A Frequency-Based Electroencephalography Approach to Real-Time Attention Detection

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Abstract

The aim of this study was to develop and validate a frequency-based algorithm for estimating attention from electroencephalography (EEG) signals. Attention is a complex multi-dimensional cognitive process that is critical in task performance and learning. There are many approaches out there that oversimplify the way to measure it. This paper provides an algorithm that focuses on delivering stable attention metrics based on neural signals.Raw EEG signals were captured using a noninvasive 10–20 electrode configuration and preprocessed by removing the Direct Current (DC) component. This step ensures that minimal drifts are caused by physiological and environmental artifacts. Signals then are segmented into windows and converted into the frequency domain using Fast Fourier Transform (FFT). This provides a simultaneous analysis of band powers. Normalizing the ratio of the bands reduces the inter-individual variability to anatomy or electrode placement. To ensure real-time usability, an Exponential Moving Average (EMA) was used for smoothing and scaling the data into a standardized 0–100 range. Testing was then conducted on a sample of 10 healthy adults during a sustained attention task involving focused reading of a standardized text over a period of 5 minutes. Each participant's comprehension of the text was then measured using a short 5 question test. Results demonstrate that among all electrodes, the FPZ showed the lowest variance between subjects and the highest stability in attention estimates after normalization and smoothing. The proposed algorithm produced consistent attention metrics across participants and proved to be stable despite signal noise and electrode placement variability. This study provides a solid method for assessing attention using EEG technology. Despite using a limited sample size, the results help identify the ideal electrode configuration. Future research will include validation on larger and more diverse populations.

Keywords: EEG-based attention; Brain–computer interfaces (BCI); Frequency-domain analysis; Cognitive focus metrics; Real-time neural signal processing.