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Magnetic Resonance Image Segmentation and its Volumetric Measurement

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***Abstract* – Image processing techniques make it possible to extract meaningful information from medical images. Magnetic resonance (MR) imaging has been widely applied in biological research and diagnostics because of its excellent soft tissue contrast, non-invasive character, high spatial resolution and easy slice selection at any orientation. The MRI-based brain volumetric is concerned with the analysis of volumes and shapes of the structural components of the human brain. It also provides a criterion, by which we recognize the presence of degenerative diseases and characterize their rates of progression to make the diagnosis and treatments as a easy task. In this paper we have proposed an automated method for volumetric measurement of Magnetic Resonance Imaging and used Self Organized Map (SOM) clustering method for their segmentations. We have used the MRI data set of 61 slices of 256×256 pixels in DICOM standard format.**

***Keywords* – MRI, CSF, Segmentation, Gray Matter, White Matter, Volumetric Measurement, SOM.**

I. INTRODUCTION

Medical imaging applications use images coming from different sources such as Magnetic Resonance Imaging (MRI), Computer Tomography (CT), Positron Emission Tomography (PET) to generate a 3D data[7].MRI presents the brain as a gray scale signal intensity range which differentiates approximately, the gray matter, white matter and CSF compartments of the brain [1]. Determination of different brain tissue volumes is valuable for progress of therapy process and planning, surgical planning and 3-D visualization of brain matter for diagnosis and abnormality detection [8]Segmentation of soft-tissue in brain images results in labeling complex structures with complicated shapes such as white matter, grey matter, CSF and other types of tissues in neurological conditions [3]. It requires high resolution MR images for the delineation of anatomical boundaries [2]. Our proposed automated segmentation method, makes it possible to estimate distributions of different tissue types in the brain and also calculates their volumes accurately.

II. ACQUISITION OF THE IMAGE

There are several types of MR sequences available for structural neuro imaging, most commonly T1-weighted, T2-weighted and Proton Density imaging. The differences in image contrast are due to the differences in relaxation properties of hydrogen nuclei between tissue types. T1-weighted imaging offers the greatest clarity between gray matter, white matter and CSF, and is therefore most frequently used for quantitative analysis of MRI. Following figure shows T1weighted image. Fig.1.

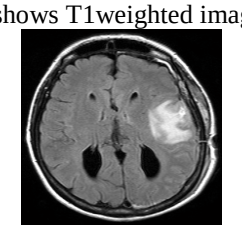

Fig.1. T1-weighted axial MR images of a human brain

III. SEGMENTATION

Segmentation referred to the process of extracting the desired object of interest in an image. Segmentation of medical images is a challenging task due to complexity of the images, as well as due to limitations of modalities to fully capture the possible deformation in each structure [4]. Image segmentation techniques can be classified on the basis of edge detection, region or surface growing, threshold level, and feature vector clustering or vector quantization [6]. Clustering methods are tools for partitioning a data set into groups of similar characteristics. Thus, clustering algorithms would naturally be applied in image segmentation [6]. In this paper we have used a SOM clustering method for the segmentation.

***SOM:** Self-Organizing Map (SOM)*

Self-Organized Map (SOM) (also called Self-Organizing feature map, Kohonen map) is an unsupervised neural network method which has properties of both vector quantization and vector projection algorithm. The prototype vectors are positioned on a regular low dimensional grid in an order fashion, making the SOM a powerful visualization tool. SOM consist of neurons on a regular low dimensional grid. The number of neuron may vary from a few dozen up to a several thousand. Each neuron is represented by a d-dimensional weight vector m= [m1, m2……, md] where d is equal to the dimensions of the input vector. The neuron is connected to the adjacent neuron by a neighborhood relation, which dictates the topology, or structure of the map. The way SOM go about reducing dimensions which plot the similarities of the data by grouping similar data items together. So SOMs accomplish two things, they reduce dimensions and display similarities.

General form of SOM Algorithm:

1. Randomize the map's nodes weight vector.
2. Grab an input vector.
3. Traverse each node in the map.

4. Use Euclidean distance formula to find the similarity between input vectors and map's node's weight vector.
5. Track the node that produces the smallest distance (this node is the best matching unit, BMU)
6. Updates the nodes in the neighborhood of best-Matching Unit (BMU) by pulling them closer to the input vector as

   $w_v(t+1) = w_v(t) + \alpha(d(t)-w_v(t))$,
7. Increment t and repeat from step no.2.

   α = momentarily decreasing learning coefficient

   It is 1 for neurons close to BMU and zero for others.

d(t)=input vector. Neighborhood function shrinks with time. At the beginning, when the neighborhood is broad, the self organizing takes place on a global scale. When the neighborhood has shrunk to just a couple of neuron, the weights are converging to local estimates [5]. SOM result can be represented as in fig .3.(a) to fig.3 (e).

IV. Volumetric Measurement of Brain Images

Segmentation algorithm assigned each voxel to grey matter, white matter, or CSF. Every single voxel in the compartmental images contains a certain probability value, ranging from zero to one, identifying the likelihood that this voxel belongs to a particular compartment. It is possible that a single voxel may be assigned to more than just one compartment. Such a segmentation process makes it possible to estimate distributions of different tissue types in the brain in addition to calculate their volumes accurately.

Step wise procedure for our new proposed method is as follows:

1**:** Get the highly contrast original MR Image.

2: Calculate the total voxel size for a given MR Image. 3: Calculation of brain voxels, gray voxels and White voxels.

4: Calculation of Volumes:

Brain volume = brain voxels*prod (voxel size)/1e6

Gray volume = gray voxels*prod (voxel size) /1e6

White volume= white voxels*prod (voxel size)/1e6

5: Calculation of densities

Gray density = gray volume / brain volume

White density = white volume / brain volume

After determining the volumes of grey matter, white matter and brain volume, an absolute volume can be calculated by summing the compartmental volumes. Total brain voxel counted by this method are 2506513 and voxel size product is 2.21570 (i.e. product of 0.8594 0.8594 3.0000). The result of our proposed method is summarized in given table. Fig.2.

BRAIN COMPARTMENTS	VOLUME	DENSITY
Brain Matter	5.5534 cm^3	0.8861%
Gray Matter	0.6485 cm^3	0.1168%
White Matter	0.4926 cm^3	0.0887%

Fig.2. Results of our proposed method

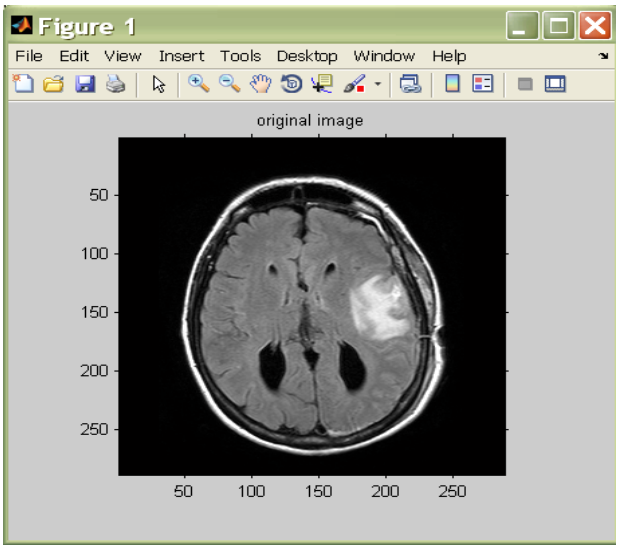

Fig.3. (a) Original Image

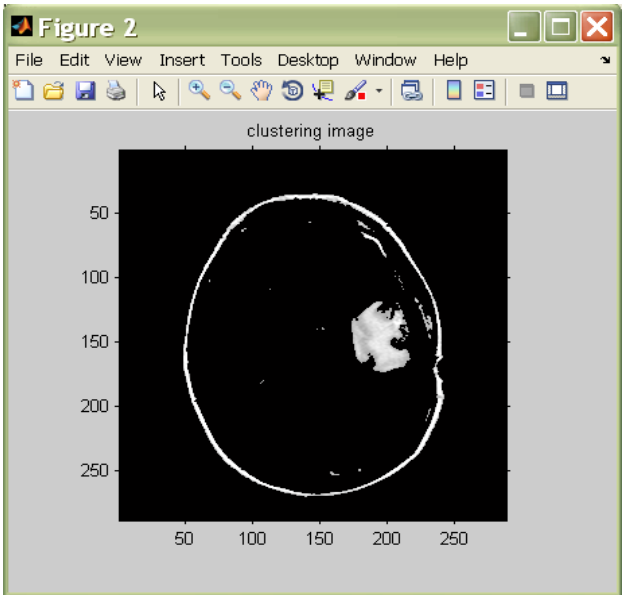

Fig.3. (b) Gaussian filtered Image

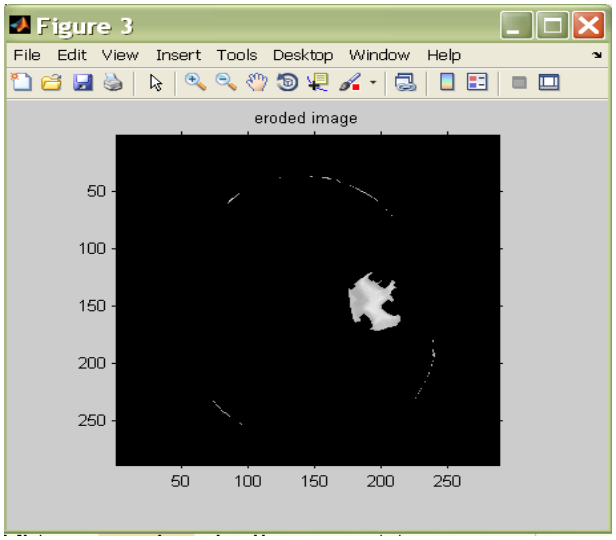

Fig.3. (c) Eroded Image

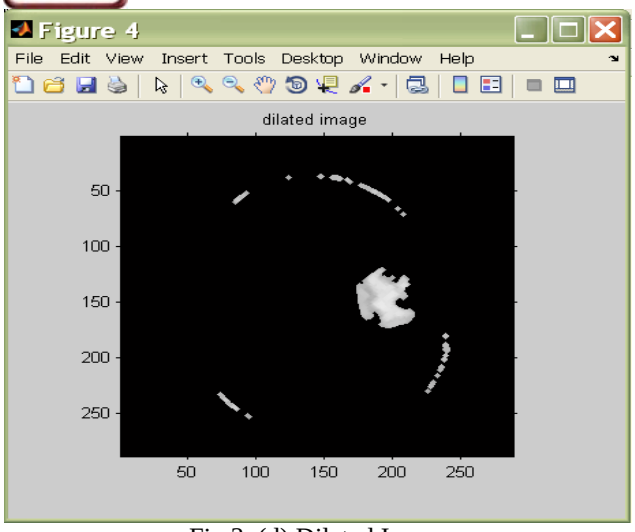

Fig.3. (d) Dilated Image

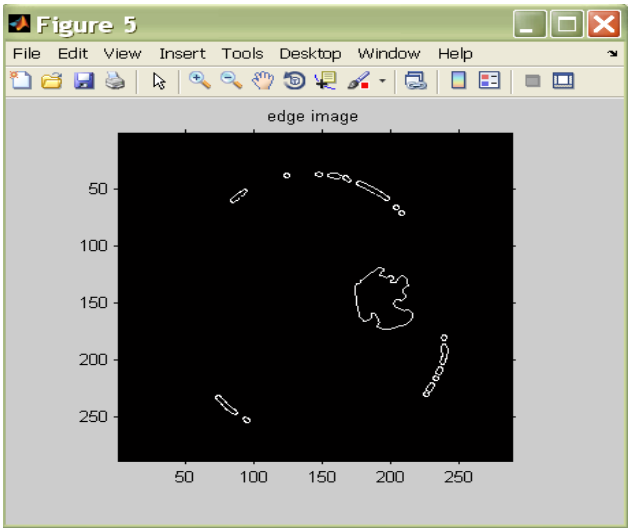

Fig.3. (e) Edge Image

V. Experimental Results and Conclusion

In this paper we have provided sufficient information for volume estimation of three brain structures i.e. gray matter, white matter, brain matter, and their respective volumes which are of particular interest in cognitive, clinical and comparative neuroscience. This new approach and SOM clustering algorithm tool implemented using MATLAB. The new method provides a useful tool to extract volume of interest directly with great accuracy.

VI. Future Implementation

In future work, we are going handle the issue of deformation of normal anatomy in the presence of space-occupying tumors. Also we are trying to develop some Volumetric measurements tools likes as Ruler, Protractor , Caliper, Profile instruments etc., so that the orientation of tumor, its total occupied area as well as its progression rate with abnormal tissues can be calculated. With the calculation of brain compartments it also possible to differentiate.

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References

[1] Giuseppe De Pietro 1, Luigi Gallo' 2 Ivana Marra' Carmen Vanzanellal,"A New Approach For Handling 3D Medical Data In An Immersive Environment", VECIMS 2007 - IEEE International Conference on Virtual Environments, Human-Computer Interfaces, and Measurement System Ostuni - Italy, 25-27 June 2007.

[2] Simon S. Keller, Neil Roberts,"Measurement of brain volume using MRI : software, techniques, choices and prerequisites", Journal of anthoprologycal sciences,vol 87(2009),pp 127-151.

[3] Renske de Boer a,b, Henri A. Vrooman a, Fedde van der Lijna, Meike W. Vernooij b,c, M. Arfan Ikram b," White matter lesion extension to automatic brain tissue segmentation on MRI".Neuroimage,45(2009),1151-1161.

[4] CRAIG L.ZIBREL: Matlab image types, Department of Mathematics and Statistics, Bowling Green State University

[5] Pravin R. Wankhede, RahulR.Ambalkar, Dr.K.B.Khanchandani, "Performance Analysis of Unsupervised Clustering Methods in Detection of Brain Tumor in MR Images International Journal of Advanced Engineering & Applications, June 2010.

[6] Karen Chia-Ren Lina, Miin-Shen Yangb, Hsiu-Chih Liuc, Jiing- Feng Lirng "Generalized Kohonen's competitive learning algorithms for ophthalmological MR image segmentation" Magnetic Resonance Imaging 21 (2003) 863–870.

[7] Verne Strudwick Caviness Jr.a,, Nicholas Theodore Langeb, Nikos Makrisa,Martha Reed Herberta, David Nelson," MRI-based brain volumetrics: emergence of a developmental brain science",Brain development:Official journal of the Japanese society of Child neurology,21(1999),289-295.

[8] R. A. Robb, "Three-Dimensional biomedical imaging", VCH, New York, 1995.

Author's Profile

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