EEG data at 256 Hz), and two recorded channels.

The specific configuration of each cell (i.e., channel pair and duration) is summarized as follows:

Cell	Condition	Channels	Duration (s)
1	Eyes open baseline	Cz, F4	30
2	Eyes closed	Cz, F4	20
3	Eyes open	Cz, F4	20
4	Cognitive challenge	Cz, F4	45
5	Pre-Omni harmonic baseline	Cz, F4	15
6	Omni harmonic assessment	Cz, F4	30
7	Eyes open baseline	O1, F4	30
8	Eyes closed	O1, F4	30
9	Eyes open	O1, F4	30
10	Eyes closed	F3, F4	45
11	Eyes closed	Fz, F4	45

Table 1: Summary of EEG tasks, channel pairs, and recording durations.

One corrupted signal (subject 7 of the female ADHD group) was identified and excluded from further analysis.

This hierarchical data organization allows for flexible analysis across multiple dimensions: by gender, diagnosis, condition, and channel pair. For subsequent preprocessing, each task will be reshaped into individual subject–channel recordings, ensuring consistent sampling durations across conditions.

4 Preprocessing

References

[1] L. Furman, "What is attention-deficit hyperactivity disorder (adhd)?" *Journal of child neurology*, vol. 20, no. 12, pp. 994–1002, 2005.

[2] G. Sadeghi Bajestani, S. Abedian, F. Makhloughi, M. Raoufitabar, and H. Saeedi, "A dataset of eeg signals from adults with adhd and healthy controls: Resting state, cognitive function, and sound listening paradigm," 2023. [Online]. Available: https://doi.org/10.17632/6k4g25fhzg.1

AI Prompt Used

1. What should I do