Coupling Human's Brain Cognitive Signals and Computer Vision

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Introduction

We propose an innovative approach for BCI systems, where EEG signals are used as an extra communication channel informing about the human perception of images. Following an event detection approach, the EEG channel provide us information about the subject's perceptive state that can be used to improve human-computer interaction. This approach is based on the recognition of high-level cognitive processes from EEG measurements, by means of new signal processing techniques.

Brain Coupled Interaction

Our framework relies on the EEG channel under Rapid Serial Visual Presentation (RSVP) protocol as new approach for learning user preference in a personalized Content Based Image Retrieval (CBIR) system.

The challenges:

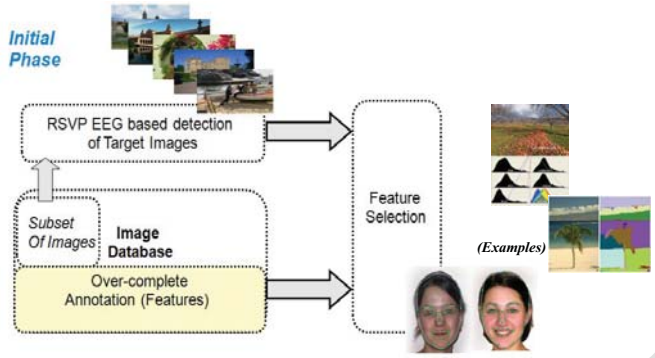
- Semantic gap between image feature and human perception
- Human perception subjectivity in finding target images
- Semantic object extraction

The components of our framework related to EEG processing:

- Detection of target images
- Correction of mistakes in the detection
- On-line speed adaptation of content presentation

Research on the detection of :

- Neural signatures of visual recognition events
- Error-related potentials
- Human engagement on the task

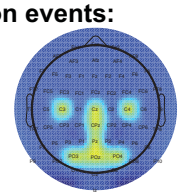


Experiment

Subjects were instructed to recognize if the object of the target class appears in the image.

- 5 RSVP streams (presentation frequency 4Hz), no inter-stimuli interval
- Each stream corresponds to a different category of target image
- 100 images per stream (10 Target images)
- Target images randomly positioned in RSVP streams

Time domain detection of visual recognition events:



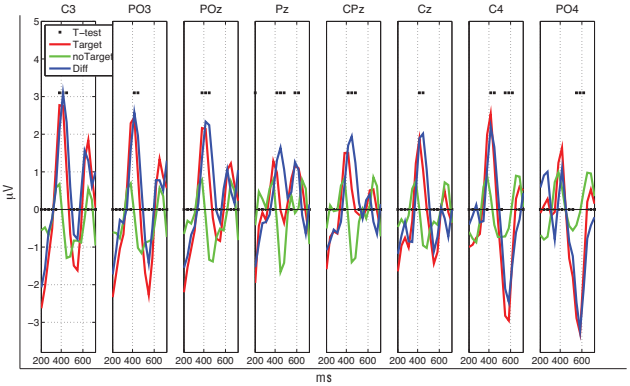
- Initial feature space:

Delta and theta bands of EEG signal

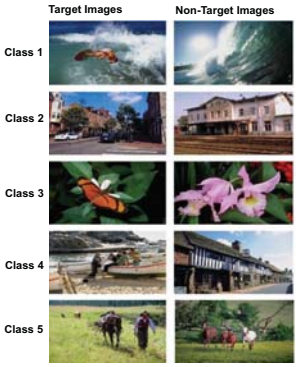
Pre-selected set of EEG channels

Time window from 200 to 700ms after stimuli

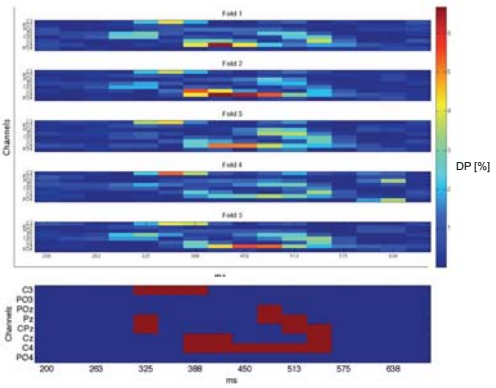
- Canonical Variate Analysis based feature dimension reduction
- Gaussian Classifier (4 prototypes per class)



T-test and Grand Average of delta and theta bands EEG signal (Image rate 4Hz)



Samples of RSVP Stimuli.



Feature dimension reduction: (up) Features' Discriminant Power - DP (down) Stable discriminant features for all folds. DP is color-coded from red to blue (red being the most discriminant features).

Results

Preliminary results of single trial classification (target versus non-target trials), performed in the time domain, reveal target recognition performance of ~ 70%. In addition, low rate of false positives is obtained, what is a key feature for further coupling with Computer Vision based methods for image retrieval. These results support our hypothesis that EEG signal decoding can keep the robustness of HVS (Human Visual System). Significant improvement of the target detection is expected with the incorporation of the error recognition, since from the behavioral response it is noticed that the subjects made mistakes.

Acknowledgements

- **Swiss National Science Foundation, Project 200021- 120293**
- **Defitech Chair in Non-Invasive Brain Machine Interfaces, EPF Lausanne**

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

EPFL
École polytechnique fédérale de Lausanne