A Methodology For Segmentation Of White Matter From Brain FMRI Images

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Abstract- *Everything we do, everything we think, we feel, every wish, dream, happiness and hope is mediated by our brain. Brain is the center of nervous system. Brain is very complex in its structure. The functionality of brain can be studied by segmenting the white matter from the grey matter of the brain fMRI images which helps you find which part of the brain is active at a particular point in time for different activities. The proposed system mainly deals with the segmentation and extraction of the white matter from the brain fMRI images. The segmented white matter from the gray matter of the brain fMRI images provides accurate results to the physician which highly influences their decisions on further treatment.*

Keywords- MRI- Magnetic Resonance imaging, fMRI Images- functional Magnetic Resonance images, White matter, Grey matter

I. INTRODUCTION

The human brain is the key organ which controls and systemizes the activities in the human body [**1**]. Our brain guides us through our lives. By identifying the world around us, loading some fragment of each unique moment, cataloguing, sorting, organizing and acting on our experiences, our brain defines us.

Gray matter is a major component of the central nervous system **[2]**. It is made up of neural cell bodies. Gray matter actually has a gray-brown color which comes from capillary blood vessels and neuronal cell bodies. The function of gray matter is to route sensory or motor stimulus to inter-neurons of the CNS in order to create a response to the stimulus through chemical synapse activity. Gray matter structures process information is conveyed via specialized nerve cell. White matter is another major component of the central nervous system **[2]**. It contains bundles of myelinated nerve cell processes, which connect various gray matter areas of the brain to each other, and carry nerve impulses between neurons. White matter forms the bulk of the deep parts of the brain and the superficial parts of the spinal cord. The white matter is white as it contains fatty substance around the nerve fibers. The white matter is the tissue through which messages pass between different areas of gray matter within the nervous system. Considering in computer network analogy, the gray matter is the actual computers themselves, whereas the white matter represents the network cables connecting the computers together.

Segmentation is a process of extracting subject or structures of interest from background and each other **[2]**. Segmentation of brain tissues, together with gray matter (GM), white matter (WM), and cerebrospinal fluid, from magnetic resonance (MR) images plays an important role in both clinical practice and neuroscience research [**3**].

Segmentation of fMRI images involves separating the white matter from non-white matter. The white matter is segmented because it is clearly differentiable from the other parts of the brain. The gray matter is then drawn over the white matter.

Currently this process is being done by hand **[4]**, where they separate the white matter from the gray, matter pixel by pixel. This method is accurate, but it takes three days to just do it for the left half of the brain image, hence not feasible for an entire brain which is a stack of images. Apart from this, there are other disadvantages of manual segmentation. It is a tedious process, interpretation of the data from one observer to the other will not be the same, there is no consistency in the result obtained and the results are not reproducible.

Magnetic resonance imaging (MRI) is a medical imaging method to form pictures of the anatomy (e.g brain) and the physiological processes of the Functional magnetic resonance imaging (fMRI) is a functional neuroimaging technique of MRI technology which measures brain activity by detecting changes associated with blood flow. fMRI is one of the latest technique developed for mapping hemodynamics of neuronal and motor event related tissue blood oxygen level dependence (BOLD) in terms of brain activation (Physiological basis and image processing in functional magnetic). fMRI is used extensively for brain mapping diagnostic Radiology, Neuroradiology, Head and Neck Imaging **[5][6]**. The fMRI image when fed into the system, the user should be able to segment the white matter from the brain fMRI image automatically and efficiently.

The main advantages to fMRI technique to image brain activity related to a specific task or sensory process include:

- It does not require injections of radioactive isotopes.
- The total scan time can be very short.

The in-plane resolution of the image is formally about 1.5 x 1.5 mm though resolutions below 1mm are possible.

In this work, we have proposed the design of a novel system mainly deals with the segmentation and extraction of the white matter from the brain fMRI images. The paper is organized as below: Section 2 proposed design of segmentation using brain fMRI images, section 3 explains implementation environment and Results. Section 4 concludes our work.

II. THE PROPOSED DESIGN OF SEGMENTATION USING BRAIN FMRI IMAGES

The proposed system mainly deals with the segmentation and extraction of the white matter from the brain fMRI images. The segmented white matter from the gray matter of the brain fMRI images provides accurate results to the physician which highly influences their decisions on further treatment.

fMRI stands for functional Magnetic Resonance images. Functional Magnetic resonance imaging can be used to map changes in brain hemodynamic that corresponds to mental operations extends traditional anatomical imaging to include maps of human brain function **[7]**. With fMRI imaging one can observe both the structures and also which structures participate in specific functions **[8]**. The fMRI provides high resolution,

The new ability to directly observe brain function opens an array of new opportunities to advance our understanding of brain organization and brain functionality.

a. Working of fMRI scanner

The magnetic field is formed by passing an electric current through wire coils in most MRI units **[9]**. Other coils, located in the machine and in some cases, placed around the part of the body being imaged, send and receive radio waves, producing signals that are detected by the coils.

A computer then processes the signals and generates a series of images each of which shows a thin slice of the body. The images can then be studied from different angles.

b. fMRI scanning

Subjects or patients participating in an fMRI experiment are asked to lie still and are usually restrained with soft pads to prevent small motions from disturbing measurements. Some labs also employ bite bars to reduce motions, although these are unpopular as they can cause some discomfort to subjects. Generally motion in excess of 3 millimeters will result in unusable data. An fMRI experiments usually last between 15 minutes and 2 hours, depending on the purpose of study.

Brain image segmentation system is given in fig 1. The process begins with starting the system. The user of the system initiates the process. The program accepts input image and begins the segmentation. The input to the Brain Image Segmentation analysis system will be a grey scale image. The processing is performed over this image by the Brain Image analysis system. The segmented image consists of brain part, which is our region of interest. This segmented image will be the output.

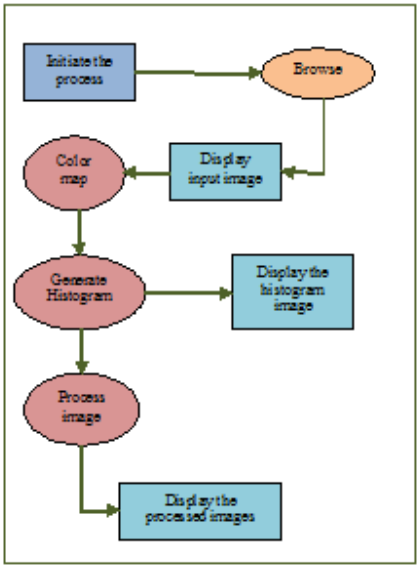

Fig 1 : Brain Image Segmentation Analysis system

The intermediate image obtained at the end of each stage will be displayed. The process continues till the completion of the processing. On completion of a process a new process can be started.

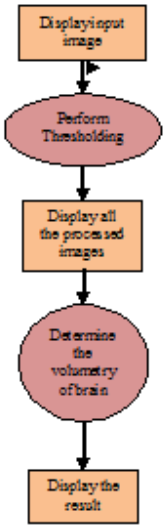

Fig 2: The segmentation process

The Fig. 2 depicts the data flow diagram for segmentation process. The input image that needs to be processed is given to segmentation process. Thresholding is performed on the input image. The final segmented image hence obtained represents the white matter of the brain

III. IMPLEMENTATION ENVIRONMENT AND RESULT

The software was tested on the following platform, and got the successful results.

CPU Speed	:	2.6 GHz
RAM	:	3.9GB
Hard Disk Capacity	:	GB
OS Used	:	Win XP XP
Tools Used	:	ITP & RIT

Unit and Integration testing was done on the following modules and executed successfully.

Module under test	Input	Output
Upload	fMRI image of type dicom	Loads the image successfully
Show_ colormap	Shows the colormap of the uploaded dicom fMRI image	Shows colormap
show_ graph	Shows the color distribution of gray and white matter in the uploaded fMRI images	Shows the hysteresis graph
Thresh_ tool	Used for the selection of threshold level	Finds the threshold level
segmentation	To perform segmentation and find the volumetric measurement of the brain image	Performs segmentation and finds volume, gray matter & white matter fraction
Upload, show_ graph	Uploading the image and then colormap is applied on the Image	Image is loaded and the colormap on the image is applied.
Upload, show_color map, show_ graph, segmentation.	Load the fMRI image, click colormap show_graph and click on segmentation button	Image is loaded, colormap is applied ,histogram displayed,segmentation is performed and volumetric measurements are shown
Exit	Close the system	Exit the system

Table 1: Test Cases

Image analysis combines techniques that compute statistics and measurements based on the gray-level intensities of the image pixels. Analyzing an image helps to understand its content and to decide which type of inspection tools to use to handle your application. Image analysis facilitates to perform basic inspection tasks such as presence or absence verification. Common tools you can use for image analysis include histograms, line profiles, and intensity measurements.

Our system deals with segmenting the white matter from brain. After segmentation is complete through visual analysis it is possible to get the quantity of brain volume, grey and white matter. But to provide detail report of the segmented images we perform analysis. Common tools used for image analysis include histograms, color map, and intensity measurements.

We use histograms to perform analysis on our input image. Histogram is a graphical representation of data distribution. It counts and graphs the total number of pixels at each grayscale level. It shows how the intensity value of an image is distributed.

During the processing stages of the image, we perform local adaptive thresholding technique on the image. Hence the image obtained after this technique will be a binary image. Below the table 2 shows the value of grey and white matter of some slices obtained.

Slice No	Brain Volume	White Matter	Grey Matter
27	0.0312	0.0190	0.0122
28	0.0308	0.0195	0.0114
29	0.0307	0.0193	0.0116
30	0.0306	0.0185	0.0120
31	0.0301	0.0165	0.0136

Table 2- Analysis results

The estimated result of this project is extracting white matter from brain image. From the output image Fig 6, physician can segment the white matter by moving the vertical line. As shown in analysis the value or the result can be obtained in the command prompt.

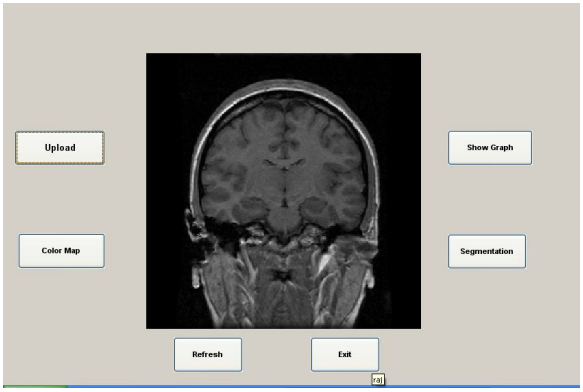

Fig 3: Application page with image input

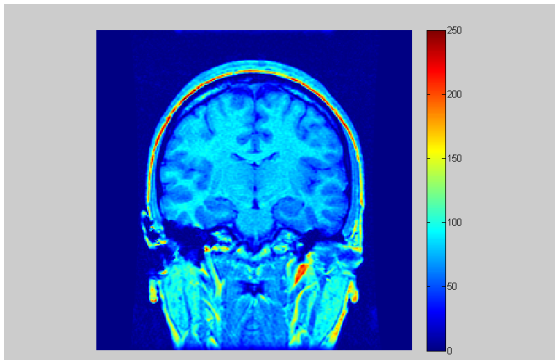

Fig 4: Color map for intensity

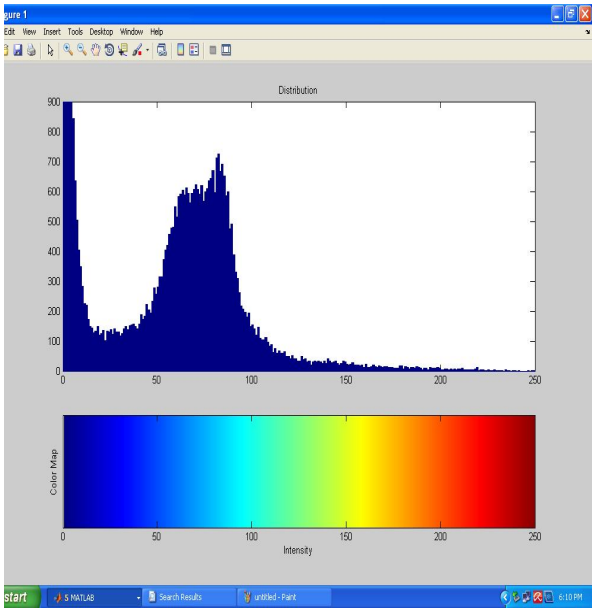

Fig 5: Histogram graph

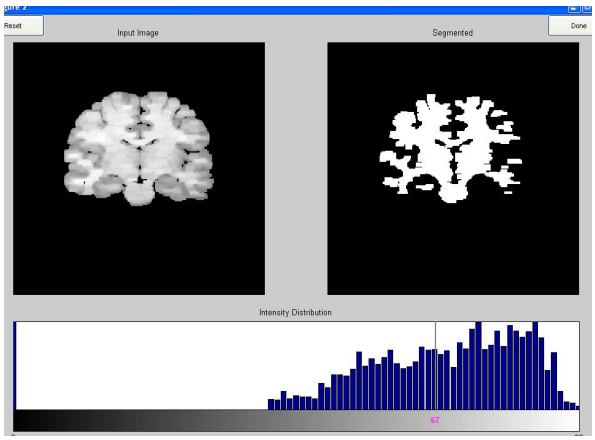

Fig 6: The result for segmented image

IV. CONCLUSION

Image segmentation plays a dynamic role in medical imaging by simplifying the explanation of regions of interest. The objective of this project is to segment the white matter from the gray matter of the brain fMRI images, to study the various functional aspects of the brain. The system is also used in defining various volumetric dimensions such as brain volume, gray matter fraction and white matter fraction. Thus, allowing the end-users to analyze the brain both qualitatively and quantitatively. The purpose serves as a guide to designers, developers and testers who are responsible for engineering the project.

The following has been achieved by our project: threshold based segmentation, Accurate location of the white matter distribution, Consumes less time, Workload on the user

is reduced, Maintainability. There is always a room for improvement. The important thing is that the system should be flexible enough for future modifications. The system has been factored into different modules to make system adapt to the further changes. Every effort has been made to cover all user requirements and make it user friendly.

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