A Survey of Comparative Segmentation Analysis For Magnetic Resonance Images

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Abstract—***Now-a-days, almost all biomedical science use magnetic resonance image for diagnosis. Segmentation plays a vital role in such biomedical science.. Hence, there is a need to improved result by proposed method as suggested by authors.. Various approaches have been reported in literature for segmentation of brain, where main objective is separating the pixels associated with different types of tissues like white matter (WM), gray matter (GM) and cerebrospinal fluid (CSF). This paper introduces an automatic model based technique for brain tissue segmentation from cerebral magnetic resonance (MR) images by using support vector machine (SVM) based classifier. A new and powerful kind of supervised machine learning with high generalization characteristics, is employedby SVM. Another classifier such as neural network plays an important role in biomedical science for improved result for health care system. This paper will analyseSegmentation algorithm and Proved comparative study.***

Keywords— ***Magnetic Resonance Images,whitematter,graymatter,cerebrospinal fluid,Support vector machine,Neural network***

I. Introduction

Image segmentation is often required as a preliminary and indispensable stage in the computer aided medical image process, particularly during the clinical analysis of magnetic resonance (MR) brain image.[1].MR brain image segmentation has wide applications. It can be used in quantitative analysis of tissue volumes in medical diagnosis. It also enables visualization of tissue structures in three dimensions, which will benefit physicians greatly not only in diagnosis but also in treatment planning. Detection of internal structure in brain MRI is widely used to diagnose several brain diseases such as epilepsy, multiple sclerosis, schizophrenia and alcoholism.

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Due to advances in computing hardware and its easy availability, the performance of MRI system has improved dramatically since its invention in early 70's and has evolved to provide fast imaging, better resolution, immunity to artefacts and cheaper cost. Magnetic resonance imaging is also applied to study the behaviour of cells and how they react with disease and treatment. Subatomic particles (electron, proton and neutron) can be imagined as spinning on their axes.

Various approaches have been reported in literature for segmentation of brain, where main objective is separating the pixels associated with different types of tissues like white matter, gray matter and cerebrospinal fluid (CSF). Of these, semi-automated methods that employ only sequence of image processing techniques are not preferred because they rely heavily on human interaction for accurate and reliable segmentation. Fully automated methods, on the other hand, are free from any human interference and can segment the brain with high precision by using computational intelligence in association with image processing algorithms. In this paper, we review the methodologies of MRI segmentation that can be used in various diagnostics such as fMRI (Functional MRI), CMRI (cardiac MRI) and MRA (Magnetic Resonance Angiography). We will also present the different techniques of computational intelligence to be efficiently used in MRI segmentation.

The paper is organized as follows. Section II discuss about the MRI can be useful for diagnosis purpose. Section III consists of different segmentation method such as SVM., Neural Network. Section IV covers the comparative study of these techniques. Section V concludes the theoretical work.

II. Magnetic Resonance Images UsedForDiagnostics

Magnetic resonance imaging includes three steps [3]

1. Place the patient in a uniform magnetic field ,
2. Displace the equilibrium magnetization vector with RF pulse,
3. Observe the signal as a the magnetization vector returns to equilibrium.

The object or patient to be scanned is assumed to be made up of voxels. The signal detected from each voxels represent the intensity level of corresponding pixel in image. Recalling NMR principle, the application of RF pulse to the object placed in magnetic field results in precision of nuclear spin of voxel(s) whose Larmor frequency matches with frequency of RF pulse .Thus , two main controlled tasks are needed to be done in MRI.[1]

1. Assigning unique Larmor frequency to each voxel of object by varying magnetic field(field gradient). For one dimension image ,only one gradient is required. Similarly for 2D and 3D imaging , two and three field gradients are necessary.[10]
2. Applying RF pulse of one of the assigned frequency to voxel would give the signal from that voxel which can be detected by RF coil and hence , the information about the voxel can be obtained for by after processing the signal.

A. *Diagnosis System*

General objectives of diagnosis system using MRI image processing can be:

- localizing the objects of interest, i.e. different organs
- taking the measurements of the extracted objects, e.g. tumor's in the Image
- interpreting the objects for diagnosis

B. *Functional MRI(fMRI)*

The processing of fMRI [6]data , obtained in response to BOLD effect in brain actually involves three stages

1. Pre-processing –registration- smoothing
   a. Registering the images
   b. Correction for subject movement during the experiments
   c. Smoothing the data to improve the signal to noise ratio(SNR)
2. Statistical analysis

   It detects the pixel in the image which shows a response to the stimulus
3. Activation images display with probability values which give the statistical analysis.

The statistical analysis ofblood oxygen level dependent (BOLD) is a critical part of the brain mapping with functional magnetic resonance imaging . Several statistical methods have been proposed . With the flexibility of fMRI and the range of possible experiments , number of different statistical processing approaches can be applied to yield strategy applying several methods to the same data may be the best approach for pulling out and evaluating the full information contents of the fMRI data. Aim of such analysis is to produce an image identifying the region which shows significant signal change in response to the task.

C. *Cardiac MRI(CMRI)*

The study of biomechanical properties of normal and abnormal heart muscle are fundamentals to investigate the cardiovascular disease and therapeutic interventions on ventricular performance . In order to make abnormal motion of heart as a indicator of heart and lung disease , its normal function should be characterized before abnormal states can be detected . The quantification myocardial strain due to contraction has been a crucial process in clinical assessments. The important issue in measuring local wall motion is the capability to localize the same point within myocardium on two images at separate parts of the cardiac cycle . Two most common techniques used in MRI to measure myocardial motion are myocardial tagging and myocardial velocity mapping. However, tagged cardiac imaging has been well established in clinical research , despite its time consuming post processing procedure. Tagged cardiac imaging permits the visualization of the muscle movements in the beating heart which can be used as diagnostic information regarding the strain patterns in the heart . We have here essential elements used in MR tagging and generation of tagging lines in image SPAMM (spatial modulation of magnetization) is used to have tagging ,tracking which in the images of different phases in cardiac cycle describes the motion of heart wall. Finally, recent technique used for motion analysisand generation of strain pattern , is discussed here. The earliest developed techniquesfor quantifying myocardial motion was based on a radiopaque fiducial markers. How ever due to limitation in existing methods that they are invasive , the development of new methods was the need of clinical world. The tagged MRI was developed to examine the heart wall motion as a non-invasivetool , by magnetically "tagging " different regions of the heart wall.

III. Proposed System

The system proposed by the authors has the following steps:

- The first is the pre-processing in which non-brain tissue is removed from the data volume. The noise is filtered out with an anisotropic diffusion filtering method which the authors used from earlier work by P. Perona and J. Malik, 'Scale-space and edge detection using anisotropic diffusion'.
- In the second step, an initial 2D slice which contains pathological voxels needs to be selected manually from the 3D model.

- Using the expectation-maximization (EM) algorithm, the image is segmented into white matter (WM), grey matter (GM) and cerebrospinal fluid (CSF).[7]
- In the fourth step, which is to extract the tumor, the authors have proposed to use a deformable model algorithm based on level set technique. The speed term which changes the implicit function depends upon the curvature term for smoothness and data term for evolution. The model shrinks when the boundary encloses parts of the background, and grows when the boundary is inside the tumor region. The speed function constraints the level-set evolution and makes it very stable. This is how the tumor is extracted.
- Once the region-of interest in the current slice is found, in the fifth step, the search to locate volumetric area constituting tumors region is identified by spatial coordinates and voxel intensity. This process is interactive since human intervention is needed to decide when to stop.
- The last step post processing is performed based on mathematical morphology operations.

An attempt has been made to determine the degree of malignancy of brain tumors using artificial intelligence. The process flow of the proposed method is shown inFig.1.1Significantshape-based boundary featuresandtexture features are extracted from region of interestsoftumour and fed to the classifier. In the classification blockinput images are analysed using two simple approaches(shape based and texture based). The ultimate classifier isan adaptive neuro-fuzzy classifier for uncertaintymanagement appears due to the insufficient information ofbrain lesions. In the detection block, tumour blocks areidentified and marked as second opinion of radiologists.[8]

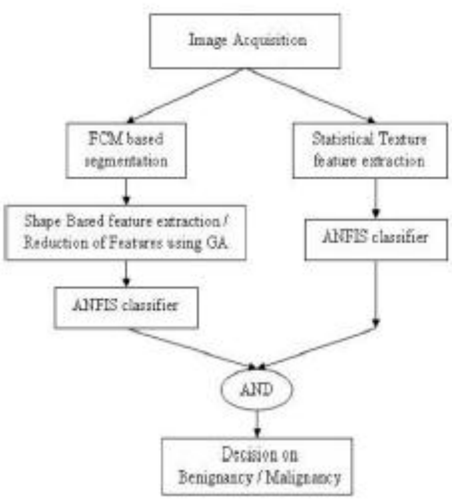

Fig. 1.1 Brief overview of proposed work

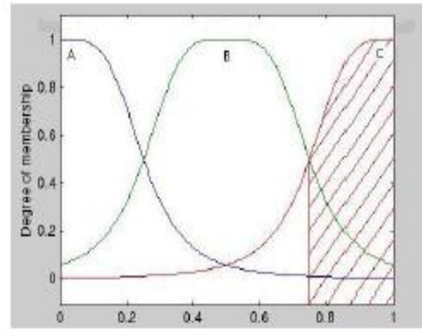

Fig. 1.2 Final fuzzy partition membership function

- In the proposed technique, fuzzy c-means clustering algorithm used for intensity based segmentation of tumors. Total number of fuzzy cluster centres chosen is three as shown in Fig. 1.2 Cluster centre**A**represents the healthy brain tissue. Second cluster **B** represents false presence of tumor region (due to surrounding inflammations and tissue deformation) and **C** represents actual tumor affected region.

IV. Classifier

A. *SVM Technique*

As least square SVM (LSSVM) with radial basis function (RBF) kernel is readily found with excellent generalization performance and low computational cost [12], it is employed to produce the class probabilities. Here, a method is used to map the LS-SVM outputs into posterior probabilities by applying a sigmoid function whose parameters are estimated from the training process. Integrating prior knowledge obtained from atlases into LS-SVM leads to improving the classification accuracy. [9,11]

Principal of SVM

Support Vector Machines as a set of supervised learning methods are used for both classification and regression problems based on Statistical Learning Theory (SLT) . SVM is designed in the first place for solving the binary problems. Recently, methods are introduced to generalize to problem into multi-classification problem. The basic idea behind SVM is to construct an optimal separating hyper-plane, which tries to maximize the margin (maximum distance to the closest data point) between feature vectors belonging to different classes, and minimize the classification error.

The theory of brain segmentation presented in [4] is based on using LS-SVM learning method. In this technique, LS-SVM regression is used for the application of function estimation. Here, we aim to estimate the class probability of each voxel based on using a supervised learning method. The training samples for the learning machine are chosen using a priori information available in atlas.

The entire segmentation process can be summarized in the following steps:
1) Pre-processing: Registration of probabilistic atlases with input data and skull-stripping should be performed before the segmentation process.
2) Sampling and feature extraction: Discretising atlases and then Sampling from each class, location and intensity of voxels can be chosen as the elements of feature vector.
3) Segmentation: Training the LS-SVM learning method, exploiting sigmoid function and updating the probabilistic atlases are the key parts of segmentation process.
4) Return to the first step to start the next iteration.
5) Exit the loop after receiving desirable results and discretising the probabilistic outputs.

Since LS-SVM learning method provide a good generalization over different types of input data and the process is performed iteratively, this method offers an acceptable accuracy of segmentation[2]

B. *Neural Network*

A multi-layer perceptron feedforward is trained based on the back error propagation algorithm. To use neural network, the feature vector is applied to the input layer of the network. With known input-output mapping, the weights of each layer are adjusted so that error between output layer and actual known outputs would be reduced. This is called as training phase. With this trained network with optimum set of weights in each layer obtained from supervised training, feature vector extracted from unknown sample is applied and output of classification is inferred from the values of the output layer nodes.[5]

V. Conclusion

The most important goal of segmentation is improved the diagnosis for health care system. If any segmentation method can be completely segments to pixal then it is considered useless. However, at the same time proposed method is comparatively simple to implement and effective in result also. Therefore , even today, there are many medical diagnosis which depend on MRI segmentation. In this paper we have discussed all detail about MRI segmentation and how it is useful for tumor application.

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