International Journal of Modern Trends in Engineering and Research
www.ijmter.com
e-ISSN No.:2349-9745, Date: 2-4 July, 2015

# 3D Reconstruction of Brain Images from 2D MRI Images* 3D Reconstruction

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**Abstract—**Brain is the most important part of the human body. It consist of different types of encephalic tissues .The boundary of each of these encephalic tissues, which makes up the brain, is highly irregular. So, traditional 3-D reconstruction algorithms, using brain MRI images do not give accurate reconstruction. Two class Support vector machines are found to be very successful for pattern recognition problems. Because of its powerful ability to solve nonlinearity problems Sphere-shaped support vector machines (SSSVMs) are used in the 3-D reconstruction. Brain tissues can be segmented based on their intensity values. Region growing method is used for segmentation of MRI images as it gives accurate results and can segment more than one type of brain tissue at a time. These segmented images are then classified using SSSVM. The selected parameters are optimized using Immune Algorithm which makes SSSVM more flexible.

**Keywords**-Encephalic tissues; Fuzzy Inference System (FIS); Radial Basis Function (RBF); Immune Algorithm (IA); Sphere Shaped Support Vector Machine(SSSVM).

## I. INTRODUCTION

In our central nervous system Human brain is the most complex and important organ. It is made up of tissues which have highly irregular shape. Hence to obtain the complete idea about the structure of these tissues in brain it is really important to convert available 2-D MRI images to a 3-D brain. This 3D view of brain will be helpful for tumor localization, surgical planning and will remove the need for rescanning. MRI image consist of a large variation in the gray-scales and highly irregular boundaries of the tissues. Existing methods will not classify different tissues always accurately. Most of the times these existing methods do not give satisfactory results as well they are tedious and time-consuming. In case of the pattern recognition problems Support vector machines (SVMs) are found to be more effective. In this paper, use of the sphere-shaped SVMs (SSSVMs) for solving the classification problems which is due to class-imbalance is discussed[6]. The main idea behind this is original 3-D object space is transferred into a high dimensional feature space with the use of kernel function of SSSVM. A compact hyper-sphere is constructed which encloses the entire target object in the feature space. The hyper-sphere represents Support Vectors which are the points lying on or near the surface of the hyper-sphere and the target class. Thus, the model of a data and 3-D object which supports the surface in the original space are obtained. This method has several advantages. It can classify all the data points independent of how irregular their boundaries are and it also classifies several different types of data points of interest and simultaneously leads to near perfect reconstruction.

This paper is organized into seven sections. In section 1 block diagram of proposed system is explained. In section 2 Image fusion technique is explained. Section 3 consists of explanation of region growing segmentation method. Section 4 explains Sphere Shaped SVM. In Section 5, Immune Algorithm is explained and Section 6 comprises of conclusion and Results.

## II. BLOCK DIAGRAM OF THE PROPOSED SYSTEM

A system is proposed for 3D reconstruction of brain. As MRI images give more information related to tissues as compared to CT scan, they are used as input to the system. Figure 1 shows block diagram of proposed system. At a time, 3 successive Input Images are taken for processing. These three Input images are fused together using Fuzzy Logic for further detailing. The fused image is then segmented using region growing technique. From the segmented images 3D view of brain is constructed using Immune sphere shaped machine.

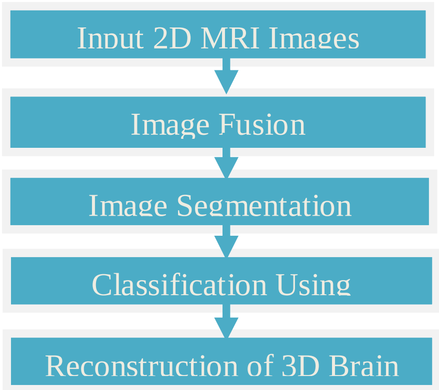



***Figure 1. Block Diagram of the Proposed System***

## III. IMAGE FUSION

Relevant information from two or more images can be combined into a single image using image fusion technique[1]. A single image should contain high spectral and high special resolution for high quality and reliable image processing. Such data is not provided by most of the available equipments. So image fusion integrating different information sources is used. Hence, use of partial and varied information which is present in multiple images is the aim of data fusion. Thus, forming a single image which has the collective features of all the input images is the basic requirement. Different methods can be used for Image fusion, here image fusion using fuzzy logic is implemented. Figure 2 indicates the block diagram of fuzzy based Image fusion technique. Figure 3 indicates result (MRI fused image) of fusion of three input images i.e; im1 ,im2, im3 after the implementation of Fuzzy logic. For fuzzy system, the fusion rules are defined which are specified in the form of "IF-THEN" statement. These rules are designed based on the combinations of input images. The implemented rule for the Fuzzy based image fusion technique is defined as in equation (1)

$$\beta(t) = \max\{P1, P2\} = \{M, L \rightarrow L\} \qquad \text{........(1)}$$

Here, pixel gray level values of MRI images are indicated by P1 and P2. Equation (1) shows that if P1is medium gray level and P2 is large gray level then output is large gray level. Likewise there are 25 possible combinations are available.

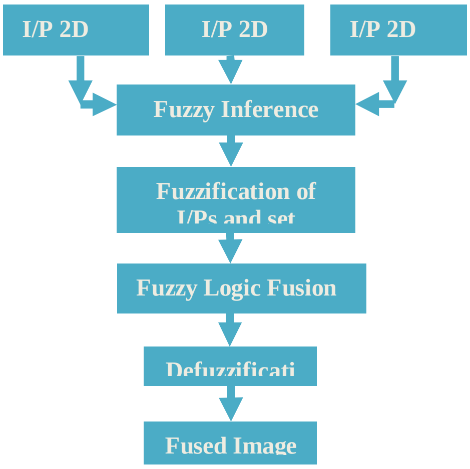



*Figure 2. Block Diagram of Fuzzy Based Image Fusion*

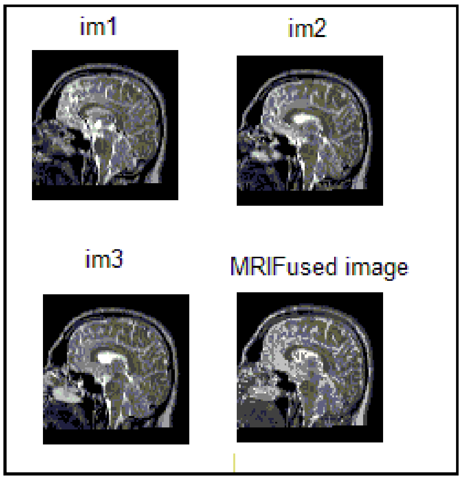



*Figure 3. Result of Image Fusion*

## IV. SEGMENTATION

Image segmentation is an important step in image processing [3]. It is a process of partitioning digital image into multiple regions (sets of pixels). It becomes easier for neurosurgeons and physicians to diagnose and investigate the structure and function of the body with the help of segmented medical image. As brain tissues have irregular boundaries and differ in their intensity values, they can be segmented based on their intensity values. Brain tumour which has intensity different from brain tissues can be easily identified.

Region growing method [4] is a simple method of image segmentation. Based on predefined criteria it groups pixels or sub regions into larger regions.

### 4.1 Region growing method of image segmentation

A region-based method[2] usually proceeds as follows: Neighboring pixels of similar intensity levels are grouped together which helps to partition the image having connected regions differing in their intensity. Adjacent regions are then merged together based on some criterion which involves sharpness or homogeneity of region boundaries. It is also a pixel-based image segmentation method as initial seed points are selected. This segmentation technique examines neighboring pixels of initial “seed points” and decides whether the pixel neighbors should be added to the region. In the same way as general data clustering algorithms the regions are formed by repeating this process.

This region growing technique[5] of segmentation is applied to the fused image .Depending upon the intensity levels the different brain tissues are segmented.

## V. SPHERE SHAPED SUPPORT VECTOR MACHINE

One of the best technique for data classification is SVM (Support Vector Machine)[8]. It is class specific algorithms, characterized by use of kernels. Separation of data points is carried out with proper margin between the classes, and with the use of number of support vectors. Support vector machines (SVMs) are effective methods for pattern recognition. For solving the classification problems which is of the class-imbalance instead of one class support vector machine the sphere-shaped SVMs[7] (SSSVMs) were proposed. The main idea is that an original 3-D object space is transferred into a high dimensional feature space by the RBF kernel function. It constructs a compact hyper-sphere such that it should enclose the target object in the feature space. The hyper-sphere represents the points lying on or near the surface of the hyper-sphere which are SVs and the target class. Thus we obtain the model of a 3-D object and data. Selecting appropriate parameters for the SSSVM and the kernel function helps to obtain the model which is more flexible and thus accurate data description is obtained. SSSVM[9] has several advantages:- First, through the flexible hyper-sphere in the feature space, a 3-D object model can be reconstructed independent of irregularity of the object. The main advantage is that it can classify data into more than one category.

## VI. IMMUNE ALGORITHM

The basic and remarkable defensive system which fights against bacteria, viruses and other disease-causing organisms is the immune system. Animals are protected from infection by foreign substance by producing millions of antibodies from hundreds of antibody genes. The immune system has given the basic idea of artificial immune algorithm. An effective use of this algorithm can be for pattern recognition, learning, memorizing, adaptability, diversity, and distributed mechanisms as these are similar to immune phenomenon in nature. Generally, the algorithm[6] starts with the assumed solution. This "solution" is not an "answer" to the problem but is the course which would be followed to obtain an optimum solution. The optimum solution cannot be reached but will require several iterations to get perfect solution.

## VII. SIMULATION RESULTS & DISCUSSION

In this section the output using SSSVM as a classifier is presented. The Algorithm was implemented in Matlab®.R2011b.MRI images were acquired using a 3-D T2 weighted fast-spin echo pulse sequence with the voxel size of 1 X 1 X 1 mm with a matrix size of 256 X 256 X 150.The brain MR images include seven contrasted objects including the Background (BG) and six kinds 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). For training and testing purpose, in this study, the images are fused together figure 3 which shows fusion of 3 slices in figure im1, im2 and im3 and then these slices were segmented using Region growing method which gives better results in presence of noise and can segment more than one type of brain tissue thus saving lot of processing time and efforts. The classification is done using SSSVM along with IA to select appropriate parameters for Redial Basis Function(RBF).With this the possibility of wrong classification is considerably reduced which is the paramount consideration in any type of medical image processing. Figure 4 shows training data in 3D space. Figure 5 indicates ISSVM classified data in 3D space. Figure 6 show all types of brain tissues classified using SSSVM in different color with great results. Figure 7 shows coronal view of 3D reconstructed brain.

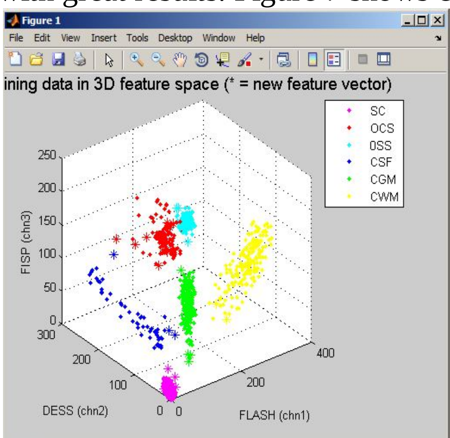



***Figure 4. Training Data in 3D Space***

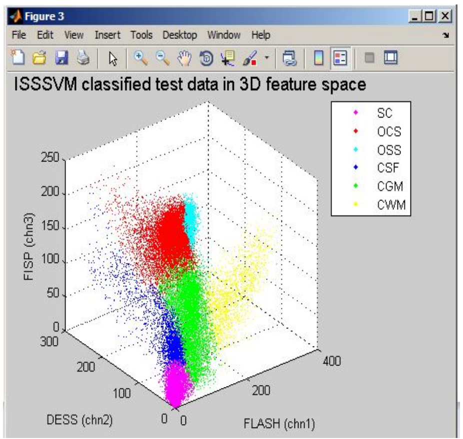
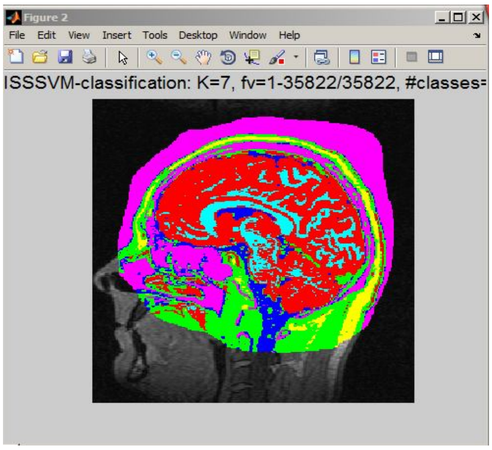



***Figure 5. ISSSVM Classified Data in 3D Space***



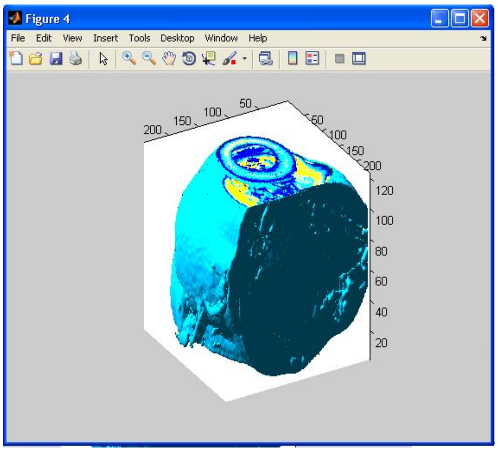




*Figure 6. Mapping of Classified Tissues on Brain Map*    *Figure 7. Coronal View of 3D Reconstructed Brain*

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