500 F-PM

Mutual Information Based Metric for Evaluation of fMRI Data Processing Approaches

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Introduction: Many techniques have been proposed for preprocessing and activation detection of functional magnetic resonance images (fMRI). The output of these techniques is usually a statistical parametric map (SPM). A common approach for evaluation is to estimate the receiver operating characteristic (ROC) curve using simulated datasets. However, task design, scanner type, and other experimental parameters that affect fMRI data may not be completely reflected in the simulated data. Consequently, the evaluation results are not realistic and cannot be readily generalized. Using information theory we propose a new approach for evaluating the performance of activation detection and preprocessing techniques in real (experimental) datasets.

Methods: The approach is based on the estimation of mutual information (MI) between fMRI time-series and a calculated SPM from independent datasets. MI is used to measure the amount of information lost during the extraction of an activation map from the fMRI time-series. The processing method that removes minimal relevant information from the dataset is rated superior. The MI between time-series of one experiment and a thresholded SPM calculated from independent repetitions of that experiment shows how well the label map distinguishes between the time series of active voxels and those of non-active voxels. We calculate the MI for different SPM thresholds and plot the mutual information curve (MI(l)) versus the number of detected voxels (*l*). Several processing strategies are compared and ranked using the mutual information.

Results: We use a set of simulation datasets to explore the consistency of our measure with ROC curves. The ROC curves for each of CCA (Friman O.;2001), GLM (Friston K.;1995), GLM-AR (Bullmore E.;2001), TIWT (Hossein-Zadeh Gh.A.;2003) and CVA (Nielsen FA.;1998) on the simulation datasets are shown in Fig.1. The MI curve versus number of detected voxels (*l*) for the simulation datasets is shown in Fig. 2.

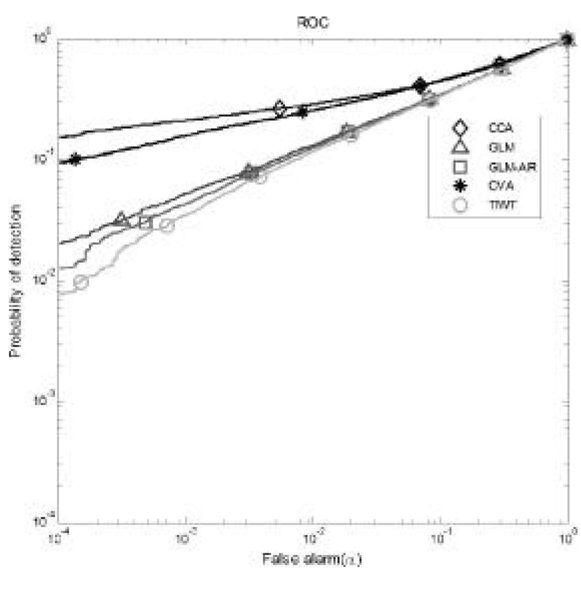

Figure 1. ROC of different methods for the simulated datasets.

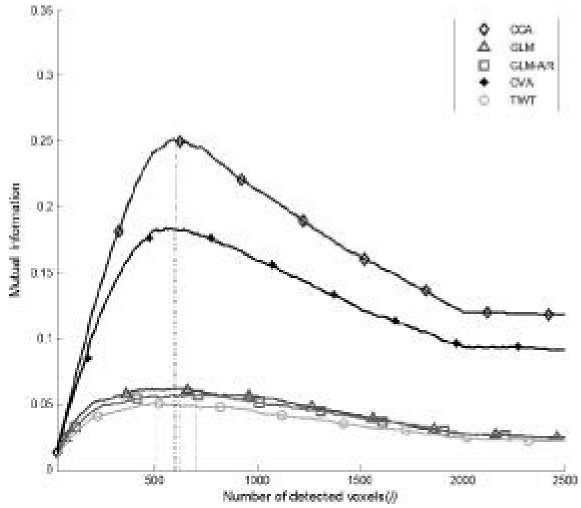

Figure 2. Mutual information MI(l) between the time-series of voxels and their labels versus the number of voxels declared active (l) for the simulated dataset.

The mutual information curves for the above mentioned methods on a set of real datasets are shown in Fig. 3. The results show that CCA has the best performance on simulation datasets and real datasets. The detected active areas using CCA and TIWT for 400 detected active voxels are shown in Fig. 4. Comparing Fig. 4(Left) and Fig. 4(Right) we can see that the detected areas using CCA are more consistent with a priori knowledge of the active areas in the motor task.

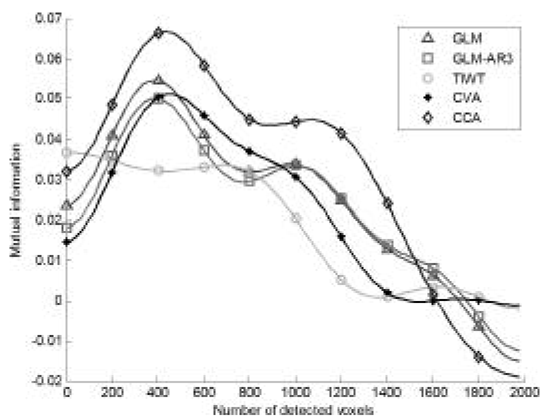

Figure 3. Mutual information (MI(l)) between the time-series of voxels and their labels versus the number of voxels declared active (l) for the motor dataset.

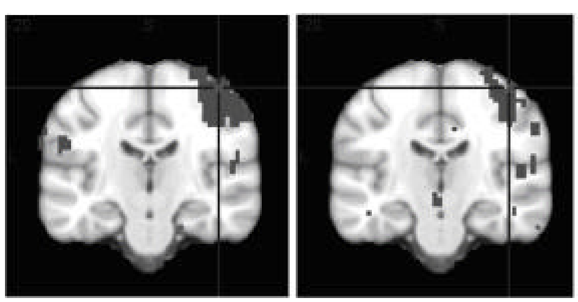

Figure 4. Detected active areas using CCA(Left) and TIWT(Right) for 400 detected active voxel.

Conclusions: In this paper, we introduce a measure based on mutual information to evaluate fMRI data processing methods without ground truth. Experimental results obtained from simulated and real datasets show that this method ranks the processing approaches tested similarly in both and matches a priori knowledge about known activation areas.

References:

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