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Design of an Experimental Platform for Hybrid EEG-fMRI Neurofeedback Studies

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E-Poster

Introduction:

Neurofeedback (NF) can be defined as the self-regulated change of a particular brain activity that is reflected in the change of a neural signal or a combination of neural signals such as EEG, fMRI, MEG, etc. There exist a variety of unimodal (i.e. EEG or fMRI) NF researches [1-2], but very few with multimodal NF applications [3]. This is primarily because of the associated technical burdens [4-6].

The purpose of this abstract is to give a technical description of the hybrid EEG-fMRI system that we have developed for our NF experiments as part of the project Hemisfer¹, including the hardware/software components and their roles.

Methods:

Our system is based on the integration and the synchronization of MR-compatible EEG and fMRI acquisitions.

The EEG signals are acquired with a 64 channel MR-compatible solution from Brain Products (BP)². The system uses a synchronization module to achieve EEG-fMRI phase synchronization, necessary for the MR gradient artifact removal [7] and an ECG channel for ballistocardiogram artifact removal [8]. These artifacts are filtered in real-time using the vendor's software (*RecView*). Next, the EEG data is sent via TCP/IP to the *EEG object* in Matlab. This object can pre-process, filter, extract features, train NF models and estimate EEG-NF in real-time. The results are sent to *Joint NF*. The MR imaging is performed on a 3T Verio Siemens scanner (VB17) with a 12-ch head coil. High resolution structural 3D T1 is acquired, followed by task-related EPI acquisitions (TR/TE=2000/23ms, 2x2x4mm³ voxel size, 32 slices). The fMRI data is sent to the acquisition computer using a client/server buffer solution from FieldTrip³. The fMRI data is received and processed in real-time by the *fMRI object* in Matlab/SPM8. Besides acquisition, this object can pre-process volumes (i.e. realignment, slice-time correction, smoothing), extract ROI(s) and features, train NF models, and estimate fMRI-NF. The NF results are sent to the *Joint NF*.

The *Joint NF* does the fusion (i.e. averaging, normalizing, modeling, etc.) of the EEG and fMRI NFs, and then sends the results to *Visualize*. *Visualize* controls the display that communicates with the subject. It has a collection of visual objects (Matlab/Psychtoolbox) for explaining the NF tasks (i.e. texts) and for animating the NF representation (i.e. 2D/3D objects). Tasks/NF are transmitted using the NordicNeuroLab⁴ hardware.

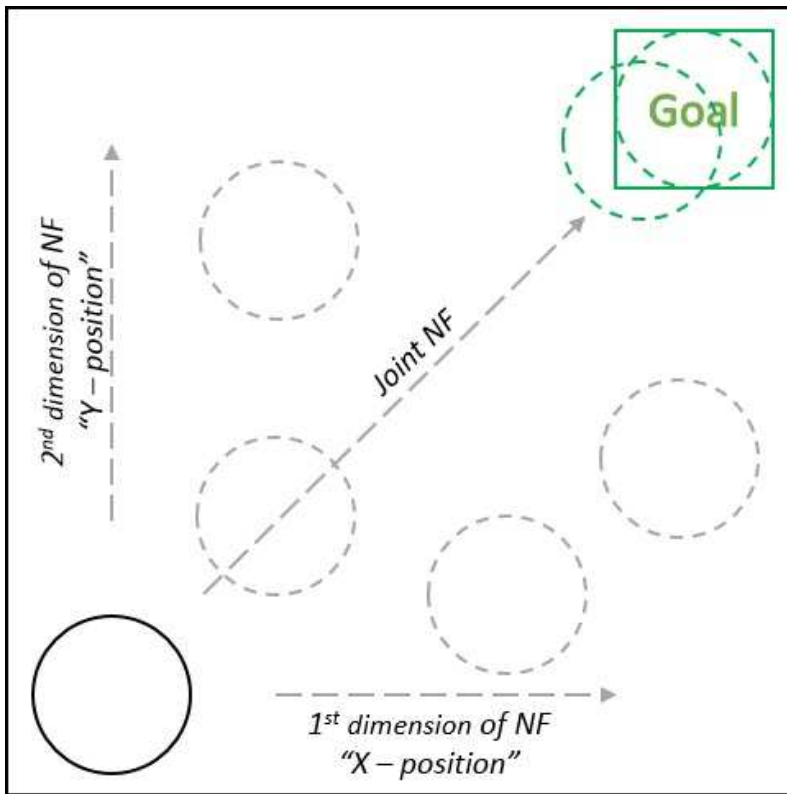


Figure 2. The NF task is to put the white circle into the green box (goal). The system uses the brain activity (EEG & fMRI) to estimate the NF and then translates it into 2D motion of the circle toward the goal.

Conclusions:

The system presented here offers a reliable platform for the hybrid EEG-fMRI NF experiments in our project. Its modular architecture is easily adaptable to different experimental environments, and offers high efficiency for optimal real-time NF applications.

¹<http://www.hemisfer.cominlabs.ueb.eu/>

²<http://www.brainproducts.com/>

³<http://www.fieldtriptoolbox.org/>

⁴<http://www.nordicneurolab.com>

Imaging Methods:

Anatomical MRI
BOLD fMRI
EEG

Modeling and Analysis Methods:

Methods Development ¹
Multivariate modeling ²

Poster Session:

Poster Session - Monday

Keywords:

Electroencephalography (EEG)
FUNCTIONAL MRI
Other - Neurofeedback, real-time EEG, real-time fMRI, system desing

¹²Indicates the priority used for review

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Yes

Please indicate below if your study was a "resting state" or "task-activation" study.

Task-activation

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

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Internal Review Board (IRB) or Animal Use and Care Committee (AUC) Approval. Please indicate approval below. Please note: Failure to have IRB or AUC approval, if applicable will lead to automatic rejection of abstract.

Not applicable

Please indicate which methods were used in your research:

Functional MRI
EEG/ERP
Structural MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

SPM
Other, Please list - Brain Vision, FieldTrip, Psychtoolbox

Provide references in author date format

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