Analysis of Brain Image Data using Sequence Analysis Techniques

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Abstract

Purpose:

To analyze the spatial patterns extracted from MRI and fMRI and facilitate searches for similar patterns in brain images based on their information content we propose the use of space filling curves and time series techniques.

Methods:

We developed a methodology for analyzing regions of interest in MRI (e.g., lesions, tumors) and fMRI (areas of brain activity). We first linearize a 3-D brain image by traversing the 3-D space using the Hilbert space-filling curve. This curve has been proved optimal in preserving the locality and clustering properties of data after the domain transformation. We then discover discriminative patterns by analyzing the spatial sequences in the transformed domain. In previous work by Kontos et al. [1], after the use of space filling curves, statistical tests of significance are applied to groups of points (that correspond to voxels) in the transformed domain to detect discriminative patterns. Here, in addition to the use of statistical tests and due to the similarity of the sequences with time series we propose the use of time series similarity techniques for further analysis of the spatial patterns. These techniques include Euclidean distance and dimensionality reduction techniq!
ues such as Discrete Fourier Transform, Discrete Wavelet Transform, Singular Value Decomposition, and Piecewise Aggregate Approximation.

Based on the distance (dissimilarity) calculated with these different methods, we performed experiments on clustering and similarity retrieval of brain images. For the experiments we used an fMRI contrast data set obtained from a study that was designed to systematically explore neuroanatomical correlates of semantic processing in Alzheimer's disease by contrasting patterns of activation in patients with those of controls during a series of semantic decision tasks. Each class of this dataset consisted of 9 subjects and the experimental results were evaluated using 9-fold cross validation.

Results:

The majority of the significant regions determined by this technique were within the medial temporal lobe. Experimental results using the time series analysis techniques when applied on the linearized brain image data showed that the discovered spatial patterns have strong discriminative power among different classes and the overall accuracy for clustering and similarity retrieval was above 90% and as high as 100% for certain experimental settings. These results are very encouraging showing that the methods are very robust and can deal with small and noisy datasets.

Conclusions:

By mapping the 3D space to 1D and applying statistical tests of significance in the linear domain, we detected discriminative patterns, which can be represented as time series. Preliminary experiments with an fMRI data set demonstrated that the employment of time series analysis methods to examine similarities among 3D images is very promising since it is very efficient and accurate.

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References:

[1] D. Kontos, V. Megalooikonomou, N. Ghubade, C. Faloutsos, "Detecting discriminative functional MRI activation patterns using space filling curves", in Proceedings of the 25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Cancun, Mexico, pp. 963-967, Sep. 2003.