BrainPrint: Innovative Head-Mounted EEG Technology for Secure Personal Identification

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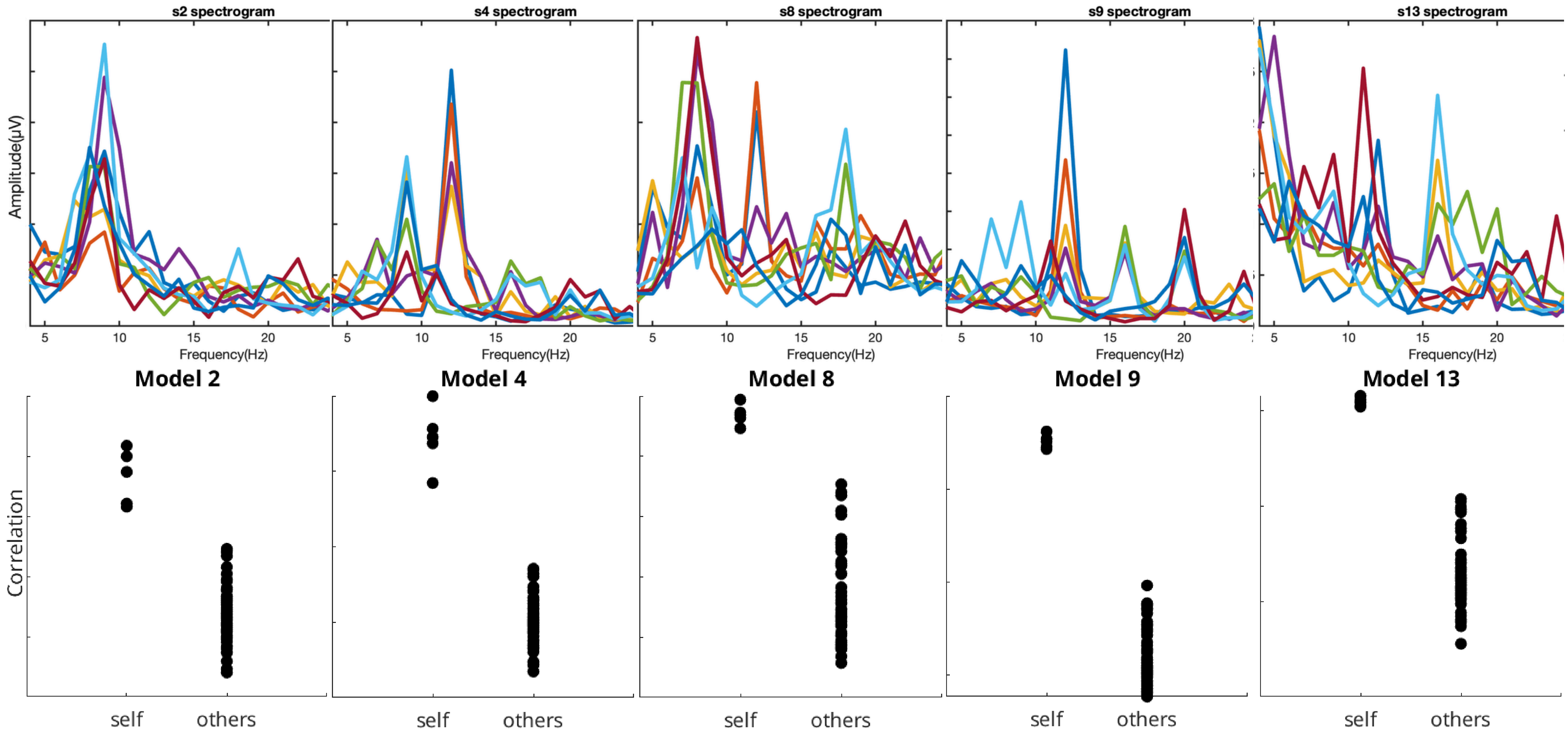
Introduction

We propose TRCCA (Task-Related Canonical Correlation Component Analysis) + fdTRCA (Frequency Domain Task-Related Component Analysis), an advanced algorithm designed for biometric authentication through steady-state visual evoked potentials (SSVEPs). This approach extracts and analyzes distinct features of SSVEPs for individual identification. By combining TRCA, Canonical Correlation Analysis (CCA), and Fast Fourier Transform (FFT), our method captures SSVEP patterns across temporal, spatial, and frequency domains, significantly improving classification accuracy and processing speed.

For practical deployment, we introduce Amber Glasses, a custom-built monocular display module with a transparent screen, specifically designed to evoke SSVEP signals while minimizing visual interference. Our Contributions are as follows:

- The first authentication algorithm utilizing SSVEP signals as a biometric input.
- Integrates TRCA, CCA, and FFT for efficient and highly accurate person identification.
- Demonstrates strong potential for secure, scalable biometric systems, with further development and integration into our custom portable BCI device: Amber Glasses.

Performance Evaluation on Public Datasets



We present the experimental results for the 5 subjects from a dual-frequency SSVEP dataset (Y. Sun et al., 2024). The top row displays their frequency responses in a format of "a-b", where "a" is the flickering frequency to the left eye while "b" is the flickering frequency to the right eye. For example, "7-9" indicates that the left eye is stimulated at 7 Hz and the right eye is at 9 Hz. The y-axis of top row shows averaged amplitude across trials for 5 participants. The bottom raw illustrates the model's performance.

Prototype

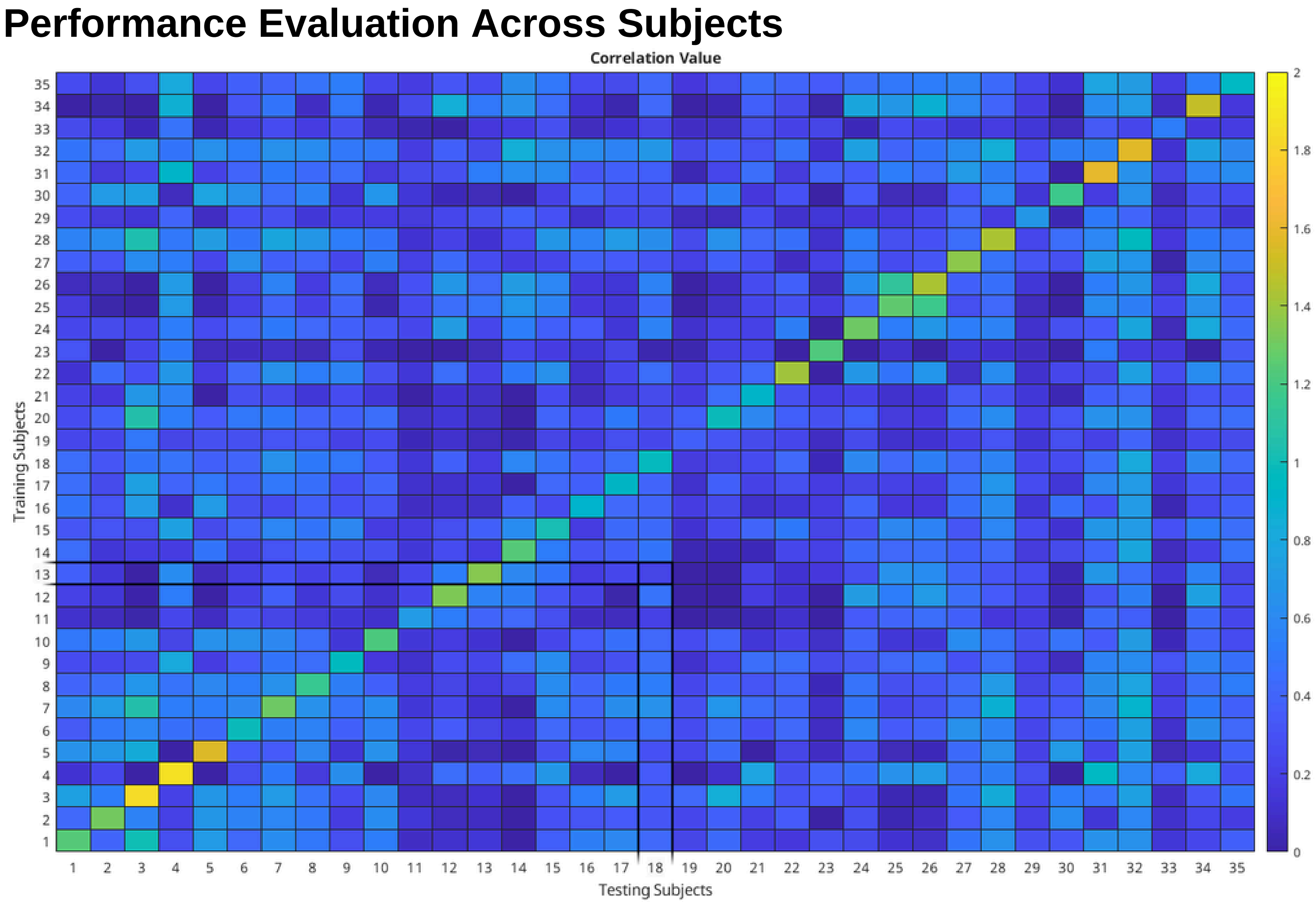
Front View

Bird Eye View

Method

- The TRCCA + fdTRCA framework employs a streamlined approach to biometric authentication by first training a model using a client's SSVEP data before proceeding with the authentication process. One of the key advantages of this method is its efficiency, as only a small number of trials are required to achieve optimal performance, enabling rapid registration compared to traditional machine learning methods.
- The TRCA component extracts task-related components from SSVEP signals by identifying spatial filters that maximize the reproducibility of SSVEP responses across multiple trials for each individual. This step significantly improves the signal-to-noise ratio, ensuring that the most relevant and subject-specific features are retained.
- CCA is applied to uncover correlations between multichannel EEG signals and reference signals corresponding to the stimulus frequencies. This alignment is critical for matching SSVEP responses to the expected frequencies induced by the visual stimuli, thus improving classification accuracy.
- Finally, FFT is employed to convert the time-domain EEG signals into the frequency domain. By isolating dominant frequency components related to the SSVEP stimuli, the algorithm can accurately distinguish between individuals based on their unique SSVEP patterns.

Performance Evaluation Across Subjects



The y-axis represents the training bouts for the model, while the x-axis shows the testing bouts. Our figure demonstrates that the model achieves higher correlation for the corresponding subject (diagonal warm color). This indicates the proposed algorithm successfully enables authentication process by accurately distinguishing between individuals.

Acknowledgment

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