Functional MRI constrained EEG sources localization for brain state classification

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Introduction Functional MRI has been shown to be capable of decode human mind states [1]; for example, to classify brain responses to categorical visual stimuli [2]. However, due to fMRI's high cost and restrictive environment, it is not practical for routine use in brain-computer interface (BCI). In contrast, EEG is more practical for BCI. In this study, we examined the feasibility of using fMRI to assist EEG signal classification by transforming scalp EEG into corresponding source activation patterns. Our approach demonstrated a dramatic improvement in classification accuracy (than usual spatial filtering method [3]), which may be highly beneficial in BCI applications.

Method Three subjects (2M1F, 23-25 y.o.) participated in the present study with scalp EEG (a 64-channel Brain Products system) and anatomical MRI data acquired. Functional MRI was acquired from only one of the subjects separately from the EEG. We presented (duration= 500ms) 4 categories of pictures (face, building, cat and vehicle) to the subjects in a simple visual perception task. In the EEG experiment, these pictures were presented in a random order with a mean ISI of 1150 ms. In the fMRI experiment, pictures of the same category were presented in blocks with random order.

SPM8 (http://www.fil.ion.ucl.ac.uk/spm/software/spm8) was used for MRI data analysis and EEG source localization. The locations of scalp electrodes were co-registered with anatomical MRI data using a 3D digitizer. With boundary-element head models generated from anatomical images, a multiple sparse priors approach (MSP) [4] was used for single trial EEG source localization in each subject. This is a current density reconstruction process with dipole positions constrained by the activations in the functional MRI data from Sub A (Fig.1). Then, the source signals within the time range of 140-200 ms were averaged for each node in the head model and thus an activation pattern map was generated for each trial. These patterns were feed into a support vector machine (SVM) for brain state classification. To compare with the source localization approach, single trial data were also analyzed with a spatial filtering approach [3], in which feature enhancement were achieved by projecting scalp EEG onto a linear subspace with the largest spatial variances.

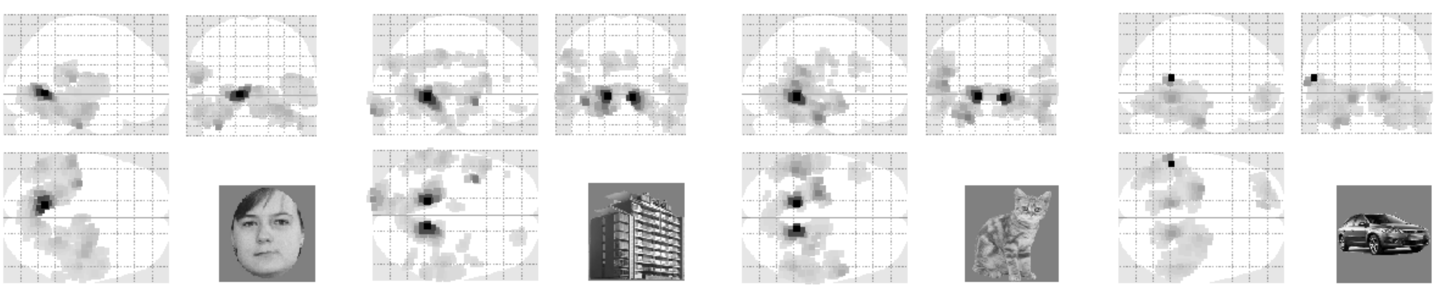

Figure 1. Current density maps of EEG sources in the 4 conditions. The maps of all subjects were constrained with fMRI from Sub A.

4-class Acc.	Source localization	Scalp EEG filtering
Sub A	99.23%	80.39%
Sub B	98.16%	80.49%
Sub C	98.38%	76.78%

Table 1. Comparison of EEG pattern classification accuracies from two feature extraction approaches.

Results Using the current density maps, the classifier achieved an accuracy of 98%-99% in distinguishing the 4 categories of visual stimuli (Table.1). In contrast, the accuracy of scalp EEG filtering approach with the same number of SVM training trials was around 80%.

Conclusion Our results indicate that (i) sources localization is a powerful features enhancement approach for noisy single trial EEG signals and (ii) this approach has potential to be used to improve BCI and mind reading.

References [1] Kay et al., 2008. Nature. 452:352. [2] Cox, Savoy, 2003. Neuroimage. 19:261. [3] Hoffmann et al, 2006. ESANN. [4] Friston et al, 2007. Neuroimage. 39:1104.

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