



3D Reconstruction of Brain MRI using Support Vector Machine

Kavita A. Ugale

M.Tech. Student Department of Computer Engineering,
Vishwakarma Institute of Technology,
Pune, Maharashtra, India

Prof. Dr. S.T. Patil

Professor, Department of Computer Engineering,
Vishwakarma Institute of Technology,
Pune, Maharashtra, India

Abstract— Human brain is the most vital and complex organ of our central nervous system. It is composed of 7 different types of tissues that are irregular in shapes. MRI scans are generally used to evaluate the internal structures of the brain. Brain MRIs are not only used to discover tumors, infection and chronic diseases but also are now increasingly used in acute settings to look for bleeds and stroke. Brain MRIs are typically ordered for many different symptoms to exclude a tumor, aneurysm or unusual infection and as a follow up for stroke, surgery, etc. Normally MRI scans are available 2D format. It is really important to convert available 2-D MR images to 3-D to determine if there are any irregularities. Multiclass support vector machine is applied for 3D reconstruction because of its ability to solve non-linearity problem. Region growing segmentation and dynamic Thresholding segmentation techniques are used for segmentation of MRI scans. After segmentation of MRI classification is done using SVM. 3-D reconstruction of medical images is widely applied to tumor localization, abnormality detection, surgical planning and removing the need for rescanning.

Keywords— MRI, 3-D Reconstruction, SVM, segmentation, region growing, thresholding.

I. INTRODUCTION

The brain is one of the most complex and magnificent organs in the human body. Our brain gives us awareness of ourselves and of our environment, processing a constant stream of sensory data. It controls our muscle movements, the secretions of our glands, and even our breathing and internal temperature. Every creative thought, feeling, and plan is developed by our brain. The brain's neurons record the memory of every event in our lives. It is composed of 7 different types of encephalic tissues, i.e. Scalp (SC), Osseous Compact Substance (OCS), Osseous Spongy Substance (OSS), Cerebral Spinal Fluid (CSF), Cerebral Gray Matter (CGM) and Cerebral White Matter (CWM). These encephalic tissues are very irregular in shape. Magnetic resonance imaging (MRI) of the brain is a safe and painless test that uses a magnetic field and radio waves to produce detailed images of the brain. MRI can detect a variety of conditions of the brain such as cysts, tumors, bleeding, swelling, developmental and structural abnormalities, infections. MRI scans generally available in 2D format. 2D images cannot accurately convey the complexities of human anatomy. So, it is really important to convert available 2-D MR images to a 3-D brain image to determine if there are any irregularities. 3D model provide better visualization. We have performed 3d reconstruction of different encephalic tissues from brain MR images. In this process we first separate brain tissues using 3 different image segmentation techniques such as region growing, fuzzy c-means and dynamic Thresholding segmentation. And SVM is used for reconstruction.

This paper covers 3-dimensional reconstructions of different encephalic tissues that determine irregularities and abnormalities in brain if there are any. Prior to reconstruction segmentation of MRI scan is done followed by classification using support vector machine. Segmentation is performed using two techniques region growing and dynamic Thresholding segmentation. The paper successfully highlights the above mentioned techniques and its results analysis. Brain MRI dataset is used as input to these image segmentation algorithms.

II. RELATED WORK

In this section, we are discussing briefly about the earlier approaches which have been carried out in the field of 3D reconstruction of brain MRI. In Karunakar et al. presents a method for 3D reconstruction. The paper involves implementing various steps of extracting the tumor from the 2D slices of MRI brain images by OTSU's threshold technique and various morphological operations and designing software for reconstructing 3D data from a set of 2D images. In this paper the author does the task providing the seed point for thresholding manually. This is a time consuming task. Thus the execution time of the algorithm increases. In Megha et al. proposed an effective and efficient approach to 3D reconstruction of brain tumor and estimation of its volume from a set of two dimensional (2D) cross sectional magnetic resonance (MR) images of the brain. The proposed 3D reconstruction approach can generate an accurate 3D model in less amount of time and thus can assist the radiologist in the diagnosis, identifying the stage of the tumor and treatment planning. In N Moon et al. proposes automatic brain segmentation method that uses an Expectation Maximization algorithm. The algorithm estimates the probability distribution of the tissue classes which consist of gray matter, white matter cerebrospinal fluid, and tumor. Prior information and assumption are required to do the segmentation. In N. Gordillo et al. developed a set of fuzzy rules to segment the tumor from the MRI images with expert

intervention and analysis of pixels using histogram. Ratan et al. uses watershed algorithm for image segmentation to get an approximate shape of the tumor. In T. Wang et al. used a Bayesian classifier to identify the location of the tumor and a fluid vector flow algorithm is used to estimate the shape of the tumor. In Nelly Gordillo presented a review of the most relevant tumor segmentation methods. According to automatic and semi-automatic segmentation methods have gained the importance due to their accuracy in identification but the end systems are used by the physicians therefore find a surprising lack of compatibility between computer vision based systems and low level segmentation methods. These approaches which lack standardized procedures still cannot gain acceptance from the pathologist for clinical task. These approaches need to be compared with real world medical issues to address problems of segmentation with best suitable approaches. The next method studied by W. Narkbuakaew, S. Sotthivirat, D. Gansawat, P. Yampri, K. Koonsanit, W. Areeproyolkij, W. Sinthupinyo, and S. Watcharabutsarakham, is "3d Surface Reconstruction Of Large Medical Data Using Marching Cubes In Vtk". A three-dimensional surface is a representation of volumetric image data in a shape form. One algorithm, which is acceptable for reconstructing a three dimensional surface, is the Marching cubes. It uses patterned cubes or isosurface to approximate contours. The marching cubes algorithm needs some processes or algorithms to reduce time and memory for reconstructing a surface from large volumetric data.

III. PROPOSED SYSTEM

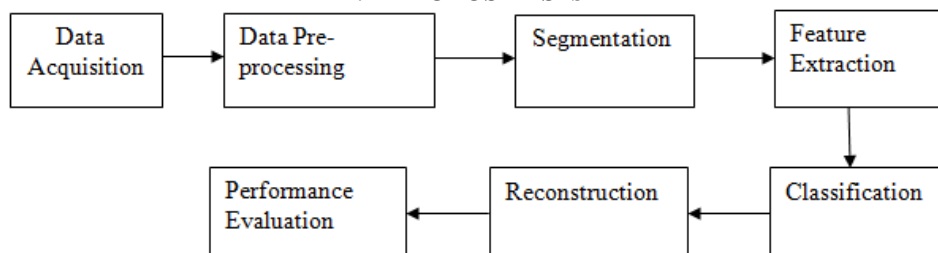


Fig.1 Proposed System

As discussed previously, the existing methods which are in practice for reconstruction may not prove fully effective in some scenarios due to the aforementioned limitations:

1. Existing methods for 3d reconstruction such as surface rendering, Marching cube has some limitations. In case of Surface rendering interior structure is not visible, only displays surface which meet a threshold density value and closest to imaginary viewer. Marching cube algorithm is time consuming process and quality of 3d reconstructed surface is poor. It represent 3d surface from large volumetric data.

2. Neural network gives multiple solutions to a problem where as SVM produces unique solution. In case of neural network there is difficulty in choosing network architecture.

This system using magnetic resonance images for 3D reconstruction is proposed in this paper that is used for tumour localization, surgical planning. The scheme is presented as a block diagram in Fig. 1. The process of translating magnetic resonance image into 3D is decomposed into four modules:

- a) Preprocessing of image;
- b) Segmentation;
- c) Feature extraction and Classification;
- d) 3D reconstruction

Now, we will discuss these modules one by one.

IV. DATA PREPROCESSING

It is first step of proposed system, the brain MRI images which are taken as input, are subjected to be corrupted by noise during scanning. In this step we convert the original MRI image into gray scale image to reduce noise and to enhance the quality of image to get more accurate results. In proposed system Median filter is used to reduce the noise. The median filter is a non linear digital filtering technique, is often used to remove noise. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise. The median is a more robust average than the mean and so a single very unrepresentative pixel in a neighborhood will not affect the median value significantly. Since the median value must actually be the value of one of the pixels in the neighborhood, the median filter does not create new unrealistic pixel values when the filter straddles an edge. For this reason the median filter is much better at preserving sharp edges than the mean filter.

V. SEGMENTATION

Image segmentation is a process of subdividing an image into its constituent parts or objects in the image. The main motive of subdividing an image into its constituent objects is that we can further analyze each of these objects or our region of interest in the image once they are identified or we have subdivided them. So, each of this constituents can be analyzed to extract some information so that those information are useful for high level machine vision applications. Generally the level of segmentation is application dependent.

There are two approached on which segmentation of an image is carried out. First approach is based on discontinuity and second based on similarity. In discontinuity based approach partition of an image is carried out on the basis of some abrupt changes in intensity levels in an image. Here, main focus is identification of points, lines, edges etc. In similarity

based approach pixels are grouped together according to homogeneity criterion. Image segmentation groups the homogeneous region based on pixel characteristics like gray level, color, texture, intensity and other features. Image data has a practical importance in medical field. In medical image analysis image segmentation identifies the boundaries of objects such as organs or abnormal regions (e.g. tumors). segmentation results make it possible for shape analysis, detecting volume changes, making precise radiation therapy treatment plan. In case of brain structure accurate classification of MRI according to tissue type at voxel level is needed. As brain structure is defined by boundaries of constituent tissues, thus accurate segmentation is important step in qualitative study. In this paper we will discuss two segmentation algorithms that are Region growing segmentation and dynamic threshold segmentation.

A. Region Growing Segmentation

Region growing segmentation is the procedure which groups the pixels or sub-regions into a larger region based on some predefined criterion. Region growing works on principal of homogeneity. The main objective is to produce homogeneous regions. Algorithms assume that region must be connected with some predefined criteria. A seed point is collected or selected based n user criterion (pixel in certain grayscale ranges). Regions are then grown from seed point to adjacent points depending on region membership criteria for example pixel intensity. oAlgorithm start from single pixel(also called seed point)and try to find other pixels. Every pixel is compared with its neighbor for similarity check Such as gray level, texture, color, shape. If the result is positive, then that particular pixel is “added” to the pixel set and a region is “grown” in this manner. The growing is stopped when the similarity test fails. In proposed system region growing segmentation segment given MRI into constituent tissues.

B. Dynamic threshold segmentation

One of the simplest approaches to segment an image is based on the intensity levels and is called as threshold based approach. Threshold based techniques classifies the image into two classes and works on the postulate that pixels belonging to certain range of intensity values represents one class and the rest of the pixels in the image represents the other class. Thresholding can be implemented either globally or locally. Global Thresholding discriminates object and background pixels by comparing with threshold value chosen and use binary partition to segment the image. The pixels that pass the threshold test are considered as object pixel and are assigned the binary value 1 and other pixels are assigned binary value 0 and treated as background pixels. The threshold based segmentation techniques are inexpensive, computationally fast and can be used in real time applications with aid of specialized hardware. Here, in dynamic Thresholding segmentation threshold value is set dynamically based on prior manual training.

VI. FEATURE EXTRACTION

There is no explicit rationale of what constitutes a feature, and it often depends on the problem or the type of application. Feature extraction involves reducing the amount of resources needed to describe a huge set of data. The features used for the proposed system are: energy, homogeneity, correlation and contrast etc have been used.

VII. CLASSIFICATION AND 3D RECONSTRUCTION

The next module is classification using support vector machine. The aim of classification is to automatically categorize all pixels in an image into classes thereby Converting image data into information. Classification process involves training dataset with known information and based of trained data each input pixel is assigned to particular class. SVM is one of the excellent tools for classification and regression problems with a good generalization performance. SVM formulates a hyper plain or a set of hyper plains to partition the two sets of data in a feature space. The key approach of SVM is to try finding the choicest hyper plain by maximizing the minimum margin between the two sets. Multiclass Support vector machine is used for classification in proposed system. Pixels are classified into classes of different encephalic tissues.radial basis kernel function is used. 3D reconstruction is process of capturing the shape and appearance of real object. In proposed system reconstruction of 2D MRI slices. First step in reconstruction is, three dimensional stack from two dimensional MRI slices was prepared. Prearranged pixels are constructed based on observed neighborhood pixels are arranged based on smooth gradient.

VIII. RESULTS

This section introduces performance metrics and discusses the result obtained. The experimental data set of 60 images has been obtained from the Atlas online. Results of region growing segmentation are shown in fig 2 which shows segmentation of input MR Image into 3 types of tissues and fig 3 shows the results of dynamic Thresholding segmentation. Results of reconstruction method1 of whole brain is shown in fig 4, fig 5, 6, 7 respectively shows reconstruction results of individual encephalic tissues. Fig 8 shows reconstruction of OSS tissue using 2nd method.

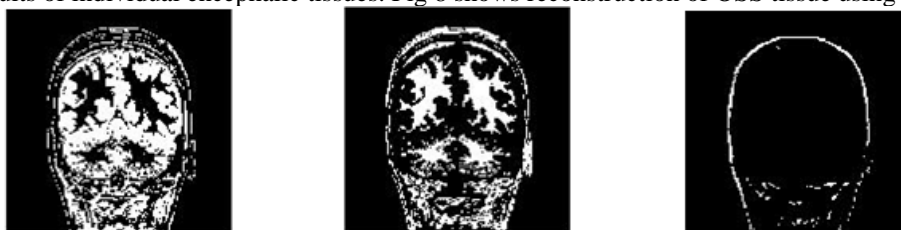


Fig.2 Result of Region growing segmentation

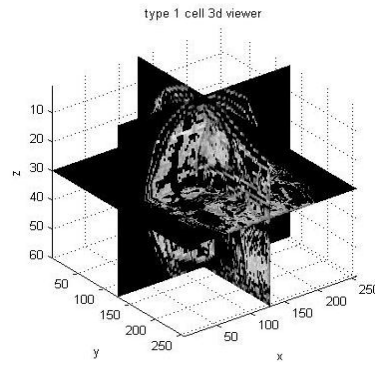


Fig.3 3D reconstruction of type1 cell

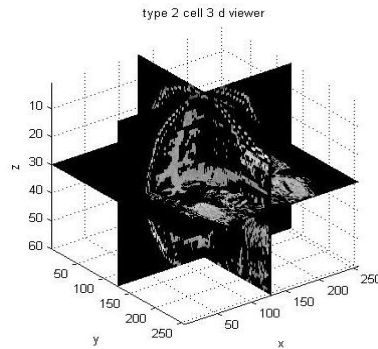


Fig.4 3D reconstruction of type2 cell

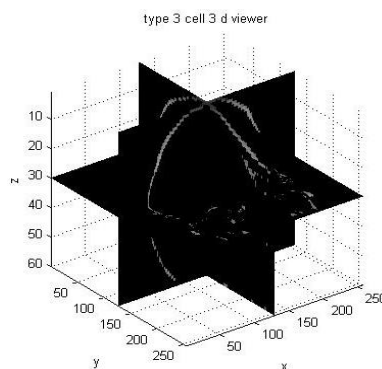


Fig.5 3D reconstruction of type3 cell

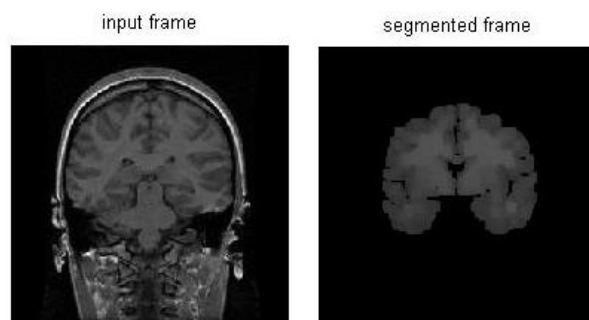


Fig.5 segmentation result of dynamic Thresholding technique

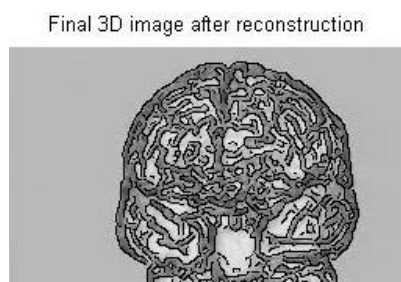


Fig. 5.9 final 3D Reconstruction of brain using Reconstruction method2

IX. CONCLUSION

The two reconstruction methods are used in above paper. First reconstruction algorithm with region growing segmentation gives 3d model of brain with accuracy 93%.the second reconstruction method with Thresholding segmentation technique gives 89% of accuracy. In both methods svm classifier is used. Both the proposed algorithm s for reconstruction involves process of segmentation, classification and finally reconstruction. Hence reconstruction is done successfully with good accuracy.

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