Improving P300 BCI Performance with OSCAR

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Introduction: Real-time artifact removal is essential for reliable EEG-based brain-computer interfaces (BCIs), as artifacts from eye blinks, muscle activity, and environmental noise degrade system performance [1]. Numerous algorithms have been developed to mitigate EEG artifacts, each with its own advantages and limitations [2]. We present an evaluation of the Online Signal Conditioning and Artifact Removal (OSCAR) module on P300 BCI performance. In particular, we assessed OSCAR LIVE, which is the real-time implementation with ≈250 ms delay and part of g.HIsys high-speed online processing for Simulink (g.tec medical engineering GmbH, Austria).

Material, Methods and Results: Dataset 1 (DS1) comprises 10 clean recordings from five subjects in auditory and visual oddball paradigms, which we randomly contaminated with template artifacts to produce 300 pseudo-recordings. Dataset 2 (DS2) consists of 120 recordings with real artifacts, obtained from five subjects and the same paradigms.

We processed all recordings using a standard P300 classification pipeline: bandpass filtering (0.5– 10 Hz), epoching (–0.1 to 0.7 s, relative to stimulus onset), decimation, and 500 repetitions of a randomized hold-out validation (20 training trials, 4 test trial averages) with a linear discriminant analysis (LDA) classifier. The pipeline was applied to raw EEG and OSCAR LIVE-preprocessed EEG.

Figure 1 shows that OSCAR LIVE improved BCI accuracy in most recordings. Using a ±5% margin to define "similar performance," OSCAR LIVE improved 76.7% of recordings and worsened 6.0% in DS1. In DS2, improvement was observed in 39.4%, with deterioration in 12.5%. Overall, OSCAR LIVE achieved similar or better performance in 94.0% of DS1 and 87.5% of DS2 recordings. Grand average performance improvement was +17.0% (DS1) and +7.1% (DS2).
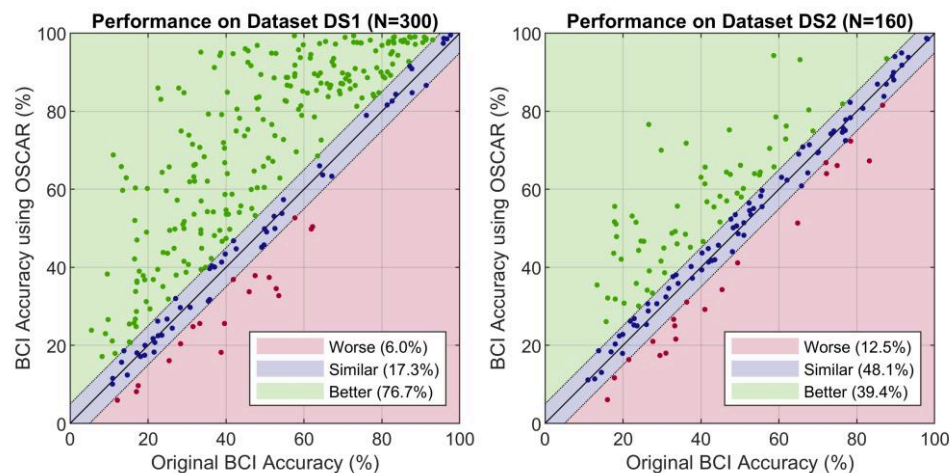

Figure 1: *Scatter plots showing P300 BCI accuracy with OSCAR versus original BCI accuracy for DS1 (left) and DS2 (right). Each dot represents the result of one recording. The red, blue, and green areas relate to worse, similar, and better performance, respectively.*

Conclusion: Our findings demonstrate that OSCAR LIVE effectively enhances P300 BCI performance for artifact-contaminated EEG recordings.

References:

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