Single trial motor imagery classification in EEG measured during fMRI image acquisition - a first glance

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Introduction

EEG-fMRI measures two different brain activity related signals simultaneously.

- EEG: electrical brain activity.
- fMRI: blood oxygenation level dependent (BOLD) signal.

Although the relationship between these two brain signals is not clear yet, the bimodal view allows new insights into brain functionality [1].

Brain-Computer Interfaces (BCIs) provide control signals derived from brain activity signals. EEG based non-invase BCIs utilize event related desynchonization (ERD) of sensorimotor rhythms (SMR). Motor imagery (MI) can induce ERD [2].

The Scope of this work is to investigate whether MI induced ERD is classifiable on a single trial basis in EEG measured with fMRI simultaneously.

Methods

The Participant (male, 23 years old), a known good MI performer, was lying in the MRI scanner and was looking at a screen via a mirror (Fig. 1).

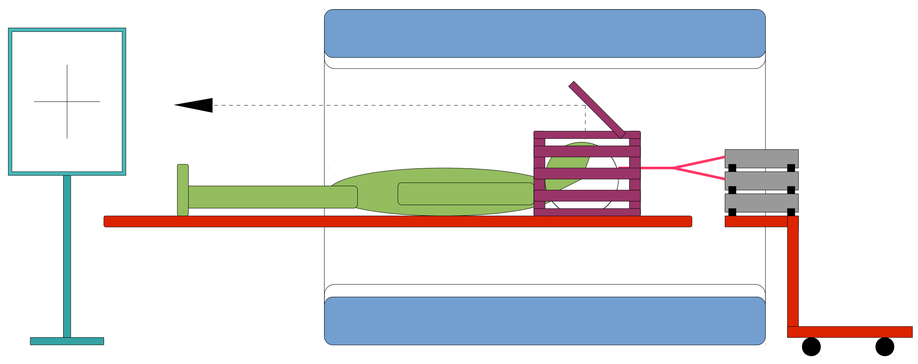

Figure 1: Simultaneous EEG-fMRI, schematic experimental setup.

The Paradigm is shown in Fig. 2. In this work we report only the right hand imagery data.

EEG recording was performed with a BrainAmp MR system:

- fMRI compatible shielded EEG amplifier (Brain Products GmbH, Gilching, Munich, Germany).
- Recorded in a Siemens Skyra 3T (Siemens AG, Munich, Germany), during an fMRI echo planar imaging (EPI) sequence. For this work we do not report the fMRI data.

EEG preprocessing: EEG recorded during fMRI sequences is heavily contaminated by artefacts:

- Gradient artefact due to gradient switching during the image acquisition.
- Cardiac related artefact, due to micro movements and blood speed changes in the high static magnetic field.

For both artefact types, we used the template subtraction approach introduced by Allen et al. [3], [4] and as implemented in the BrainVision Analyzer2 software (Brain Products GmbH, Gilching, Munich, Germany) for artefact reduction.

ERDS map: The event-related desynchronization/synchronization (ERDS) time-frequency maps were computed according to ref. [5].

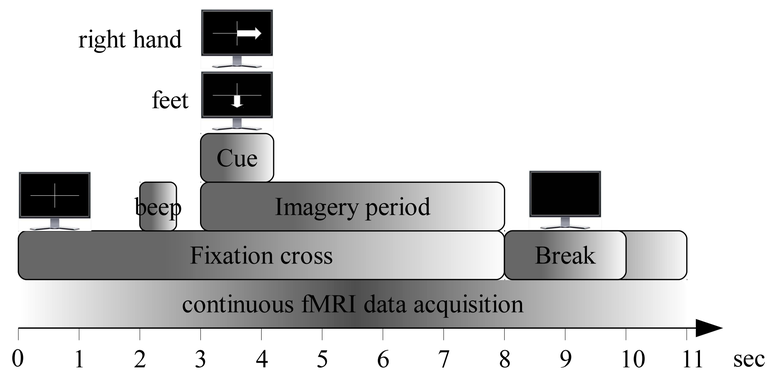

Figure 2: EEG recorded by a standard cue-based Graz-BCI paradigm [2].

Single trial classification: We used two time segments of each trial's laplacian derivation at C3:

- Rest condition(start t = 1 s, length 1 s).
- MI condition (start t = 4.5 s, length 1 s).

We calculated the log band power of the segment's Fourier transformations and used two bands (11-12 Hz and 21-22 Hz) of the values as features for a linear discriminant analysis (LDA). To estimate a single trial classification accuracy, we used a leave-one-out-cross-validation (LOOCV).

Results

Fig. 3 A was calculated with the data recorded simultaneously with fMRI (30 trials). Fig. 3 B was calculated using data measured outside the scanner (90 trials).
78,33% of the samples were correctly classified in the LOOCV. The chance level was 64,54%.

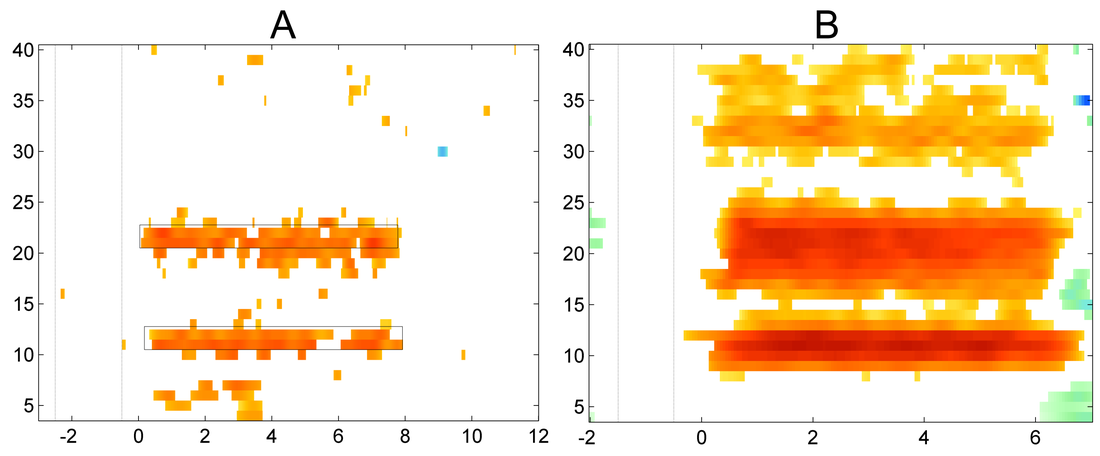

Figure 3: ERDS maps (BP). Part A: Inside the scanner, 30 trials. Part B: Outside the scanner, 90 trials. Lap C3, fs: 250/512 Hz, Bootstrap significance test ($\alpha = 0.01$)

Discussion

- Similar patterns found (mu band and beta band).
- Due to more trials, the patterns are more pronounced in Fig. 3 B.
- ERD/S is mostly preserved by the artefacts correction algorithms.
- Nevertheless, the computed LOOCV accuracy of 78 % points on potential improvements, as the participant is known to achieve up to 100 % accuracy outside the scanner.

Summing up, ERDS phenomena can be classified on single trial basis although when the raw EEG is contaminated with fMRI related artefacts, but there is potential for improvements.

References

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