Diffusion Tensor Imaging with Pattern and Surface-based Morphometry-An Analysis of Brain Activity Changes with Image Compression

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ABSTRACT
Human brain consists of million neurons. Diffusion tensor imaging is an advanced technique to measure the nervous system tissues. Imaging has been a powerful technique to navigate us through this vast entity and identify the places where biological events of interest occur. Pattern based morphometry is an application for measuring the change in brain parametric mapping. Morphometry is identifying and characterizing differences and correlation between brain shapes among population. Study of brain activities has drawn attention among many researchers on different diseases counting schizophrenia, autism, Alzheimer and Turner's syndrome. Morphometric analysis forces a pact between sensitivity and specificity that has drawn attention. A novel technique that illustrates the neurological study of brain with DTI and various patterns of morphometric brain change. To keep the localization and sensitivity contributed by the analyses, while maintaining the specificity and sensitivity. The aim of this paper is to increase the specificity, and to study the neurological change across the groups with image compression.

KEYWORDS: Brain, image matching, image registration, image analysis, magnetic resonance imaging (MRI), Multivariate analysis, Pattern based morphometry (PBM), Surface based Morphometry (SBM), Diffusion tensor imaging (DTI)

INTRODUCTION
These days Medical Imaging with Biomedical Engineering has become a part in clinical applications. Detecting modification in non-biological structure could be a difficult task which can be either longitudinal or cross-scale[4]. Estimates of survey are reliant on numerous factors. Some factors are with the images and others with its methods. There are diverse forms of examination of brain such as Single-photon emission computed tomography (SPECT), Computed tomography (CT), Positron Emission Tomography (PET), and Magnetic resonance imaging (MRI). In this MRI is widely used to detect abnormality localization in patients which is subjected to noise while segmentation.

To detect the neurological change across groups DTI signifies translational motion. Diffusion tensor imaging of live and fixed brains reveals three important facts: (1) move of liquid molecules; (2) DTI uses this liquid motion as a probe to infer the neuroanatomy; and (3) the information DTI carries is dominated by anatomy and less influenced by physiology. Deformation varies in different ways (i.e.) the amount of...
deformation depends on the morphology of the subject. Image compression is used to analyse among the group, where large amount of data is used.

Fig. 1: Six regions present in brain image usually used for morphometric analysis.

Figure-2. Transistional liquid molecules.

In this paper we will exploit a new technique Diffusion Tensor Imaging (DTI) along with Pattern and Surface based Morphometry (PBM) and (SBM), in which former is a data driven technique and later measures geometric models of cortical surfaces.

Background:

The specificity of region-based approach along with the boundary-based approach were used to combine the localization and sensitivity advantages. By using TBM we can find the volume changes typically that appear at tissue boundaries in homogenous brain regions [1]. Brain registration is also one of the tools used for studying morphometry. Registration can be difficult depending on anatomical variability and complexity in structures. Log-jacobian images of such warps should be uniformly close to zero [1].

Multiple atlases of brain MRI is collected across subjects and computed. For atlases OASIS (Open Access series of Imaging Studies) database is used that range from 18 to 96[15].

Fig. 3: Atlases across different ages for subjects in the OASIS data set.

The atlases compute sharpness and features of image to higher degree. A method to overlay the images from their source and the manipulation of their transparency attributes or by assigning them to different color channels. Image fusion can be performed at three different levels 1.Pixel/data level, 2.Feature/attribute level and 3.Symbol/decision level. These are done to serve for different purposes. Fusion rule is being used here to determine the fusion results [12].

Multistructure diffeomorphic registration approach to approve accuracy and robustness [2]. Many Group-based Neuroanatomical studies is the extraction of morphometric features that can be used for characterization of anatomical variability across or within groups .This study has approaches like voxel-based and tensor-based. Voxel-based morphometry computes the changes in volume due to registration [6]. It generates specific hypothesis about brain changes overtime. It is an automated technique that has grown in popularity .It uses statistics to identify difference in brain anatomy between collections of subjects, which in turn can be used to assume the presence of atrophy or, less normally, tissue development in subjects with disease.
Tensor-based morphometry is done in deformation fields. TBM uses the log-determinant Jacobians. Studies the longitudinal changes. The image determines the multistucture and MRI-based approach. Elevated specific absorption rate (SAR) associated with increased main magnetic field strength remains a major safety concern in ultra–high-field (UHF) [14]. SAR calculation requires the knowledge of electric field induced, and the local electrical properties of tissues.

Cortical thickness estimation performed [8] in-vivo via MRI is a technique to understand the progression of neuro-degenerative diseases. Longitudinal results for control and AD (Alzheimer Disease) subjects are done by three methods [4] . 1. Free surfer, 2. Laplacian, 3. Registration. Free Surfer cortical thickness pipeline processing involves intensity normalization, registration, segmentation and automatic topology correction. Laplacian method segments Gray matter (GM), White Matter (WM) and cerebro spinal fluid (CSF) is done in T1 weighted image of tissue type. Registration method calculates WM, GM & CSF segmentation and a greedy diffeomorphic registration was being used. Various methods are used to compute deformation of brain. Pattern based morphometry is used to discover this dictionary of image patterns. The identification is done using MATLAB.

Proposed Method:
To analyse these patterns we use DTI along with pattern and surface based morphometry. Here DTI is used to measure the neuroanatomy of liquid molecules. Pattern based morphometry uses the dictionary learning algorithm to characterize the differences among the groups while the surface based morphometry models the cortical surface. DTI works on the image contrast in MRI.

Algorithm used in DTI-PSBM (Diffusion Tensor Imaging with Pattern and Surface Based Morphometry) is
1. Identify the abnormality
2. Extraction of cortical surface
3. Evaluation of cortical surface
4. Diffusion Evaluation
5. Reconstruction
6. Analysis of Group

Identify The Abnormality:
Large set of different images is generated by subtracting an image in Group 1 (G1) from its neighbor Group 2 (G2). G1 contains set of images M=[a1,...,am] and G2 contains set of images N=[b1,...,bn], then the image is generated as
GOI= M – N (for all am & bn images)
Any image generated by subtracting an image in Group 1 from its neighbor in Group 2 can be expressed as a straight combination of a dictionary of image patterns that extricate the two groups. It is done to discover this dictionary of image patterns.

**Extraction Of Cortical Surface:**
Layer of cortical surface is being measured and extracted. The cortical surface has the grey matter, white matter and CSF (cerebrospinal fluid). Many manipulations are applied to the surface.

**Evaluation Of Cortical Surface:**
Evaluates grey and white matter of the simulated images and renders cerebrospinal volume from pial surface. The variational derivative of the matching term $M$ takes the form,

$$
\delta M = m(T_1, T_2, u, \nabla g(x))
$$

Where $m$ is a scalar function and $\Delta T_1(g(x))$ is the intensity gradient of $T_1$ at the location specified by $g(x)$ and $T_1$ is the target image. This generates high-dimensional morphological patterns representing group differences. Image is smoothed and reconstructed by surface-based analysis. Track changes associated with age and disease process globally.

**Diffusion Evaluation:**
Diffusion tensor imaging of live and fixed brains reveals three important facts: (1) move of liquid molecules; (2) DTI uses this liquid motion as a probe to infer the neuroanatomy; and (3) the information DTI carries is dominated by anatomy and less influenced by physiology.

$$
S_1 = PD(1 - e^{-b_1/TE/T_1}) e^{-b_2/TE/T_2} e^{-b_D/1}
$$

$$
S_2 = S_0 e^{-b_2/2}
$$

$$
S_1 = e^{-(b_2 - b_1)/D}
$$

$$
D = -\ln S_2 / (b_2 - b_1)
$$

**Fig.7:** TE (echo time) and TR (repetition time) are related to the timing and $b$ values are related to a pair of pulsed field gradients.

Then the diffusion tensor value is calculated

$$
T_x(D) = D_{xx} + D_{yy} + D_{zz}
$$

**Reconstruction:**
Image is being smoothed by the moving average smoothing technique and the image is being reconstructed.

**Group Analysis:**
Once the reconstruction has been computed, images are fed into wavelet decomposition and compressed. A group analysis is performed across control groups with the following 1. White matter 2. Grey matter 3. Cerebro Spinal Fluid and 4. Transition of liquid molecules with pattern of images which is compared with age and gender of the control groups.

**Experimental Results:**
The abnormality between groups are identified by subtracting between the groups. Then cortical surface’s grey matter, white matter and CSF (cerebrospinal fluid) are extracted where many manipulations are done.
Fig. 8: a) CSF b) WM c) GM.

By using, DTI we will infer neuroanatomy of the brain abnormality.

Fig. 9: Evaluation of diffusion tensor.

Group analysis is performed from the obtained values

Conclusion:
The technique of DTI with PBM and SBM measures volume and surface of MR images and computes the inverse consistency of it and identifies across five control groups leaving the penalty term. Sensitivity has been increased along specificity and localization. Results are to be analyzed. Future result can be on 3D brain images.

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