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Noise Suppression of fMRI Data Considering Correlations in Spatial and Data Temporal Neighborhood

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Introduction

Due to high intrinsic noise in the functional images and the small effect of BOLD change on the intensity of the signal, fMRI data suffers from a low signal-to-noise ratio (SNR) [1]. As the result, functional MR images are often pre-processed for denoising before being subjected to statistical analysis.

To avoid the shortcoming of Gaussian smoothing approach, several methods have been proposed. For example, in [3], Kay et al. present GLMdenoise, a technique that improves SNR by entering noise regressors into a general linear model (GLM) analysis of fMRI data. The noise regressors are derived by conducting an initial model fit to determine voxels unrelated to the experimental paradigm, performing principal components analysis (PCA) on the time-series of these voxels, and using cross-validation to select the optimal number of principal components to use as noise regressors.

Another method for denoising fMRI data is Salimi's approach which has provided a solution for denoising fMRI data via accurate classification of ICA components [4].

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While univariate (single voxel) analysis is extensively applied in fMRI, and temporal correlations are the focus of most investigations, only a few applications investigate the spatial dependence of fMRI data. [2]

Method

In the current paper, we have proposed a new method for noise removal of functional magnetic resonance imaging by involving temporal and spatial neighborhood of each voxel in the model. Our method is as follows: At first, in the framework of GLM, we have used WLS to minimize the noise term as it can be seen in Eqn. (1):

$$E = \sum We^2 = \sum_i \sum_j \sum_k \sum_p w_{ijkp}(b_j^i - A_{j,1}\beta_1^i - \ldots - A_{j,c}\beta_c^i)(b_p^k - A_{p,1}\beta_1^k - \ldots - A_{p,c}\beta_c^k) \quad (1)$$

where b, A, and β indicate raw fMRI data, design matrix, and parameters vector, respectively. After that, we have employed the gradient descent algorithm to find the optimum values for βs. These optimum values may be reached by solving the achieved equation from the gradient descent algorithm.

Results

In order to evaluate the proposed method, we made use of simulated fMRI data which the mask activation region can be seen in Fig1. First, we have applied our method to the data and then, we used SPM12 toolbox for statistical analyzing of obtained data from our method. The result can be seen in Fig2. The result of SPM12 without applying our method to the data is illustrated in Fig3.

Conclusion

Experimental results show that current denoising method has more efficiency than the SPM's. Taking advantage of temporal and spatial neighborhood information in data makes this method beneficial.

References

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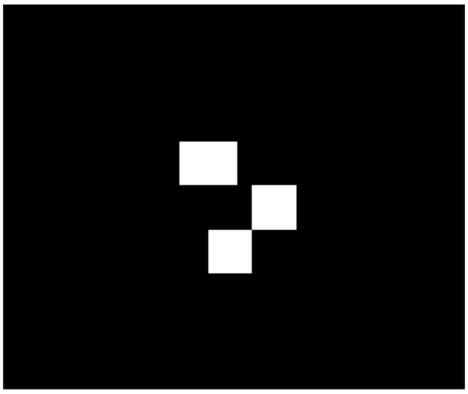

Fig1. The binary region mask for the activation of the simulated fMRI data.

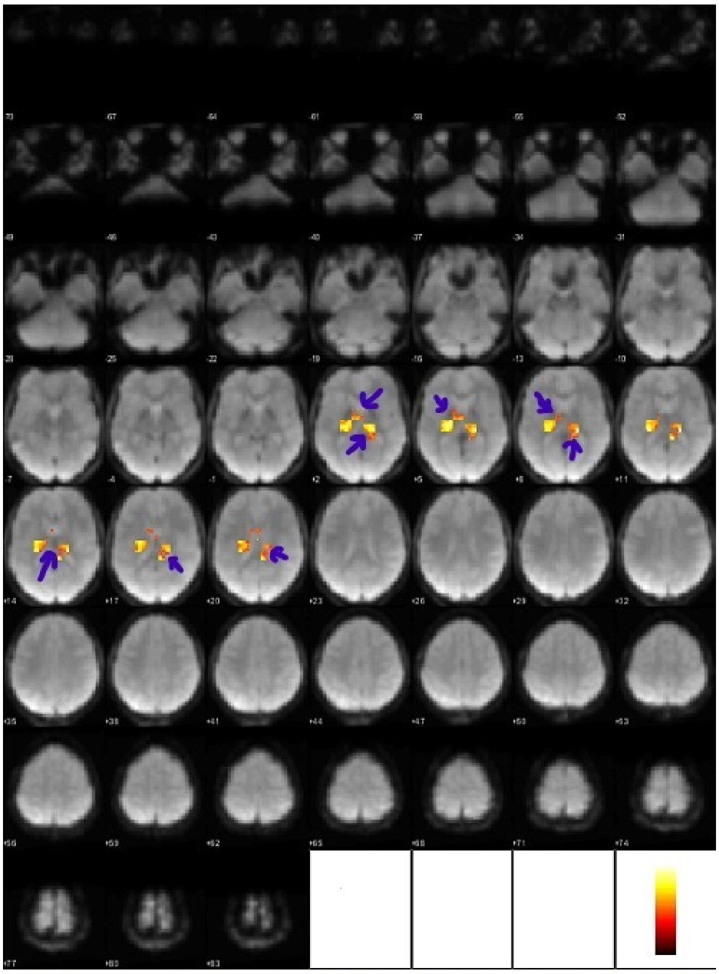

Fig2. the result of proposed method shows in this figure.the specied spots has are the differences voxels between current denoising method and SPM's.

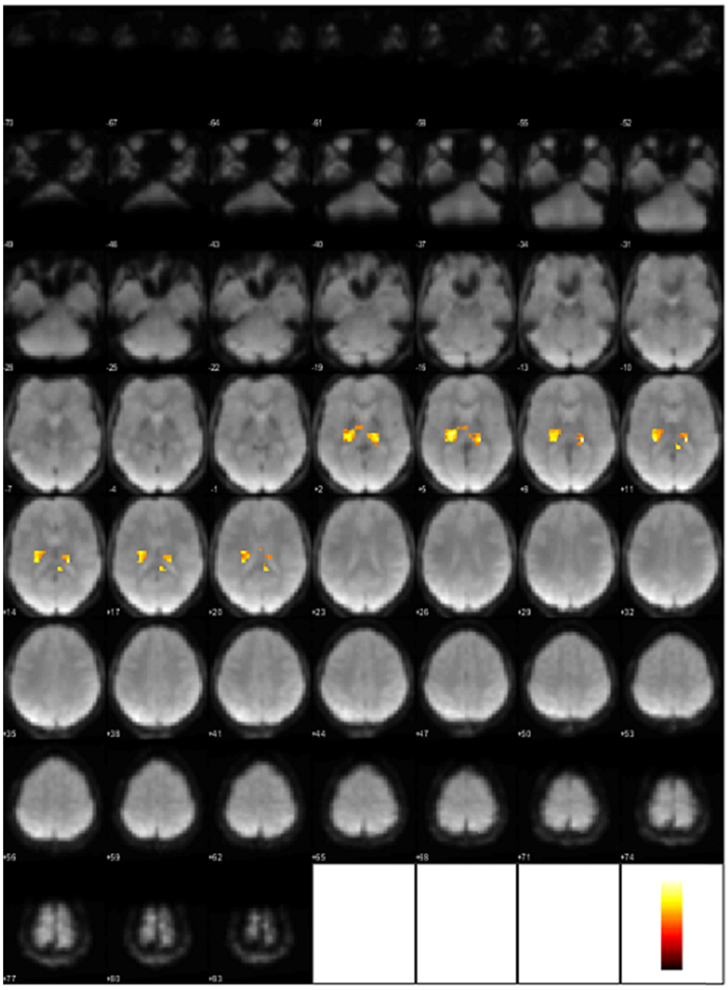

Fig3. The founded activation regions without using the proposed method.