Real-Time Denoising of EEG Signals in BCIs for Children with Disabilities

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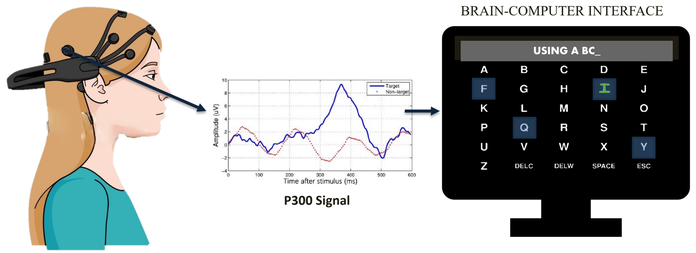
1. BACKGROUND

What are Brain Computer Interfaces and the P300?

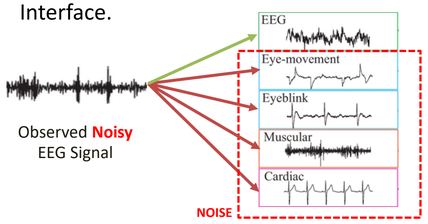


BCI's are systems that enable users to control external applications using just their brain activity (EEG).

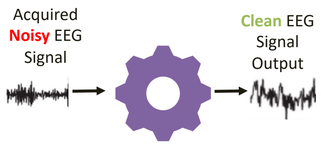
The **P300** is an event-related potential in EEG signals that occurs approximately 300 ms after a sudden change in stimuli.

PROBLEM

- EEG signal is contained with several unwanted signals such as eyeblinks etc.
- These artifacts/noise reduce the effectiveness of the Brain-Computer Interface.



OBJECTIVE



Develop a software that can remove noise from EEG signal in real-time

2. METHODS

Collected raw EEG signal

Used state-of-the-art offline denoising tool – Independent Component Analysis (ICA) to clean EEG signal

Used signal to create clean EEG database

Trained four neural network architectures

1. Simple Convolutional Neural Network (SCNN)
2. Complex Convolutional Neural Network (CCNN)
3. Recurrent Neural Network (RNN)
4. Fully Connected Neural Network (FCNN)

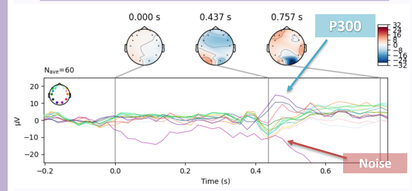
Used model to denoise EEG signal

Developing a Real-Time Denoising Tool while Preserving the P300 signal to Enhance BCI Experience for Children with Disabilities Enabling Effective Control.

3. RESULTS

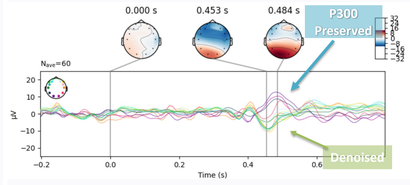
In our study, we conducted a comparative analysis of the P300 latency and amplitude across raw EEG signals, ICA, and our denoising software model.

Raw EEG Signal (No Software)



Mean Training Accuracy: **98.3%**
Peak Latency: **656.875 ms**
Peak Amplitude: **13.873 µV**

State-of-the-art Denoising (ICA)

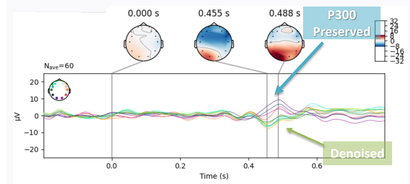


Mean Training Accuracy: **98.7%**
Peak Latency: **484.375 ms**
Peak Amplitude: **11.719 µV**

Preliminary Analysis

- RNN model outperforms other models
- RNN model is comparable to ground-truth ICA
- The P300 latency and amplitude are preserved
- The RNN model successfully removes eyeblink artifacts, enhancing the quality of EEG signals

Our Denoising Model (RNN)



Mean Training Accuracy: **99.4%**
Peak Latency: **490.234 ms**
Peak Amplitude: **9.208 µV**

4. NEXT STEPS

Increase Clean EEG Database

Explore different Neural Networks

Test on real EEG data collected from children with disabilities

Test robustness with other artifacts

5. RELEVANCE

- Enables children with involuntary movements to seamlessly utilize BCI technology, free from disruptive artifacts

- Enhances the accessibility and usability of BCIs by significantly improving the accuracy and precision of the system

- Improve the robustness of BCIs, enabling their effective deployment in real-world, non-laboratory environments

6. ACKNOWLEDGEMENTS

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