Software for the Visualization of fMRI Data

A. Mockus, W. F. Eddy, S. Y. Chang, K. R. Thulborn

November 24, 1997

INTRODUCTION

Reliable detection of activation regions in the human brain using fMRI studies is difficult due to relatively large, non-stationary (in spatial and time domains), and non homogeneous noise. To address this issue we introduce an interactive system to visually and quantitatively analyze large datasets of sequences of fMRI images.

METHODS

To detect activation in an fMRI study a large number of images are obtained under different experimental conditions and the averaged difference image (between the conditions) is divided by the standard error image (within the conditions) to get statistical parametric maps (SPM). The SPMs are then thresholded to obtain active regions. Due to the non-homogeneous and non-stationary noise (in time as well as in spatial domains) this technique (because it assumes stationary noise) often results in multiple spuriously active voxels with low thresholds, and many genuinely active areas of the brain do not light up with high thresholds.

We introduce interactive software to simultaneously display all the images in the fMRI study sequence as well as all the time series plots of the intensity of a signal at every voxel with the aim to visually identify bad images and/or voxels and to remove them from further consideration.

The software allows the classification of the voxels into active and inactive with regard to similarity between the time series of intensity at a voxel and the time series of the stimulus. Other classification methods in the software can employ spectral properties as well as time and spatial trends.

EXAMPLE

To demonstrate and to test our system we used a primary visual processing study as an example because of the relatively well understood nature of the underlying neural process, known locations of the active areas, and the multiple repeats of the same experiment.

The experimental paradigm was a flashing hemifield checkerboard stimulus at 8Hz alternated with a central fixation without checkerboard. The sequence 15 seconds fixation, 15 seconds right hemifield, 15 seconds fixation, 15 seconds left hemifield was repeated 5 times for a total of 300 four slice images of occipital lobes collected over 5 minutes. The imaging was performed using gradient echo, echo-planar imaging (TE=50ms, TR=1000ms, 5mm thickness, 1mm gap, 128x64 acquisition matrix, 4 slices, axial plane). The study was repeated five times.

Two sample views are provided in Figure 1.

RESULTS

The simultaneous interactive visual display of multiple images and multiple time series allows quick and robust detection of unusual images and/or voxels. Such observations can then be removed from further analysis.
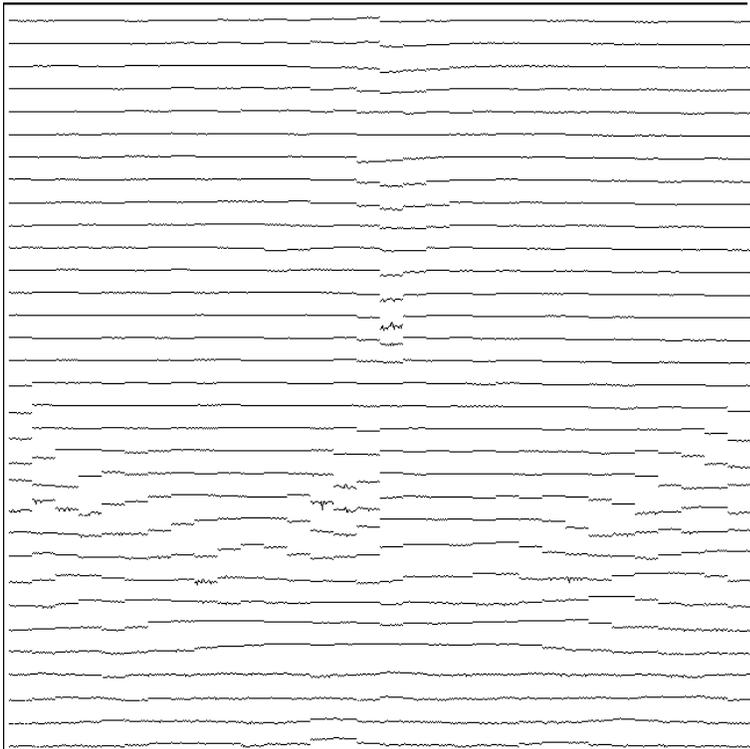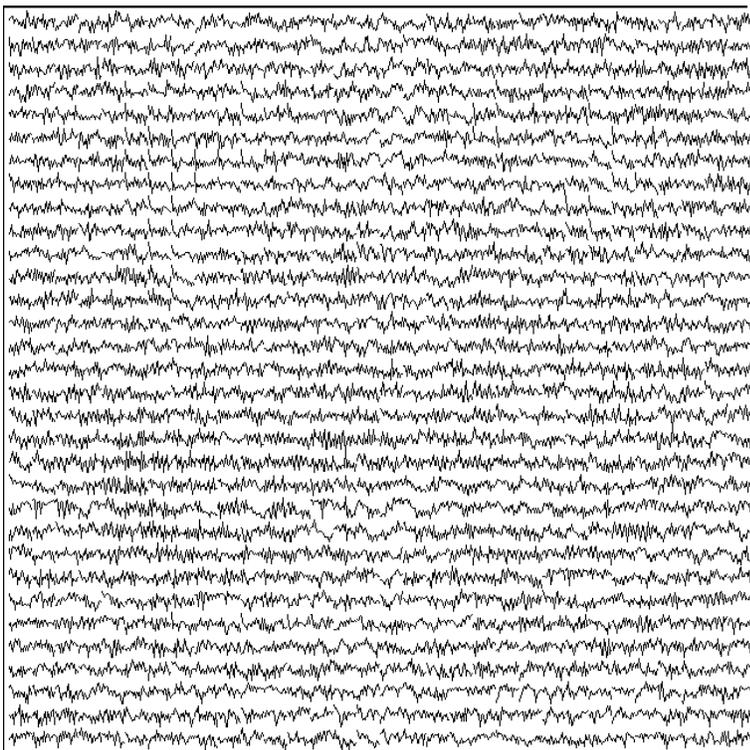
Figure 1: Two views of 32×32 time series for the pixels of the second axial slice of occipital lobes. The same scaling is used for all the time series on the left, while each time series is scaled relatively on the right.

The visual display clearly demonstrates that the preconceived notions of homogeneous and stationary noise in fMRI images are grossly violated even in a very simple fMRI study (see Figures 1 and 2).

Unusual trends in time or spatial domain can be detected and adjusted for using the array of visual representation and analysis tools available.

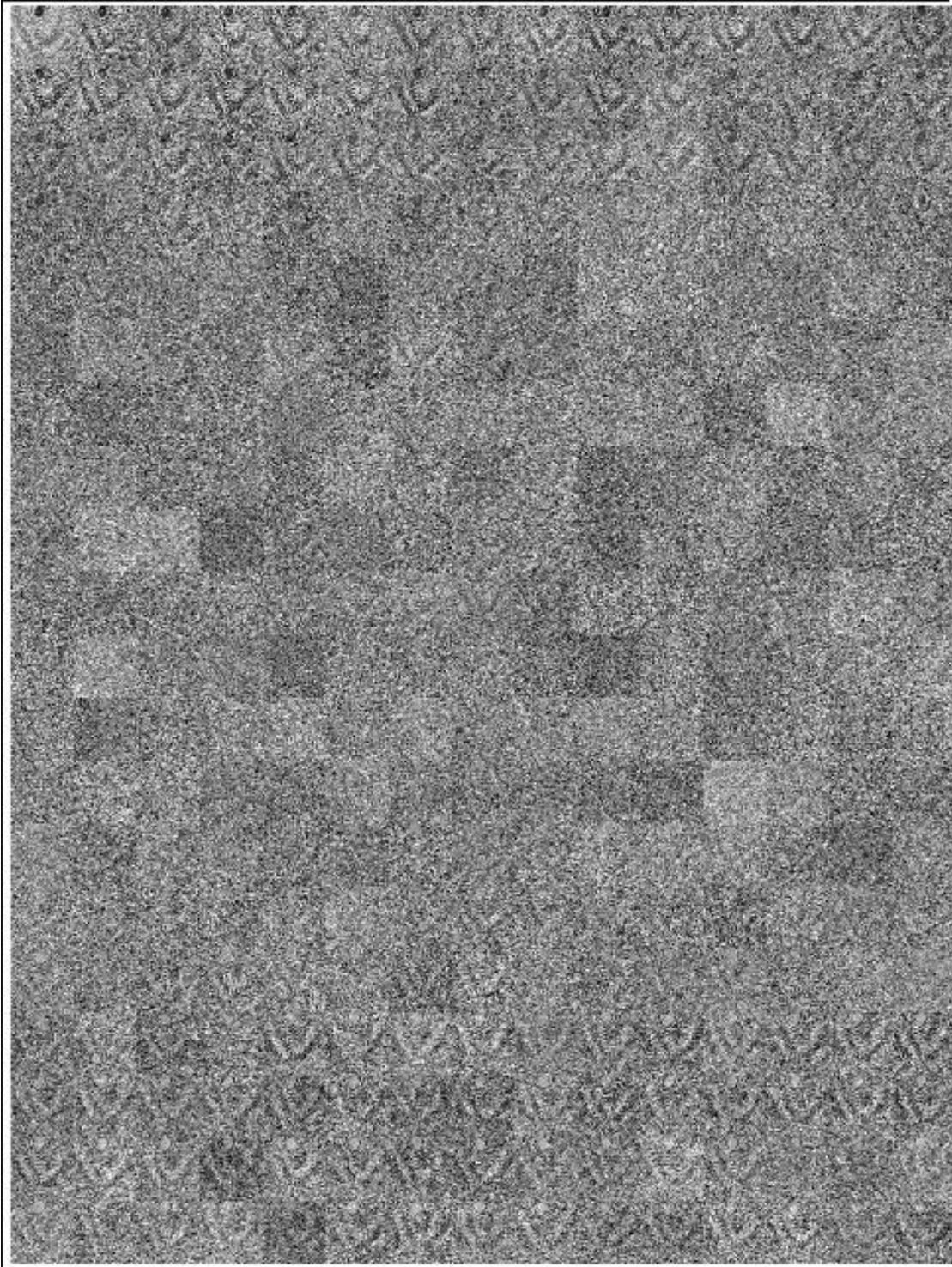Multiple activation maps at various thresholds and using different methods can be interactively generated and compared.

Figure 2: A view of 300 images (differences from the mean image) for the second axial slice of occipital lobes. Each row contains 15 (32×32 pixel) images corresponding to one stimulus condition. The apparent patterns in the beginning and in the end of the sequence demonstrate non-stationary behavior in time.