Study of Techniques used for Medical Image Segmentation Based on SOM

K. B. Vaishnavee, K. Amshakala

Abstract*— In image processing, segmentation is an important technique which is based on the homogeneous features utilized to partition the image into various regions. In Medical field MR images are widely used, but due to its noise, intensity in homogeneity, Partial Volume Effect (PVE) through voluntary and involuntary movement of the patients and equipments the segmentation process is highly complex. White Matter (WM), Grey matter (GM) and Cerebrospinal Fluid (CSF) are the three main tissue segmentation of MR brain image segmentation. The accurate segmentation of brain tissues facilitates the estimation of tissue volume, tumor detection and estimation of volumes of tumor, which is done by making the image smoother and thus easier to measure. In addition this technique facilitates to estimate the Region of Interest (ROI) in an image. Segmentation is mainly classified as supervised and unsupervised and based on these two there have been various techniques developed for the image segmentation. In medical field, the supervised has less demand as it requires prior knowledge from the external entity. On the other hand, unsupervised segmentation provides more accurate result where it does not need any prior knowledge at any time. The well known Self Organizing Map (SOM) segmentation technique is a type of unsupervised clustering technique utilized to make image quite simple and yields significant accurate segmentation results for the MRI images. This survey paper addresses the various existing methodologies for segmentation of MRI images and presents the issues and advantages related to those approaches.

Index Terms*— MRI Brain image, Segmentation, SOM - Self-organizing maps, Image Segmentation, unsupervised segmentation.

I. INTRODUCTION

In recent years image processing is widely used in multidirectional applications. With the rapid development of digitization the medical images have been digitized and image processing is used to store and analyze the image in medical applications [1]. It is more difficult through the state – of– the – art techniques where the medical image cannot be highly interpreted and thus produces less accuracy results by consuming large time. It is highly difficult when the regions with abnormal color and shape are predicted through radiologists. The accurate segmentation result of the medical image is the main criteria to design such an image processing and computer vision applications. At first segmentation is defined as the procedure that partitions different regions of the image based on various criteria.

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Wide range of medical applications necessitates medical image segmentation such as surgical planning, post-surgical assessment, abnormality detection and detecting the severity of the disease [2].

Though there is a variety of automatic and semi-automatic methods available, in many cases they do not succeed due to the unknown and irregular noise inhomogenity, poor contrast and weak boundaries in an image. Especially the complicated anatomical structures of the image need precise and more accurate segmentation for clinical diagnosis such as MRI and other medical images [3]. Tumor detection, their classification, edema, necrotic tissue, haemorage detection and brain image segmentation from MRI images is complex and more difficult to achieve and thus requires an accurate and faithful segmentation. Earlier, in brain the detection of abnormal parts were done through MRI imaging technique. The main advantage of MRI image acquisition over Computerized Tomography (CT) is, in the field of neuropathology the parameters can be adjusted to generate high contrast image with various gray level model [4]. So that the MRI image segmentation stands in the recent research area of Medical imaging. To achieve this, various approaches are utilized based on supervised or unsupervised category. The supervised segmentation needs an outside support by human, whereas unsupervised segmentation does not need any support which is an automatic approach based on features of the image. More clearly to say, the clustering methods plays the main role in image segmentation. SOM [5] is one of the clustering methods used for unsupervised segmentation particularly in medical imaging. SOM is the neural network based algorithms that automatically makes similarity maps based on the input where it diagrams high dimensional data to a low dimensional discrete structure of neurons in the image. In order to segment the MRI brain images various applications are based on SOM approach. The automatic SOM based segmentation method was used earlier which is considered as knowledge based expert system [6]. It produces the high segmentation and labeling accuracies for brain tissues in most of the applications. Ortiz et al. [7] utilized SOM segmentation approach for MR image with two fully unsupervised segmentation methods such as histogram and inherent features based methods. The first method based on the histogram features is highly fast and efficient and other one based on inherent features mined from the image is more robust and produces accurate result against noisy and bad intensity constraints of the image. Ortiz et al [8] defines the image segmentation that is used to divide the images into multiple parts as the main step in image processing. In that, each

segment part represents some kind of information to the user in the form of color, intensity or texture, so for any image it is considered important to isolate the boundaries in the form of segments. In this process a single value will be assigned to every pixel of an image with the intension of making it simple to distinguish among various regions. This discrimination is done based on three criteria's that is color, intensity and texture of the input image. As a result, the appropriate segmentation technique is preferred and the problem domain is observed by the investigator [9]. In every field of science the segmentation plays a vital role and hence should not be neglected, used mainly for the noise removal process [10], computer vision and military etc., The segmentation process is also used in the image retrieval applications [11] by feature extraction and recognition of objects from the given input image; they are used in content based image retrieval area. Since each image is having its own features and these features vary from image to image, the image segmentation is a perfect method to observe such features from every image [12]. Choosing the appropriate segmentation technique for the particular image type is more difficult as well. The segmentation can be also classified into three types, segmentation based on the classical approach, Artificial intelligence techniques and last is the hybrid techniques and these are applicable based on the particular image type [13]. Various popular image segmentation methods are working based on the Edge, Artificial Neural Network (ANN), Fuzzy concept, Partial Differential Equation (PDE). Threshold based and region based segmentation methods produce perfect segmentation results. For example, the threshold segmentation framework is given in Fig.1.

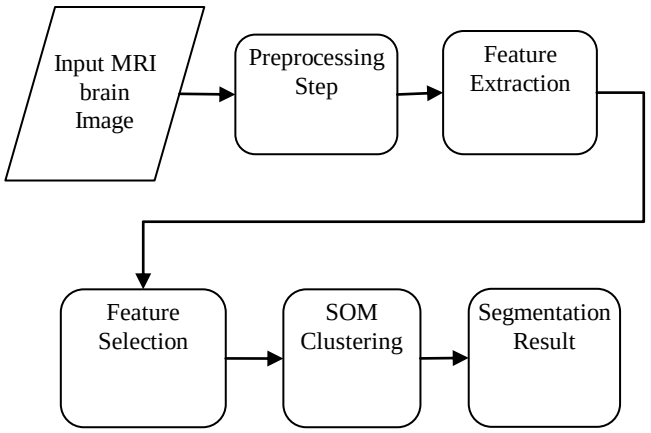

Fig. 1 Threshold based image segmentation

As well, the segmentation technique is used in neuroscience; brain anatomy mapping, brain development study and analysis, and neuroanatomical variability analysis in normal brains that necessitates the recognition of brain constitutions in MRI images [14]. It also plays vital role in clinical identification of neurodegenerative, psychiatric disorders, treatment evaluation, and surgical planning. In the study of brain development with neuroscience as field, mapping of functional anatomy is activated onto brain anatomy. The analysis of neuroanatomical variability in normal brains is required to identify brain structures in MRI images [14]. At the whole the main goal of this article is to analyzes and review the different segmentation methods based on the SOM technique by listing the merits and demerits.

II. SELF ORGANIZING MAP (SOM)

Kohenen [5] introduced SOM, sometimes called Kohenen map which is a feed-forward neural network. It projects a high dimensional space into a low dimensional space of SOM that contains 2D array of nodes. Weight vector, w_i is migrated with each node of the same dimension to position the map space. The weight vector for each node finds an unsupervised, iterative learning process. The best matching unit (BMU), iteration of similar node is found by a similarity measure. Rickard et al. [15] used multi-scale analysis and SOM. Mammogram images were segmented by Chang and Teng [1] who proposed a two-stage SOM for dominant color components identification and segmenting a medical image. Three parts of self Organizing map as follows:

I. Competition: The output layer of neuron determines the value of a function called discriminate function for each input neuron. The winner contains neuron which have largest discriminate function
II. Cooperative: The spatial location of the topological neighborhood describes the winner neuron.
III. Synaptic weight Adaptation: The individual value of discriminate function enables the exited neuron to increase the relation of input pattern.

III. EXISTING METHODS AND MODEL

Neurons organized in a lattice are called as SOM network. The topology of the map indicates that neurons are connected to the adjacent neurons by a neighborhood relation. The high-dimensional input space to the low-dimensional lattice of neurons is implemented by non linear projection of the network. Clustering tool for high-dimensional data serves as SOM, where topology constructs high-dimensional space on the lattice of neurons and is mapped with relative topology distances saved between input vectors. SOM training process is quite simple. Reference vector is associated with each neuron and all the reference vectors are initially designated randomly. All the reference vectors are compared with each input vector whose reference vector is the neuron which is most similar to the input vector to be identified. The reference vectors neighboring are the identified neuron which gets moved to the input vector.

3.1 Image Segmentation Techniques

Various techniques and overview of all the related image segmentation techniques are proposed in this article. Recent research in image segmentation techniques are also overviewed in this article. A hybrid solution for image segmentation contains two or more techniques and after the analysis of different techniques provides the best approach to solve the problem of image segmentation.

3.2 SOM and Ensemble

SOM neural networks method of image segmentation is proposed by Jiang et al. Images are clustered according to the color and spatial features, with many

SOM neural networks combining the clustering results to give the final segmentation. The power of ensemble learning paradigms utilizes the method to generate robust clustering results, and therefore achieves robust image segmentation performance than the image segmentation methods on either SOM neural network or k-means clustering. Jiang et al.'s framework [16] proposed the limitation method that the number of regions to be segmented out should be manually set. It improves the utility of method to adapt the appropriate number of regions to be segmented out.

3.3 Two Unsupervised Approaches for Brain Image Segmentation

Two unsupervised approaches for brain image segmentation are described by Ortiz et al [7]. The whole volume histogram evaluates useful information initially processed by using self-organizing maps (SOM), which is faster and computationally more efficient than previous reported methods. Four stages of second method includes MRI brain image acquisition, first and second order feature extraction using overlapping windows, evolutionary computing-based feature selection and finally the map units are grouped by means of a novel SOM clustering algorithm. Noisy or bad intensity normalization conditions provides better results using high resolution images, outperforming the results provided by other algorithms.

3.4 Self Organizing Map Artificial Neural Network

This paper proposes novel segmentation method using artificial neural network (ANN) for color image segmentation. Images are represented in a modified L*u*v* color space for increasing color variants. Image segmentation uses self- organizing neural network with unsupervised learning based on color reduction. In color reduction, Self- Organizing Map (SOM) network projects the images into a small set of prototype. Greater speed, stability and flexibility are provided because of stability–plasticity balance of the network which is highly de-coupled from the all other parameters. Satisfactory segmentation does not create most sophisticated technique even on difficult scenes.

3.5 SOM Mahalanobis distance

Self organizing mapping network describes winner unit in this article. Mahalanobis distance calculates the distance between the input vector and the weight vector to choose the unit weight vector which has the smallest mahalanobis distance from the input vector. Selecting threshold point is the case of segmentation which indicates that final segments are not indicated to get optimal result. Satellite images are segmented with no prior knowledge of objects.

3.6 Hierarchical Self-Organizing Map

The proposal for the collection of novel schemes training samples is based on homogeneity. Two-stage hierarchical self-organizing map (HSOM) carries out the Natural scene segmentation. The sample selection based on homogeneity, self learning ability and adaptability of the HSOM proposed the method to couple the information fusion mechanism. This validated the experiments for good segmentation result, on different natural scene images. The final number of colors is the limitation of method which specifies a priori.

3.7 Principle Component Analysis and Self-Organizing Map

The fundamental stage of segmentation is BET mainly used for preprocessing the images. The sub images are extracted into small windows and diverse features. The PCA selection method reduces the feature set. SOM reduces feature vector for the purpose of clustering to evaluate the result of Tanimoto similarity index. The segmentation results are improved by feature selection process with PCA algorithm which reduces the computation time and gives optimum results. The performance of SOM is evaluated to compute the different number of features and map quality (quantization and topological error) for different trained SOM. The processing time and the overall segmentation time reduce the PCA selection.

3.8 SOM with Markov Random Field

The SOM network segment the MR brain image by the using Markov Random Field (MRF) model of Y. Li et al. [21]. Markov Random Field model segments the size, shape, and orientation of regions with spatial information algorithm to improve the segmentation results. Extra data samples are not used in the training set to provide better results to help MRF. Eliminating the effect of noise and constructing smoothened segmented regions are not considered as an important segmentation process for MRF term. Mean squared errors measure the segmentation performance. SOM results some drawbacks even though it is good for medical image segmentation. The feature vectors are built upon the quality of SOM for training. A self-organizing feature map (SOFM) network depends upon the new unsupervised MR image segmentation methods proposed in this article. Markov Random Field (MRF) model includes spatial constraints algorithm. Extra data samples in the training set or a complicated network structure are not used to improve the segmentation results with clique potential of prior distribution of MRF term.

3.9 SOM-FCM

The volume images are extracted by 3D statistical features of segmentation technique. The unsupervised vector quantization and fuzzy clustering techniques are based on recent method addition to this technique and does not provide any priori information. Internet Brain Image Repository (IBSR) uses real brain images with resulting fuzzy segmentation method to address the problem of partial volume effect (PVE).

3.10 SOM Neural Network

Image segmentation is described at Kohonen's self-organizing map (SOM) neural network for color images. SOM training is performed on the wavelet-transformed image and reduces the training time of the SOM. It is also observed to retain more compact segments. The co-efficients of the wavelet transformed image are approximate to work equally well for

non-noisy as well as noisy images. Training is performed by approximation co-efficients where advanced technique is computationally less expensive [10].

3.11 FEM-K-Means

An efficient and improved semi-automated Fuzzy EM based techniques for 3-D MR segmentation with efficient and improved human brain images is presented in this article. The initial step of FEM along with histogram based K means labels individual pixels/voxels of a 3D anatomical MR image (MRI) followed by classification of main tissues in the brain, namely Gray matter (GM), White matter (WM) and CSF (Celebro-spinal fluid).The estimation of FEM's membership function are calculated through a histogram-based method.

3.12 SOM-SWT

The brain image segmentation's unsupervised approaches are present in this article with four stages. The bias field and random noise are eliminated by pre-processing step of filtering initially by anisotropic diffusion. Different tissues are distinguished by multi-resolution information to obtain images applied with Stationary wavelet transform (SWT). The extraction of spatial filtering to the coefficients of SWT applies different tissues of statistical information. The raw wavelet transform coefficients features are combined together to obtain a feature vector and are applied to the SOM network. The competitive unsupervised training methodology is used to segment images in SOM.

3.13 Self-Organizing Map and Adaptive Resonance Theory

The adaptive resonance theory (ART) of Carpenter and Grossberg and the self-organizing map (SOM) of Kohonen, model stunned the limitations of (i) the stability–plasticity trade-offs in neural architectures that employ ART; and (ii) the on-line learning property that lack in the SOM. Initial experimental model of SOMART related to Fuzzy ART motivate the main contribution to exploit the generation of growing featured map. The novel lateral control of plasticity obtained a new model of SmART that resolves the stability–plasticity problem and is found to perform well in RGB colour space which is more coherent than Fuzzy ART. The overall survey is tabled as below:

AUTHOR	YEAR	METHOD	MAIN ADVANTAGES	DRAWBACKS
Kohenen	2001	SOM	High-dimensional data is applied for clustering tool which make quite simple	Lower Dimensional output map provides SOM training
Yuan et al	2004	SOM and Ensemble (SOM neural network or k-means clustering)	Clustering results are generated vigorously	The segmentation for number of region is manually set to be outdated.
Ortizabca et al	2013	Two Unsupervised Approaches for Brain Image Segmentation	High resolution images outcomes with better segmentation	Cost of estimation is high
Saeid et al	2013	Self Organizing Map Artificial Neural Network	Greater speed, stability and flexibility	It cannot work better at the difficult scenes
Sourav et al	2013	SOM Mahalalobis distance	The case of segmentation may or may not select threshold point always to get ideal result	Satellite based images does not have prior knowledge
Heng-Da et al	2005	Hierarchical Self-Organizing Map	Natural color images can lead to good segmentation	The colors has to be specified with final number as a priori.
Jesna et al	2014	Principle Component Analysis and Self-Organizing Map	The processing time and the overall segmentation time are reduced by PCA selection. The feature vectors are reduced to SOM for clustering	The feature selection of PCA can remove the sensitive data
Li et al	2005	SOM with Markov Random Field	Segmentation results are improved by markov random field (mrf) model	The feature vectors depend on quality of SOM used for training
Andrés et al	2013	SOM-FCM	Volume image extract 3D statistical features	Partial volume effect (PVE)problem are addressed
Arfan et al	2011	SOM Neural Network	SOM make more compact segments than reducing the training time	
Kanimozhi et al	2013	FEM-K-Means	3-D MR segmentation provides better results of human brain images	
Yeo et al	2005	SOM-SWT	Input images generate more segmented details	
Samir et al	2012	Self-Organizing Map and Adaptive Resonance Theory	Fuzzy ART is more coherent	

IV. CONCLUSION

Recent research in various techniques of image segmentation and overview of all related image segmentation techniques are presented in this article. SOM is analyzed by MR brain images for SOM segmentation with different survey methods. The survey implements SOM to give better segmentation results. The feature vectors are selected by hard clustering algorithm of SOM in normal situation. SOM is visible by some drawbacks anyhow it is good for medical image segmentation. After the analysis of different techniques of image segmentation, it is observed that feature vectors obtain quality SOM which is used for training. The hybrid solution for image segmentation contains different techniques of image segmentation which is the best approach to solve the problem of image segmentation.

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