A Novel Method in Functional Magnetic Resonance Imaging Analysis Based on Spatial Clustering

S. C-J. Chen[1], C-C. Chuang[2], M. Su[2], Y-T. Kuo[3], and K-S. Chuang[4]

[1]Department of Medical Imaging and Radiological Sciences, Kaohsiung Medical University, Kaohsiung, Taiwan, Taiwan, [2]National Tsing-Hua University, [3]Kaohsiung Medical University, [4]Department of Biomedical Engineering and Environmental Sciences, National Tsing-Hua University, Hsin-Chu, Taiwan, Taiwan

Introduction

When the time windows of brain responses during fMRI scans are completely unknown, like during drug stimulation or in the case of epileptic patients, paradigm-dependent methods cannot be used. The activation of brain cells is highly correlated both in time and in space. Modified temporal clustering analysis (MTCA) has been proposed to detect brain activation when the information about its timing and location are completely unknown. However, the performance of this method degrades for signals in case of low contrast noise ratio (*CNR*). In this study, we propose a new method called spatial clustering analysis (SCA) utilizing the spatial correlation that detects brain activation even in signals with low *CNR*.

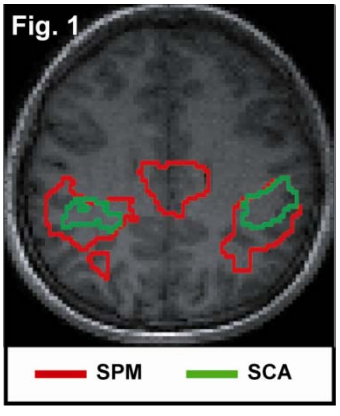
Method

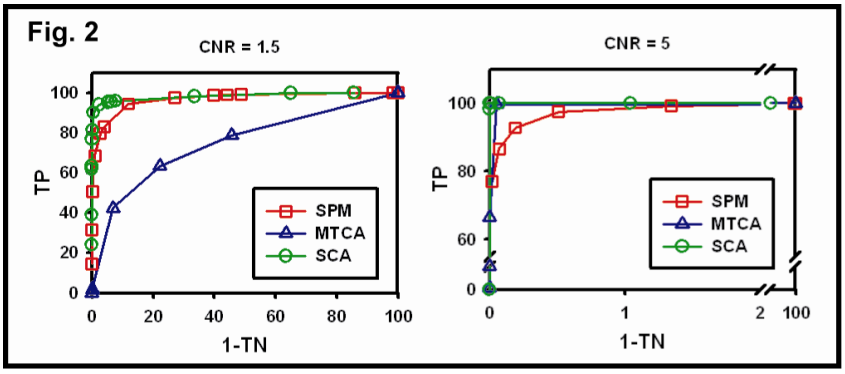
The potential time response window can be thought to be localized around the peak of the time activity curve. The determination of the time interval of the response is a two-loop process. In the first loop, a time window around the peak with a fixed window (~10s) is employed. We then calculate the correlation between each pixel and its neighborhood within this time window. If the pixel's correlation is statistically different from others we then claim the pixel is activated. In the second loop, we use these activated pixels to refine the time window of the response. For each activated pixel i, the response time window is determined from the peak and the width at half maximum at the left (B_i) and right-hand sides (E_i) of the peak. The response interval of the activation $[B_{avg}\ E_{avg}]$ is then defined to be the average of B_i and E_i of all activated pixels. The new time window is used to relocate the activated regions. For multiple events, the search of activated clusters is an iterative process. After a cluster is located, the intensities within the response time window of all pixels are replaced by zeros and the algorithm starts looking for the next potential activation time window and then the new activation regions.

Both simulated data of various *CNR* and data from *in vivo* fMRI finger-tapping task experiments are employed to compare the method. A stimulus time series convolved with a canonical hemodynamic response function (HRF) is employed to simulate the temporal response function.

Results and Discussion

Fig. 1 compares the activation maps detected by SPM and SCA. All maps are found to be inside the motor cortex area. Some differences in the activation area can be seen due to differences in the time window selected by SCA and SPM and due to the smoothing process performed in SPM. The activation map shows that the pixels involved in the activation are clustered and thus, validates our assumption that activated pixels are spatially correlated. Fig. 2 shows the ROC for activity detection on simulation data using SPM, MTCA, and SCA. When *CNR* (=5) is large, these three methods perform equally well. However, for small *CNR* (=1.5), SCA performs best with the largest area under the curve. The advantages of this method are: (1) detection of multiple peaks without prior information about the timing and number of stimuli; and (2) automatic detection of activated region regardless of the shape of the response function for each stimulus.





Reference

Yee S H and Gao J H 2002 Improved detection of time windows of brain responses in fMRI using modified temporal clustering analysis *Magn. Reson. Imaging* **20** 17-26