SSVEP Detection and Classification for EEG-Based BCIs

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MOTIVATION

- SSVEP-based BCIs provide a non-invasive and cost-effective solution for enabling direct brain-to-device communication, requiring minimal training.
- This technology can be beneficial for individuals with severe motor impairments, allowing them to control assistive devices, communicate, and interact with their environment effectively.

IMPLEMENTATION

- Signal Preprocessing: The SSVEP signals were filtered between 6 to 64 Hz to isolate the relevant frequency range..
- Feature Extraction: The resulting CCA-enhanced data was transformed using Continuous Wavelet Transform (CWT) to extract time-frequency features.
- Classification: The CWT features were input into a Convolutional Neural Network (CNN) for classification.

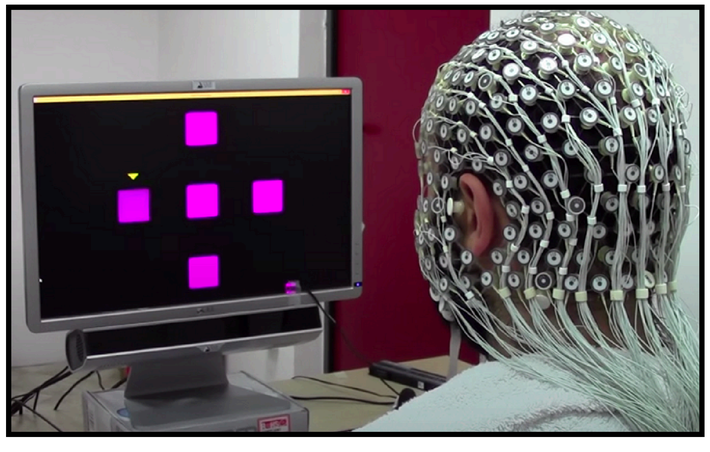

fig. 2 ‘Image showing a participant using high density EEG for SSVEP data generation’.
Source: http://www.mamem.eu

THEORY

- Steady-State Visual Evoked Potentials are brain responses elicited when a user focuses on visual stimuli flickering at specific frequencies. The brain's EEG signals resonate at the same frequencies as the stimuli, enabling precise detection of the user's focus.
- Canonical Correlation Analysis (CCA) is a statistical method used to find the relationship between two sets of data by maximizing their correlation. In SSVEP BCI, it compares EEG signals with reference signals at different stimulus frequencies.

PROBLEM STATEMENT

To address the lack of accessible communication and control solutions for paralyzed, elderly, and motor-impaired individuals by developing a non-invasive SSVEP-based BCI system to improve independence and quality of life.

ANALYSIS

- The SSVEP benchmark dataset was used to test the model.
- Fast-ICA algorithm was used to remove the artifacts, out of all the 64 independent components, only ten of those were used that had an influence in the Occipital Praietal region of the brain.
- SSVEPs are more influential in the brains visual cortex, ie. the Occipital region, hence data from only 3 channels, O1,O2,Oz was used.
- Mortlet wavelets were use for Continuous Wavelet Transform.

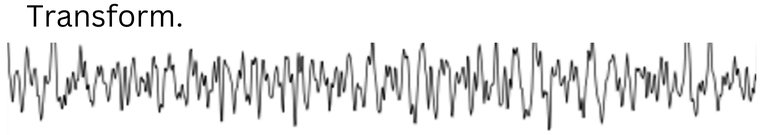

fig 1 - SSVEP signal from the elctrode O1 of the occipital region of the brain generated with 8Hz frequency as stimulus.

RESULTS AND CONCLUSION

performance metrics for various models we have experimented on:

- FastICA + CCA+CWT+CNN: 78%
- FastICA + ShallowConvNet: 79.04%
- FastICA + EEGNet: 84.76%
- FastICA + DeepConvNet: 89.14%

The experiments demonstrate the potential of SSVEP-based BCI systems as effective multiclass classifiers, achieving high accuracy across 5 classes. Notably, the combination of FastICA with DeepConvNet achieved the highest accuracy, showcasing the capability of deep learning to extract robust features for precise classification.