Pattern and Surface-based Morphometric Analysis of Brain Activity Changes with Image Compression

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Abstract-Tensor-based morphometry is a prevailing tool that automatically computes longitudinal change in brain structure. We propose a new method named as pattern based with surface based morphometry on brain changes with compression. This method is used to improve sensitivity without increase in noise. Thus it will have enhanced power to detect differences within normal aging and along the spectrum of cognitive impairment. Our propose method also used to compress magnetic resonance images (MRIs) based on compression ratio(CR), peak signal-to-noise ratio(PSNR) and encoding time.

Keywords - Brain, image matching, image registration, image analysis, magnetic resonance imaging (MRI), Multivariate analysis, Pattern based morphometry (PBM), Surface based Morphometry (SBM).

I. INTRODUCTION

Brain morphometry is a subfield of both morphometry and the brain sciences that concerned with the measurement of brain structures, changes development, aging, learning, disease and evolution. Autopsy-like dissection is generally impossible on living brains and brain morphometry starts with non-invasive neuroimaging data, obtained from magnetic resonance imaging (or MRI). These data are digital, which allows researchers to analyze the brain images further by using advanced mathematical and statistical methods such as shape quantification, multivariate analysis. This allows researchers to quantify anatomical features of the brain in terms of shape, mass, volume and to derive more specific information, such as encephalization quotient, grey matter density and white matter connectivity, gyrification, cerebrospinal fluid. These variables can then be mapped within the brain volume or on the brain surface, providing convenient way, to assess their pattern and extent more times, across individuals or even between biological species. This is rapidly evolving along with neuroimaging techniques — which deliver the underlying data but develops part independently from them, as part of the emerging field of neuroinformatics, which is concerned with developing and adapting algorithms to analyze those data.

In morphometry there are three methods, namely voxel based, deformation-based and tensor-based morphometry. Voxel based morphometry (VBM) is widely used in the neuroimaging community to infer group differences in brain morphology. VBM is effective in quantifying the group differences highly localized in space. PBM is a data driven technique and uses a dictionary learning algorithm to extract global patterns that characterize group differences. Deformation-based morphometry (DBM) is a method for identifying macroscopic anatomical differences among the brains of different population. It involves normalizing the structural MR images of a number of subjects so that they all conform to the same stereotaxic space then Multivariate statistics are applied. Tensor-based morphometry (TBM) is introduced as a method of identifying regional structural differences from the gradients of deformations fields. It encodes the relative positions of different brain structures, such as volumes, lengths and areas are encoded in their gradients. Various functions of these tensor-fields can be used to characterize shape differences. Feature-based morphometry (FBM), a new fully data-driven technique for discovering patterns of group-related anatomical structure in volumetric imagery.

Another form of morphometry involves examining the local composition of brain. The Grey and white matter voxels can be identified by image segmentation method, before apply morphometry methods- study the spatial distribution of the tissues and these are referred as voxel-based morphometry (VBM). Currently, the difficulty of computing very high resolution deformation fields (required for TBM at small scales) makes voxel-based morphometry a simple and pragmatic approach to addressing small scale differences that is within the capabilities of most research units. To compress magnetic resonance images (MRIs) based on compression ratio (CR), peak signal-to-noise ratio (PSNR) and encoding time.

II. BACKGROUND

The Kullback – Liebler Penalty Term [1] use a fluid-flow implementation in which the matching term is MI (mutual information), the velocity is computed by Gaussian convolution, and the penalty term is based on the Kullback-Liebler divergence metric and a method for change detection, called G-KL, compares it to a TBM method having no boundary information (KL). The method is so named because it incorporates the penalty term while G-KL (gradient correction to KL) also uses additional boundary information. The boundary-based information can improve the
sensitivity-localization. We compare estimates of brain change from KL and G-KL with prior estimates from independent methods of automatic brain segmentation and manual delineation. This method compare change detection between KL and G-KL in subjects having cognition of normal, mild impairment and Alzheimer’s disease, using data from Alzheimer’s Disease Neuroimaging Initiative (ADNI).

A multistructure diffeomorphic registration approach [2] that uses concurrent subcortical and cortical shape matching to guide the overall-registration. The validation experiments were carried out on openly available datasets demonstrate comparable or improved alignment of sub-cortical and cortical brain structures over leading brain registration algorithms. A group-wise average atlas built with multistructure registration accounts for greater inter-subject variability and provides more sensitive tensor-based morphometry measurements. Diffeomorphic registration algorithms that ensure the resulting transformations are one to one, invertible and smooth, are desirable because they preserve the topological properties of the underlying anatomy.

Pattern based morphometry(PBM) [3] is a data driven technique, uses a dictionary learning algorithm to extract global patterns that characterize group differences. PBM is based on K-SVD. K-SVD is a dictionary learning algorithm that has been successfully applied to problems in computer vision. The principle behind K-SVD is that it can represent a large set of images as a sparse linear combination of a small set of ‘basis images’. K-SVD solves a matrix decomposition problem to extract a dictionary of K patterns from(X). These patterns in this dictionary can be combined to reconstruct any element of X.

Voxel-based morphometry (VBM) and Surface-based analysis (SBA) [4] - VBM is a non-linear registration which allows local areas to stretch and compress. It creates a deformation field which is a map of how far each voxel in the input image must move to land at the matching point in the template image. This deformation is applied to the input image to create an image that is in voxel space - for voxel registration with the template. The deformed image is then segmented into tissue classes (gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF)) based upon the intensity in the image. The first step of SBA is the extraction of the cortical surface. Cortex is the outer layer of the brain and has an inherent 2-dimensional structure. Voxel-Based Morphometry - An Automated Technique for Assessing Structural Changes in the Brain [5] - In this method both gray and white matter volumes can be assessed by VBM, then VBM studies concentrate mainly on gray matter, Changes in white-matter are assessed more accurately using imaging techniques such as diffusion tensor imaging. A comparison of voxel and surface based cortical thickness estimation methods [6] provides a needed comparison of the surface-based method Free Surfer and two voxel-based methods using clinical data. It test the effects of computing regional statistics using two different atlases and demonstrate that this makes a significant difference to the cortical thickness, we can assess the reproducibility, and show Free Surfer has a regional standard deviation of thickness difference on same day scans that is significantly lower than either a Laplacian /Registration based method.

Cross-Scale Coefficient Selection for Volumetric Medical Image Fusion [8] a straightforward multimodal image fusion method is to overlay the source images by manipulating their transparency attributes or by assigning them to different color channels. This overlaying scheme is a fundamental approach in color fusion, a type of image fusion that uses color to expand the amount of information conveyed in a single image, but it does not necessarily enhance the image contrast or make image features more distinguishable. Image fusion can be performed at three different levels, i.e. pixel/data level, feature/attribute level, and symbol/decision, each of which serves different purposes. Multiple Atlas Construction From A Heterogeneous Brain MR Image Collection [10] - This algorithm incorporates a nearest neighbor graph (NN) is used to model the manifold structure of M and the graph partition algorithm is applied to the NN graph to compute clusters of the input images. Every atlas is computed as the mean of the images belong to each cluster on M. It is distinguished by its emphasis on the sharpness of the computed atlases and the requirement of rotational invariance.

### III PROPOSED METHOD

Methods used to analyse are pattern-based and surface-based. Pattern-based morphometry (PBM) is a data driven technique. It uses dictionary-learning algorithm to extract global patterns that characterize group-differences.

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Fig.1. Pattern and Surface-based Morphometric Compression
Surface-based analysis derive measures of morphometry from geometric models of the cortical surface. Algorithm used for Pattern-based and surface-based morphometry (P-S BM). PBM, which does not suffer from the limitations of VBM. The usual TBM algorithm optimizes an energy functional \( E \) to generate a matching \( u \) between the images. \( E \) has the format
\[
E(T_1, T_2, u) = M(T_1, T_2, u) + \lambda R(u) \tag{1}
\]
Where an image dissimilarity term and \( R \) is a regularizing penalty term, both dependent on deformation \( u \). PBM can identify subtypes of patterns that don’t necessarily involve the same brain regions and facilitate a global analysis of heterogeneous diseases. Also PBM could be extended to diffusion imaging, fMRI and longitudinal analysis.

A. Pre-processing And Change In-Synthetic Images

This is the procedure done before processing by correcting image from different errors. Different images is generated by subtracting an image in group from its neighbour group and discovers dictionary of image patterns.

B. Surface Extraction

Cortical white matter and cortical grey matter is extracted from the surface and Cerebrospinal fluid is extracted from pial surface, many manipulations are applied to the surface.

C. Evaluation Of Extraction

It 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,
\[
\frac{\partial}{\partial u} M = m(T_1, T_2, u) \nabla T_1(g(x)) \tag{2}
\]
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.

D. Brain Development

MR imaging is rarely performed during pregnancy and the neonatal period, to avoid stress of mother and child. In case of birth complications and other events, such data are being acquired. For instance, Dubois et al. analyzed gyrification in premature newborns at birth and found it to be predictive of a functional score at term-equivalent age, and Serag et al. built a 4D atlas of the developing neonatal brain which has led to the construction of brain growth curves from 28–44 weeks postmenstrual age. Beyond that, there have been a number of large-scale longitudinal MR-morphometric studies (often combined with cross-sectional approaches and other neuroimaging modalities) of normal brain development in humans.

E. Aging

While white matter increases throughout early development, adolescence, and gray matter decreases. The situation is different beyond the age of about 50 years when atrophy affects gray and possibly white matter. The convincing explanation is that, individual neurons die, leading to the loss of their cell bodies (i.e. gray matter) and their myelinated axons (i.e. white matter). The gray matter changes can be observed via both gray matter density and gyrification. The white matter loss is not nearly as clear as that for gray matter indicates that changes also occur in nonneural tissue, e.g. the vasculature or microglia.

F. Brain Disease

Brain diseases are field brain morphometry is often applied, and the volume of the literature on this is vast. Euler Integration is given by,
\[
u(x, t + \Delta t) = u(x, t) + (v - v \cdot \nabla u)\Delta t. \tag{3}
\]
This formula is based on a discrete approximation to the total time derivative of \( u \). The size of the time increment \( \Delta t \) is often varied so that a maximal displacement is not exceeded at each iteration.
G. Brain Evolution

Brain changes also accumulate over periods longer than an individual life but even though twin studies have established that human brain structure is heritable. However, in the context of disorders with a known or suspected hereditary component, more studies have compared the brain morphometry of patients with both that of non-affected controls and that of subjects at high risk for developing the disorder. The next group usually includes family members.

Postmortem samples of living or extinct species, on other hand, generally allow to obtain MR image qualities sufficient for morphometric analyses, Preservation artifacts would have to be taken. Previous MR imaging studies include specimens preserved in formalin, by freezing or in alcohol.

H. Brain Analysis

Analysis of cognitive processes in man usually involves multiple examination modalities. It maps different aspects of the brain. One or more functional modalities are involved. These different examination methods yield complimentary information about Anatomical, Metabolical and Neurophysiological state of the brain. Handling of image datasets (MRI, PET, SPECT, CCT) and signal datasets (EEG, MEG) which allows a combined analysis of these data sources in a four dimensional coordinate space x, y, z, and time.

Magnetic resonance imaging (MRI) provides detailed information about brain tumor anatomy, cellular structure and vascular supply. It's an important tool for diagnosis, treatment and monitoring of disease. This article provides an overview of brain tumor, with a focus on gliomas, followed by a description of the principles of MRI signal and image generation. It then reviews the most established MRI techniques for brain tumor imaging, and their clinical utilities for differential diagnosis, tumor grading, and response to treatment assessment. The neurosurgical applications of MRI used to maximize tumor resection while avoiding damage to healthy brain tissue are also described. Conventional MRI exploits three physical properties of tissue protons to generate signals that are imaged as areas of different contrast, which reflects, anatomy and physiology of the organ, under investigation. Protons are positively-charged particles inside the nucleus of elements’ atoms. Because it is mainly made up of water, the most abundant element in our body is hydrogen, each atom of which has one proton. To understand how the MRI signal is generated, and can imagine this proton as a minute magnet bar that moves like a spinning top.

IV EXPERIMENTAL RESULTS

OUTPUT

Fig.2, Surface Extraction

Fig.3, Normal Image

Fig.4, Abnormal Image

Fig.5, Identifying Abnormality

Fig.6, Identification Of Disease
TABLE I. VALUES FOR SYNTHETIC IMAGES COMPARED TO G-KL AND KL ESTIMATES. FOR EACH TISSUE, THE MOST ACCURATE ESTIMATES OF ACTUAL CHANGE ARE IN BOLD

<table>
<thead>
<tr>
<th>Method</th>
<th>CSF (%) change</th>
<th>Gray (%) change</th>
<th>White (%) change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Truth</td>
<td>0</td>
<td>-12.52</td>
<td>0</td>
</tr>
<tr>
<td>G-KL</td>
<td>-1.06</td>
<td>-10.79</td>
<td>+0.19</td>
</tr>
<tr>
<td>KL</td>
<td>-0.19</td>
<td>-6.88</td>
<td>-0.34</td>
</tr>
</tbody>
</table>

V CONCLUSION

Pattern-based morphometry (PBM) is a data driven technique and uses dictionary learning algorithm to extract global patterns. Surface-based analysis derives morphometric measures from geometric models of the cortical surface. The technique of PBM with SBM measures both volume and surface of MR images and computes the inverse consistency of it and identifies across three control groups leaving penalty term. Sensitivity is increased with specificity and localization.

REFERENCES

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