Identifying Discriminative fMRI Activation Signatures in Alzheimer's Disease: Studying a Series of Semantic Decision Tasks

Despina Kontos1,2, Vasileios Megalooikonomou1,2, Qiang Wang1,2,James Ford3, Fillia Makedon3,Andrew Saykin4,5

1 Department of Computer and Information Sciences, Temple University, Philadelphia, PA, USA
2 Center for Information Science and Technology, Temple University, Philadelphia, PA, USA
3 Department of Computer Science, Dartmouth College, Hanover, NH, USA
4 Brain Imaging Laboratory, Departments of Psychiatry & Radiology, Dartmouth Medical School, Lebanon, NH, USA
5 New Hampshire Hospital, Concord, NH, USA

Abstract

Purpose:

To discover discriminative fMRI activation patterns in Alzheimer's disease.We have applied computationally intelligent data mining tools based on adaptive exploration of the 3D space. We study how different semantic decision tasks affect the activation levels observed in the brain of control and patient samples.

Methods:

We applied a data mining technique developed by Megalooikonomou et al. [1], which is based on adaptive recursive partitioning of the 3D space. Statistical Parametric Mapping uses voxel-wise statistical tests and reduces the multiple comparison problem using clustering approaches as a post-processing step. The technique in [1] applies statistical tests on progressively smaller regions until areas are found that have high discriminative power.

We apply this technique with the t-test, ranksum test, and correlation test. We perform analysis of fMRI Alzheimer's contrast data sets that included 9 control and 9 patient samples. The particular study [2] was designed to explore neuroanatomical correlates of semantic processing in Alzheimer disease 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: (a) Category exemplar (catx): identify word pairs with correct category exemplar relationships from among incorrect
ones, (b) Category function (catf): identify word pairs with correct category function relationships from among incorrect ones, (c) Nonsense pairs (nonpr): listen to nonsense pseudo-word pairs and decide if they are the same or different, and (d) Episodic recognition memory task (imprec): identify formerly heard words and pseudowords encountered in catx and catf tasks above versus new foils. The experimental results were evaluated with classification using 9-fold cross validation and neural networks.

Results:

The adaptive recursive partitioning technique elucidated large hemispheric and lobar effect differences between Alzheimer's patients and controls for all the semantic decision tasks. The figures show the particular areas discovered for each task. The classification accuracies were mostly over 90% depending on experimental settings such as the statistical test applied, the threshold used to stop splitting, and the size of the smallest area considered.

Conclusions:

We discovered discriminative areas of brain activation by applying computationally intelligent data mining tools on patterns of neural activation in Alzheimer's patients and controls samples during a series of semantic decision tasks.The proposed approach can be useful in assisting early diagnosis of Alzheimer's disease.

Acknowledgements:

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References:

[1] V. Megalooikonomou, D. Kontos, D. Pokrajac, A. Lazarevic, Z. Obradovic, O. Boyko, A. Saykin, J. Ford, F. Makedon, "Classification and Mining of Brain Image Data Using Adaptive Recursive Partitioning Methods: Application to Alzheimer Disease and Brain Activation Patterns", presented at the Human Brain Mapping Conference (OHBM'03), New York, NY, Jun. 2003.

[2] A.J. Saykin, L.A. Flashman, S.A. Frutiger, S.C.Johnson, A.C.Mamourian, C.H.Moritz, J.R.O'Jile, H.J. Riordan, R.B. Santulli, C.A. Smith, and J.B. Weaver, "Neuroanatomic substrates of semantic memory impairment in Alzheimer's disease: Patterns of functional MRI activation", Journal of the International Neuropsychological Society, 5,377-392, 1999.

Figures:

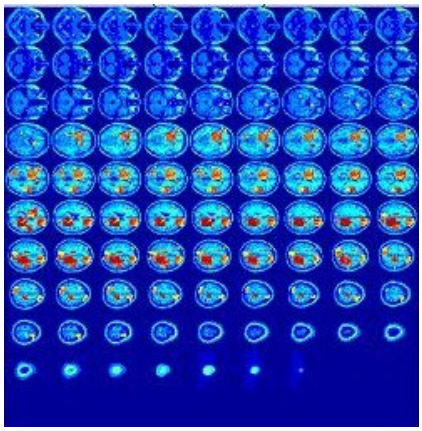

Fig.1 : Discriminative regions indicated for the CATX task when t-test was applied with significance threshold 0.01 and tree depth 4.

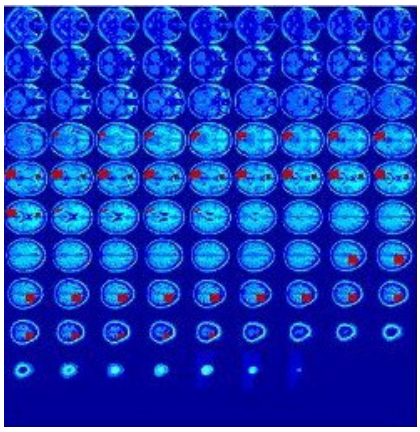

Fig.2 : Discriminative regions indicated for the CATF task when ranksum was applied with significance threshold 0.01 and tree depth 4.

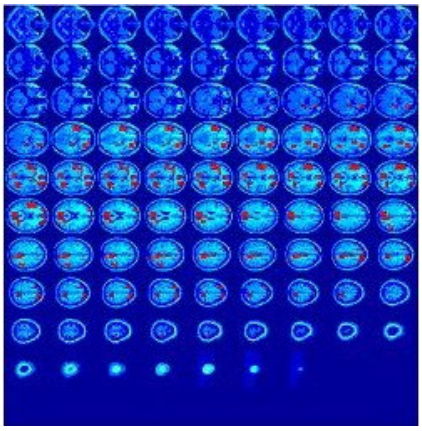

Fig.3 : Discriminative regions indicated for the IMPREC task when t-test was applied with significance threshold 0.05 and tree depth 4.

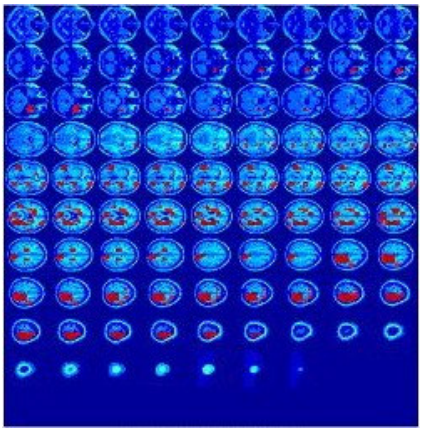

Fig.4 : Discriminative regions indicated for the NONPR task when t-test was applied with significance threshold 0.05 and tree depth 4.