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Classification and Mining of Brain Image Data Using Adaptive Recursive Partitioning Methods: Application to Alzheimer Disease and Brain Activation Patterns

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Modeling & Analysis

Abstract

Purpose:

To effectively identify discriminative spatial areas in MRI and fMRI and make image classification, similarity searches and mining of associations between spatial distributions and other clinical assessment feasible we have developed brain informatics tools that are based on adaptive recursive partitioning and use of statistical tests.

Method

We developed a methodology for classification and association mining that is based on adaptive recursive partitioning of a 3D volume into a number of hyper-rectangles. The goal is to efficiently identify spatial regions that are associated with non-spatial variables thus reducing the computational complexity of the voxel-based approach and resolving the multiple comparisons problem due to reduction on the number of tests performed. The main idea is that a particular hyper-rectangle is further partitioned if it does not have high discriminative power determined by a statistical test (chi-square/Fisher's exact, t-test, Wilcoxon rank sum test), but it is sufficiently large for further splitting. The statistical test is applied so many times as the number of partitions rather than as the number of voxels in a voxel-based analysis. In preliminary analysis, we consider, as a potential attribute for each hyper-rectangle, the sum of mean value of voxels that belong to regions of interest. The attributes of the final discriminative hyper-rectangles form new attributes that are used with classification models such as neural networks and decision trees.

Using the proposed adaptive recursive partitioning method we performed initial analysis of an fMRI Alzheimer's contrast data set. The particular study [1] was designed to systematically explore neuroanatomical correlates of semantic processing in Alzheimer disease by contrasting patterns of neural activation in patients with those of controls during a series of semantic decision tasks. These tasks were selected to differentially probe semantic knowledge of categorical, functional, and phonological congruence between word pairs. Each class of this dataset consisted of 9 subjects and the experimental results were evaluated using 9-fold cross validation.

Results

The adaptive recursive partitioning technique found certain activation areas within the medial temporal lobe that discriminate best Alzheimer patients from controls. Although the classification accuracy of statistical distance based and maximum likelihood methods was almost 50% (same as random guess) the proposed adaptive recursive partitioning technique achieved classification accuracy of 90%. This result is really impressive given the small data set of 9 controls and 9 subjects, its heterogeneity, and difficulty in generalizing the patterns observed.

Conclusions

The proposed method has been shown capable of identifying discriminative spatial areas of brain activation maps between Alzheimer and normal subjects providing also accurate classification. The proposed approach being general enough can be potential applied to elucidate structure-function relationships and be valuable to human brain mapping.

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References

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