Project Report
Autism Spectrum Disorder Detection Using EEG & Deep Learning

By

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Overview

This project focused on detecting **Autism Spectrum Disorder (ASD)** using EEG (Electroencephalography) signals, particularly analyzing the **P300 wave**, which is associated with attention and cognitive response. The aim was to build a **deep learning-based system** that can classify P300 signals and identify key EEG channels critical for ASD detection.

Objectives

- Develop a **CNN-RNN hybrid model** to classify P300 signals from ASD subjects.
- Use **Grad-CAM** to identify the most important EEG channels for classification.
- Optimize the classification process by using only those critical channels without significantly sacrificing accuracy.

Dataset

- **BCIAUT-P300 EEG Dataset** (Kaggle):
  - ❖ 15 ASD subjects
  - ❖ 7 sessions per subject (total 105 sessions)
  - ❖ EEG signals recorded from 8 scalp channels: `C3, Cz, C4, CPz, P3, Pz, P4, POz`
  - ❖ Tasks performed in a **VR-based BCI environment** with joint attention activities.
  - ❖ Data categorized into **P300 (target)** and **non-P300 (non-target)** epochs.

Preprocessing

- **Filtering**: Notch filter @50Hz for powerline noise, Bandpass filter (2–30Hz) to preserve P300 signals.
- **Epoch extraction**: EEG segmented into 350-sample epochs post-stimulus.
- **Labeling**: Epochs were labeled as `1` for target (P300) and `0` for non-target.
- **Data imbalance**: Resolved using **random oversampling**.
- **Batching**: Equal sampling per class (32 target, 32 non-target per batch).

Model Architecture: CNN-RNN Hybrid

- **3 Convolutional layers** (64, 128, 256 filters), each followed by MaxPooling and Dropout.
- **Simple RNN layer** for temporal feature extraction.
- **Dense layers** for binary classification.
- **Optimizer**: Adam, **Loss**: Categorical Crossentropy.
- **Total Parameters**: ~861K.

Subject-wise Performance

Model tested individually per subject:

SBJ No.	CNN-RNN Performance Accuracy
01	86 %
02	**92%**
03	88%
04	86%
05	87%
06	87%
07	88%
08	91%
09	87%
10	**92%**
11	89%
12	87%
13	**74%**
14	77%
15	88%

- **Highest Accuracy**: 92% (Subject 2 & 10)
- **Lowest Accuracy**: 74% (Subject 13)

Channel Optimization (Grad-CAM + VGG-16)

- **Grad-CAM** used to compute channel-wise saliency maps.
- Identified 4 critical channels: **P3, P4, Pz, POz**
- Retrained model on:
    1. **All 8 channels** – Accuracy: **86.72%**
    2. **Only 4 critical channels** – Accuracy: **85.87%**
    3. **4 duplicated to fill 8 channels** – Accuracy stable, no overfitting.

Key Takeaways

- CNN-RNN is effective for classifying EEG-based P300 signals in ASD patients.
- Using just 4 most important EEG channels, classification performance remained high—ideal for **real-time, low-resource BCI systems**.
- Grad-CAM provided explainability and efficiency by reducing channel usage with minimal accuracy drop.

Future Work

- Generalize the model to neurotypical subjects or mixed datasets.
- Improve real-time applicability using lightweight models.
- Explore multi-modal approaches integrating behavioral data.
