Modified bootstrap resampling technique considering temporal correlation in fMRI

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INTRODUCTION

Traditionally, Test Retest methods have been used to determine reliability of task activated parameters [1]. Recently, resampling techniques like jacknife and bootstrap [2] have been used in lieu of test retest to determine the confidence intervals of fMRI parameters. Resampling techniques assume that there is no temporal correlation in the time series data. However, this is not necessarily true in fMRI, where temporal correlation can be due to physiological perturbations like the cardiac pulsations, respiration and CSF pulsations. In this study, the bootstrap resampling technique was modified to consider temporal correlation in fMRI signal and to obtain confidence interval of various fMRI parameters.

MATERIALS AND METHODS

Five healthy volunteers (four male and one female) between 18-31 years of age were scanned after obtaining their written consents. For each experiment the dB/dt limit was kept below the approved limit specified by the FDA.

All fMRI data were obtained using a dedicated 1.5T (GE) scanner equipped with three axis, balanced torque head gradient coil and shielded end cap quadrature transmit and receive bridcage radio-frequency coil. High resolution T1 weighted anatomical image was first obtained during the during scanning sessions, where a gradient recalled at steady state (GRASS) pulse sequence with TR=600ms, TE = 10ms. FOV=24cm and a matrix size of 256x256 was used. The fMRI scan was done using a gradient recalled T2 * weighted echo planar imaging (EPI) pulse sequence, were TR = 2000ms, TE = 40ms, FOV = 24cms, and a slice thickness of 8mm. 90 sequential images were acquired during each functional MRI run.

The subjects were instructed to perform finger tapping for 20 secs in a self paced manner, alternating with 20secs of rest, for a total period of 180 secs . This ON/OFF timing was visually cued to the patients using a computer controlled stimulus delivery system.

Autocorrelation function was used on the resting data set to determine the temporal correlation in fMRI signal .The blocksize was determined by using the magnitude and the periodicity of the autocorrelated data set. Bootstrap resampling technique incorporating time dependency was performed on the task activated data set. The time series of the data set was divided into large number of blocks where the size of each was determined using the autocorrelation function. Each block was then replicated 1000 times and randomized. The corresponding ideal boxcar reference waveform was also similarly divided into blocks and randomized. Large numbers of blocks are picked from this randomized data set to match the length of time series of data set. The correlation coefficients are determined for each resampled data set. The process of randomizing and determining correlation coefficients was repeated 1000 times to obtain 1000 correlation images. The mean and standard deviation of the correlation coefficient was calculated for each voxel. The confidence interval was then determined for each voxel.

RESULTS

In this study, the block size was found to be about 6 (i.e. 12 sec) using the autocorrelation function. There were 90 time points in the functional dataset, thus the time series was divided in 15 blocks each consisting of 6 elements. The bootstrap resampling technique considering temporal correlation was repeated 1000 times resulting in 1000 correlation coefficient images .The mean of the correlation coefficient obtained at active regions incorporating temporal correlation was higher when compared to the correlation coefficients obtained without considering temporal correlation, shown in Fig (1).

CONCLUSION

Taking into account temporal correlation in fMRI signal resampling using Bootstrap Technique results in higher correlation coefficients leading to better reliability in detection of task activated regions.

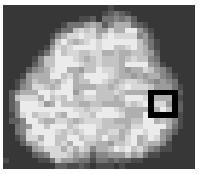

Fig 1(a)

0.41	0.65	0.23
0.18	0.61	0.62
0.42	0.58	0.71

Fig 1(b)

0.53	0.72	0..28
0.29	0.71	0.70
0.62	0.65	0.74

Fig 1(c)

Fig 1(a): fMRI image obtained during finger tapping . Fig 1(b) Represents the mean of 1000 correlation coefficients obtained using bootstrap resampling technique of the pixels within the box shown in Fig 1(a). Fig 1(c) Represents the mean of 1000 correlation coefficients obtained using bootstrap resampling technique considering temporal correlation of the pixels within the box shown in Fig 1(a).

Reference:

1. Genovese C.R, Noll D.C, Eddy W.F. Estimating test-retest reliability in functional MR Imaging. I: Statistical methodology. Magnetic resonance in Medicine. 1997:38:470-507.

2.Biswal B B, Taylor P A, Ulmer J L, Use of Jacknife Resampling Technique to Estimate the Confidence Interval of fMRI Parameters, Journal of Computer Assisted Tomography, 2001; 25:113-120.