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Research Article

fMRI Image Analysis using Pixel Neighborhood Segmentation Techniques

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Abstract

The FMRI images are spatially noisy and require a great amount of image pre-processing operations in order to extract the desired trend. Further, the direct implementation of spatial filter on fMRI images using loops is not computationally efficient and takes long time. Therefore, the dimension of the fMRI image data has to be brought down by using the principal component analysis. In fact, after using the PCA on fMRI data, the image data should come to the order from where they can be processed spatially using the image processing techniques. Therefore, specific spatial filters that filter out noisy pixels in 2-d in form of pixels and later on voxels in 3-d, at a high speed are the requirement of the presented work. This task is taken up by bringing the fMRI image to 2-d image frames. In the existing MRI analysis, it never gives estimation about the correlation between particular activity the person is engaged in, and the brain thematic region. However, this can be approximated by statistically analyzing the MRI images after stimulated by engaging the person under scanner towards a target functional activity e.g. by giving some logical calculation. Also, the brain mapping or functional MRI predictions is multivariate problem where, the observations are less than the variables comprising that observation. This problem has been framed in statistical domain and a penalized function methodology has been adopted to correlate the functional activity to the particular brain area.

Keywords: *fMRI Image, Pixel Neighborhood Segmentation etc.*

Introduction

The brain, like any other organ in the body requires a steady supply of oxygen in order to metabolize glucose to provide energy. This oxygen is supplied by the component of blood called haemoglobin that has magnetic properties which can be measured in a certain volume of oxygen present in the brain. This volumetric dependency gave rise to a method for measuring the brain activation using MRI, commonly known as Functional Magnetic Resonance Imaging (fMRI).

Functional MRI presents an imagery view of the brain activity by quantifying the blood oxygen level dependant (BOLD) based electronic signals. The blood flow increases in the area of brain where some activity is triggered. This gives rise to depletion of previous blood with that of new blood stream. The depleted blood is less magnetic in nature than that of the fresh blood that goes into the respective area of the brain. This change in magnetic nature of blood is the basic principal behind the functional MRI. The contrast due to the BOLD effect combined with fast acquisition techniques, allows the visualization of certain brain processes. However, such contrast changes are not directly visible, which implicates the use of computational algorithms for the visualization of these same areas.

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However, the measurement of change in magnetic behaviour of blood is very noisy. But fMRI is the only best known source till today in order to analyze the brain activity.

In the presented wok, it s proposed to segment the given fMRI image within from the section of the brain where a strong change of magnetic behavior is observed. This change in behavior is estimated via the voxels group analysis. There are many voxel groups active or inactive in the fMRI image data. The first task is to cluster the voxels of same group and second task is to analyze how far is one cluster from other cluster. The voxels groups may be categorized based on F-test or ANOVA test depending upon the suitability of the method in terms of computational efficiency. Focus on voxels groups that seems to be active may be enhanced to some extent so as to give a brighter picture of the brain activity.

Related Works

The presented work emphasis on effect of background image in combination with face image. Further, the stimulus of fear factor based on some degree of frightened conditions, contribute significantly in the change in BOLD levels in fMRI images. Therefore, the BOLD regions could be segmented in an efficient manner using the image processing tools. The segmented BOLD regions may be statistically analysed for progress of the activated regions based on area, size or dia. The same may confirmed by

reproducing the fear factor by different means and segmenting the BOLD regions and again analyzing (T. Shimada *et al*, 2007)

fMRI image analysis and related tools are discussed in length. A time series analysis of brain activity based data is suggested and validated. A region of curve based segmentation technique is suggested. Four methods of fMRI analysis are discussed and validated. SPM method has come out to be the best performing method among all (J. Yang *et al*, 1997)

Effect of event related BOLD size variation is studied. The BOLD regions are segmented using the region of interest based algorithms. Independent component analysis and least mean square algorithm is discussed for analysis of the hypothesis driven brain activities (M. Mckeown *et al*, 2006)

Principal component analysis is made on fMRI images for brain mapping activities. The work gives an approach for selecting optimal components for discriminant analysis. Such an approach is useful when further detailed analyses for discrimination or characterization requires dimensionality reduction (J.Liu *et al* ,2008)

An independent component analysis is suggested minimum description length (MDL) criteria. The fMRI images are dimensionally reduced in order to improve the speed of operation of brain mapping analysis (M.Akhbari *et al*, 2009)

A stroke impact has been studied in fMRI image data. A feed forward back-propagation neural network is trained using different case studies of stroke impact patients. A set of weight vector is inference out for testing the fMRI data from unknown sources other that those of training data. The results are up to the mark and showed good correlation among the brain activity and BOLD regions (R.Carrillo *et al*, 2009)

A cocaine addiction based activity is mapped using fMRI image analysis. The fMRI images are exposed to sparse matrix regularization algorithm. The dimension is reduced in spatial domain and BOLD regions are segmented using k-means support. The size and area related parameters are computed in each fMRI image frame and results are deduced and mapped with that of differently cocaine addicted persons for validation purposes (K.Gkirtzou *et al*, 2013)

Proposed Algorithm

The proposed algorithm consists of the following parts:
MRI images raw data set preparation/collection from available sources

- Development of MRI image format reader in matlab
- PCA analysis of fMRI image data to brought down to 2-d images
- Spatial Smoothening of 2-d images and later on fMRI images
- Activation area detection and prediction using statistical analysis (penalization methodology)
- Analysis and Validation of the detected brain area

Following scheme is adopted to achieve the above mentioned objectives:

- MRI images raw data set preparation/collection from available sources
- MRI raw data can be availed form the open source www.openfmri.com. The available data is in nii.gtz format. A single subject fMRI image data may be of the order of GBs.
- Development of MRI image format reader in matlab
- The available fMRI data is in nii.gtz, .hdr and .img format. The image data has to be read in matlab as one of the primary step in the proposed thesis work. The available tool for reading of the same is SPM, MRI, mricron and file viewer.
- Spatial Smoothening of fMRI images

The fMRI data is very noisy due to high magnetic susceptibility towards head movement and other environmental conditions. Therefore, Spatial filters are required to correct the fMRI data for analysis purposes.
Activation area detection and prediction using statistical analysis (penalization methodology)

fMRI image analysis is multivariate analysis problem i.e. no. of observations are less than the variables comprising the observations.

Analysis and Validation of the detected brain area

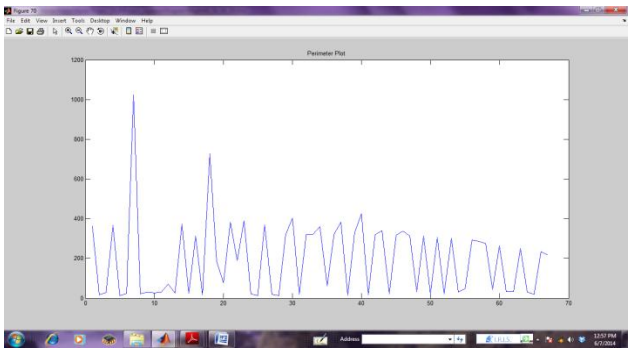

Fig. 1 (Perimeter Plot)

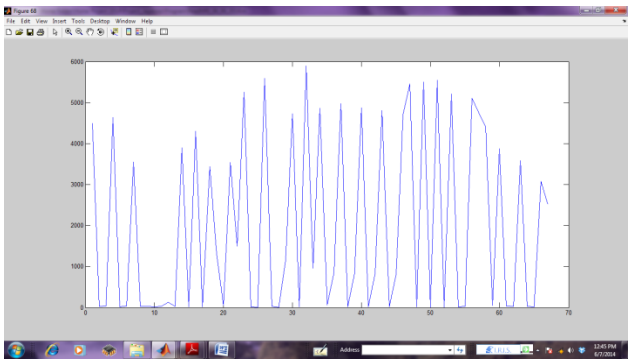

Fig. 2 (Area Plot)

Above graph represents the fmri image segmented parts vs their respective area and perimeter profile signature for a person under sleeping or resting mode. The same can be validated and confirmed when more no. of FMRI images are brought under the algorithm process.

Conclusion

The proposed technique of segmentation using pixel neighborhood technique has been proved to be an accurate

segmentation algorithm as the MRI images are sharp in nature and provide a good clustering base based on pixel neighborhood.An 8-pixel connectivity is used in the presented case i.e. all around search is performed for the labeling of the segmented part in the given MRI image segment. The area of each segment is stored in an area array and the index is maintained according the segment number. The algorithm is performed over the entire images frames in the MRI video sequence and analysis is made based on area variation. The area variation becomes the signature of the brain activity and can be mapped with the person's activity under scanner.

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