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A Survey on Analysis of MRI Images of Brain

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***Abstract* – Image analysis is a process where various computational techniques are applied on digital images to extract important information from the image and thereby significant conclusions from the concerned image can be obtained. Images having medical importance are now-a-days is the centre point of attraction in the field of image processing due to their high values and complications in nature. The present paper deals with a summary of the techniques and methods applied in analyzing the brain images. An image is normally analyzed from the perspective of its segmentation, edge detection, registration and morphology or motion analysis. Different types of brain images like MRI, CT, PET EEG are being used by the medical practitioners as the source for the detection of abnormalities in the brain. In the present paper, whole concentration has been given only on the MRI images. Lot many operations on MRI images of the brain are being applied. A study has been made on the techniques being applied for processing of MRI images of the brain and anysis has been made through their applications, modalities, advantages, limitations, efficiencies and results obtained by the researchers in this area.**

***Keywords* – Brain Abnormalities, CT, Image Processing, MRI.**

I. Introduction

Image analysis is a procedure employed to extract information hidden in the images. This process basically goals at identifying, analyzing and labeling the texture together with the geometry of digital images. The facts, statistics and subsequently the significance of the image are purpose of the procedures used on behalf of its development and achievement. The features by which a digital image is recognized and characterized are of spectral and symmetrical environment. Brain image analysis is a subfield of image analysis and comprises a huge range of applications [1] in detecting, diagnosing and treating brain related issues and diseases.

Detection of abnormalities is a serious and one of the sole issues in medical science. Abnormalities in the brain are the major causes for the increase in mortality among the human beings. Imaging plays a central role in the diagnosis and treatment planning of brain abnormalities. Imaging of the tumors can be done by CT scan, Ultrasound and MRI etc. The MRI (Magnetic Resonance Imaging) method is the best due to its higher resolution. But there are many problems in detection of brain abnormalities in MR imaging. An important step in most medical imaging analysis systems is to extract the boundary of an area we are interested in. Possible applications include the delineation of brain tumors in computed tomography (CT) or MRI sequences for planning radiation therapy treatment, the extraction of the epicardial and endocardial boundaries of the left ventricle for studying cardiac functions such as the pressure-volume ratio, and the volumetric measurement of absolute white and gray matters for the study of degenerative diseases.

A technique in which the data from an image are digitized and various computational techniques are applied to the data, generally with a digital computer, in order to create an enhanced image that is more useful or pleasing to a human observer, or to perform some of the interpretation and recognition tasks usually performed by humans is also known as image processing. An image is usually interpreted as a two dimensional array of brightness values, and is most familiarly represented by such patterns as those of a photographic print, slide, television screen, or movie screen. An image can be processed optically or digitally with a computer. Image processing is an active area of research in such diverse fields as medicine, astronomy, microscopy, seismology, defense, industrial quality control, and the publication and entertainment industries.

Brain images are analyzed from the perspective of the following fields of image processing:

II. Image Segmentation

In image processing, image segmentation is the process of partitioning a digital image into multiple segments or sets of pixels, also known as superpixels. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like Marching cubes. [2]

In medical imaging, segmentation is vital for feature extraction, image measurements and image display. Segmentation of the brain structure from magnetic resonance imaging (MRI) has received paramount importance as MRI distinguishes itself from other modalities and MRI can be applied in the volumetric analysis of brain tissues such as multiple sclerosis, schizophrenia, epilepsy, Parkinson's disease, Alzheimer's disease, cerebral atrophy, etc.

III. Edge Detection

Edge detection is an essential instrument in image processing, principally in the capacities of feature detection and extraction which target on classifying facts in a digital image at which the image illumination sharply changes. It refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include:

• *Edge orientation:* The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges.

• *Noise environment:* Edge detection is difficult in noisy images, since both the noise and the edges contain high-frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. This results in less accurate localization of the detected edges.

• *Edge structure:* Not all edges involve a step change in intensity. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual change in intensity. The operator needs to be chosen to be responsive to such a gradual change in those cases. Newer wavelet-based techniques actually characterize the nature of the transition for each edge in order to distinguish, for example, edges associated with hair from edges associated with a face.

IV. Image Registration

Image registration is the process of combination the different sets of data of the same object, which come from different modalities (CT, MRI, SPECT, PET etc.). Pre-processing algorithms improve image quality and image registration algorithms transform the object of images into one coordinate system. As a result, registered image would be more informative than original images. Many image processing applications like remote sensing for change detection, estimation of wind speed and direction for weather forecasting, fusion of medical images like PET-MRI, CT-PET etc need image registration. Image registration is a process of aligning two images acquired by same/different sensors, at different times or from different viewpoint. To register images, we need to determine geometric transformation that aligns images with respect to the reference image. The most common transformations are rigid, affine, projective, perspective and global. Over the years, a large range of techniques has been developed for various types of problems. There are some practical application fields of registration which can be put as: (i) Integrating information taken from different sensors (Multimodal registration), (ii) Finding changes in images taken at different times or under different conditions (Temporal registration), (iii) Inferring three dimensional information from images in which either the camera or the objects in the scene have moved (Viewpoint registration), (iv) For model based object recognition (Template registration) etc.

V. Morphology

Morphology is a comprehensive traditional process of image processing procedures that course images centered on shapes. A morphological process utilizes a structuring component to an input image while generating an output image of equal dimension.

VI. Motion Analysis

Motion analysis is a subject in image processing that lessons approaches and methods in which two or additional successive images from an image arrangement are treated to produce material centered on the deceptive motion in the images.

The categories of papers acknowledged comprise those that shield the progress and execution of procedures and approaches centered on the usage of practical mathematics and physics to resolve the succeeding sorts of difficulties by means of medical image datasets.

The first paper in this regard is a MRI brain segmentation method [3]. The procedure presented is for finding brain and contours. Also genuine computation form for EEG and MEG investigation is proposed. The work proposed in [4] is a 3D volume information segmentation centered on 2D image segments. This paper proposed in [5] an approach to threshold the histogram according to the similarity between gray levels. Such a similarity is assessed through a fuzzy measure. This method overcomes the local minima that affect most of the conventional methods. By utilizing the customer presented image mask containing the concerned regions or structural data, the half automatic segmentation method is able to produce segmented fresh volume dataset and regional data. The object centered volume apparition procedure is capable of using this segmented dataset and regional data to carry out structural centered treatment and visualization. The method described in [6] presents the geometric active contour models for detecting the edges and segmentation [7] of MRI and CT images. Method defined is based on feature matrices and then added to the novel snake paradigm S. Shenet. al [2003] proposed a paper on segmentation and preprocessing of MR images of brain. This paper describes a process for improving the segmentation of brain magnetic resonance (MR) images. It involves two stages; preprocessing and segmentation. During preprocessing, the image intensities are first

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standardized using the pixel histograms. Morphological processing is then used to remove the non-brain regions. During the segmentation process, normal and abnormal brain tissues are segmented using both the traditional fuzzy c-means (FCM) clustering algorithm, and a new improved FCM algorithm. Neighborhood effects are considered in the latter method to overcome noise. Segmentation results show that this method is more robust to noise and can improve the integrity of the segmentation performance [8]. Another automatic brain segmentation of MRI images is addressed in paper [9]; proposed method follows two steps:

i) Initial model is created first
ii) Secondly that model deformation to map the precise contour of brain.

Automatic segmentation is thus performed by following these two steps. The method described in [10] is the process of registration of brain images. The images are multimodal of MRI and SPECT. This was the big problem because of non-availability of any land mark. To overcome this problem, the method uses the anatomic invent brain properties. The method is also presented for missing information i.e., pathological cases. A hybrid method in [11] is introduced for brain segmentation in 3D MRI images. Yan Zhu et. al [1997] proposed a method for tumor boundary detection using neural network. This paper presents a new approach for detection of brain tumor boundaries in medical images using a Hopfield neural network. The boundary detection problem is formulated as an optimization process that seeks the boundary points to minimize energy functional based on an active contour model [12]. Fuzzy region growing and edge detection is introduced. The proposed technique combines the edge detection method and region growing method. In [13] a novel system is presented to segment automatically from the MRI brain images paper presented in [14] a prototype system to evaluate the performance of the proposed methods, comparing detection accuracy and robustness with 3D visualization.

Another method of segmenting heads from the MRI images is discussed in [15]; the method is introduced for reconstruction of EEG and MEG model. Brains are detected and contour as well. The method described in [16] is a hybrid method. It is the combination of parametric bias field correction (PABIC), fuzzy connectedness (FC) and atlas registration. Main theme of proposed work is to use full parameters of FC segmentation. Segmented results are then combined with PABIC algorithm to get better results. The method described in [17] is presented to segment the new born brain from MRI brain images. The algorithm is robust for adult and new born brains. The algorithm is automatic and doesn't require any manual data. The method proposed in [18] is the process of segmentation of brain MRI images [2] by using tree-cutting technique. The method has three steps:

i) Preprocessing, it gives tree labels which is then used as an input to the tree-metric graph cuts algorithm
ii) TM gives the optimal labels and
iii) TC algorithm generates mapping by seeing respected labels to tissue classes. The method described in [19] is an automatic algorithm to segment spleen area from the abdominal MRI images. First image enhancement is done. Then in order to split the image water shed and neural network methods are used. Neural network is used to train the spleen feature extraction. In [20] the difficulty is addressed in segmentation and also in estimation of volume because of less difference between the grey matter and white matter. The method used to overcome this problem makes use of purple voxels intensity to separate the blue matter and white matter. Also to determine the intensity of voxel fraction, least squares vector estimator is used. In [21] a novel method is introduced for segmentation of brain tissues MRI images. First noise is reduced and then water shed algorithm is used for segmentation. Fuzzy clustering algorithm is used to segment the non-segmented portion of brain. The method combines two processes in order to carry out the edge detection process. The processes are distant dipolar field and intermolecular multiple-quantum coherences. The results showed that method extant abundant evidence about numerous types of edges of object areas and able to detect all types of boundaries. Edge detection of CT images through canny edge detector is presented in [22]. The method makes use of canny detector together with the concept of image fusion. It has been shown through simulations of computer that proposed method can effectively edge-detect MRI images of brain as well as resistant to noise in an environment of spontaneous noise. It can also detect more edges of MRI brain images effectively as well as overcomes the canny algorithm disadvantages. Image registration for MR and CT images can be analyzed in [23]; a half programmed inflexible MR-CT registration process intended for Liver Cancer Surgery for MR images where cancer materials are clotted through ablation of microwave. The experimental results showed that registration of MRI image up to 1.45mm is achieved through the process. Another MRI registration process can be analyzed in [24]. The method is basically centered on optimizing a diffeomorphic demons cost function. Another MR images segmentation and registration method is presented in [25]. The method presents a fuzzy framework in this regard. MRI morphology can be analyzed in [26] and [27]. Table 1 gives a comparison of MRI brain images analysis methods.

Table I: Comparison of MRI Brain Images Analysis Techniques

Serial No.	Application	Advantage	Limitations	Results
1	MRI brain segmentation [3]	Has application to MRI as well as to EEG and MEG		It has been shown through results that the technique handles MRI segmentation in an effective way

2	MRI volume visualization [4]	Handles both 2D and3D data		The results show that the method gains a powerful ability of structural manipulation and volume visualization
3	Segmentation of MRI images [6]	Feature segmentation of even noisy images	Difficult formulation	Results of this technique show that it is better, fast and accurate as compared to other algorithms
4	Segmentation of MRI medical images [9]	The advantage is that the proposed method is very fast in segmentation and automatic as well	Less accurate with noisy images	Average differences are 1.7% and 2.7%
5	MRI images registration of medical sector[10]	If there is a picture with less information, it will handle it		Results show that the proposed method is better for dealing missing information pictures
6	MRI brain segmentation in medical sector[15]	Advantage of this method is that it can segment and detect brain as well as contour	Limitation is that calculation is difficult for contour detection	Proposed method shows better results for contour and brain detection as well as for segmentation
7	MRI brain sector [11]	Advantage is that it is more robust as compared to the individual implemented techniques	Limitation is that data is complex because of 3D images	Improved results are obtained through 3D segmentation of MRI Brain Images
8	MRI brain sector [13]	Advantage of this method is that it is fast and easy to understand		The proposed method is tested and compared with ordinary algorithms and it shows better results
9	Brain images of MRI [16]	Advantage of this method is that it is fast and easy to understand	Limitation is that it has greater tile of computations	The proposed method shows better results as compared to other methods and algorithms
10	Medical MRI brain department [17]	Advantage of the work is that it does not require any manual data	Limitation of this method is that it shows less accurate results on adult brain images	The suggested technique gives more accurate experimental results in comparison with existing methods
11	MRI brain department [18]	It has greater speed and accuracy and it is simple as well	Limitation is not mentioned	Results show that the method proposed is fast and more accurate as compared to algorithms already existing
12	MRI edge detection [28]	Enhances the image features		Results indicate that promising outcomes have been achieved by the method
13	MRI edge detection [29]	Provides comparison on two methods		Results indicate that SUSAN method yields superior results as compared to Sobel edge detection process
14	MRI-CT image registration [23]	Effective for both MR and CT image registration		The experimental results show that registration of MRI image up to 1.45mm is achieved through the process
15	MRI edge detection [18]	Able to detect all sorts of boundary regions		The results show that method extants abundant evidence about numerous types of edges of object areas
16	MRI edge detection [22]	Handles both noise and edge detection processes		Effective results are obtained
17	MR images segmentation and registration [25]	Handles both segmentation and registration processes		Fast and effective method in regard of MR images segmentation and registration
18	MR image morphology[26]	Fast and accurate morphology method	Computationally a bit complex	Method is robust and effective
19	MRI segmentation [27]	The method does not require any manual connections	Computationally complex	Acceptable segmentation results are achieved

VII. Conclusion

Analysis of the processed image data is one of the hot topics in imaging field where Segmentation plays vital role. Segmentation of medical images can be divided into two classifications: a) manual, semi-automatic and automatic, b) pixel based local method and region based global method. Brain MR Image is a complex system to be segmented with efficient method for having variable kind of tissues many of the methods are used for segmentation of brain images but they are time consuming. Though they are more accurate for very tiny tumor but still many of them are not so fast and takes more memory. On an average many of the method of segmentation takes around 5 to 10 sec to analyze the single data.

In the above section we discussed different methods and approaches presented in the prospect of image analysis i.e., image segmentation, edge detection, registration and motion analysis. From the above analysis we can say that huge work has been done in regard of medical image segmentation and edge detection but not much effort is carried out in the prospect of brain image registration and motion analysis. Comparison table demonstrates the effectiveness and efficiency of different methods in this prospect. This paper is based on short discussion and description of various brain image analysis methods from the perspective of brain image segmentation, brain images edge detection, brain images registration, brain images morphology and brain images motion analysis.

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