SURVEY PAPER ON BRAIN TUMOR SEGMENTATION TECHNIQUES

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ABSTRACT

Image processing is used widely in solving a variety of problems. The important and complex phase of image processing is image segmentation. This paper provides a brief description on some of the segmentation algorithms specifically on brain tumor MR Images. Later in this paper, simple comparisons are made between the listed algorithms. This work helps in understanding some of the existing brain MR Image segmentation algorithms better.

KEYWORDS

Image processing, Image segmentation, Brain tumor, MRI (Magnetic Resonance Image)

INTRODUCTION

A brain is the important part of human body and it's the most complex one. Nothing can function without brain. Certain diseases of brain can make drastic changes in human body and completely turn their life upside down. One such disease is Brain tumor. This disease can happen to anyone regardless of age.

An INTRACRANIAL NEOPLASM or BRAIN TUMOR occur when the cells from within the brain grow abnormally or excessively. Tumors can be both cancerous as well as non-cancerous. Cancerous tumors are referred as malignant and non-cancerous cells are referred as benign. When these tumors grow inside brain, it creates a pressure that causes brain damage and may lead to death. Tumors have been majorly divided into two types Primary tumors which originates from within the brain, most of primary tumors are benign type of tumors which appears as normal tissues when viewed thorough microscope and Secondary tumors occurs when cancer cells spread to your brain from another organ such as lungs or breasts. Even though benign tumors are non-cancerous it is still dangerous as brain is enclosed in the skull, so these tumors can damage the brain tissues. Therefore, proper diagnosis and treatment is required for any type tumors.

Image processing is basic step in identifying the tumor that helps in proceeding with further treatments. Digital Image processing is one of the field where we use computer algorithms that helps to perform image processing on digital images. Choosing Digital Image processing over Analog Image processing (in which image processing is the task conducted on two dimensional analog signals by analog means) has many advantages. Firstly, digital image processing provides a wide range algorithms compared to analog so we have more choices in selecting the best suitable algorithm. Secondly, digital processing can avoid buildup of noise and signal distortion. Finally, the main advantage is that using digital image processing the images can be modeled to multi-dimensional image which

is not possible with analog image processing.

Digital Image processing consist of numerous types involved some of them are image Acquisition, Image Enhancement, Image Restoration, Compression, Image segmentation, object recognition and so on. The most important step is the Image Segmentation as identifying the exact tumor area would ease process of deciding on the further treatment. Image segmentation is the process of partitioning a digital image into multiple segments. The main objective is to change the representation of the image into something which is meaningful.

Therefore, identification of accurate tumor area has greater importance. In United States an estimation of 23,800 adults will be diagnosed with primary brain tumors which accounts for 85% to 90% of all primary CNS tumors. In 2013, approximately, 4,300 children younger than age20 were diagnosed with primary brain tumors, of 3,000 were under age15.The malignant type of cancers can lead to people's death. Some cancers can be removed but some cannot. So, from past few decades' doctors are trying to treat people with these dangerous cancerous cells. Brain tumor is most treatable and curable if detected in early stages of growth of abnormal tissues in brain. Brain tumor segmentation is the crucial step amongst the whole of digital image processing. There are many algorithms that is been used to segment the tumor more efficiently and it has been the key interest of researcher in recent times realizing the importance in detecting the exact tumor area.

In this work, we have focused on survey of various well-known brain tumor image segmentation techniques. The various algorithms that these techniques contained are Artificial Bee Colony and Fuzzy C-means, Pixel classification based K-means and SVM, Cellular Automata based Fuzzy C-means, Hybrid Intelligent, Improved Fuzzy C-means and Watershed, Bacteria Foraging Optimization, Deep Learning based, Convolution neural Network and Cuckoo search optimization.

REVIEW ON BRAIN TUMOR SEGMENTATION TECHNIQUES

1. Unsupervised Artificial Bee Colony algorithm and FCM clustering

By knowing importance of tumorsegmentation of MRI brain images, in this paper, "Brain Tumor Segmentation in MRI images using Unsupervised Artificial Bee Colony algorithm and FCM clustering" [1] the author has proposed a fast MRI brain image segmentation method which uses Artificial Bee Colony algorithm and Fuzzy C-means algorithm. ABC algorithm is used to find optimized threshold.

The original image is decomposed by discrete wavelet transforms to get well ordered fitness function for ABC algorithm. Then a filtered image is reconstructed with low frequency by performing noise reduction to approximation image. The segmented image is clustered using FCM algorithm which is used in identifying the brain tumor.

In this paper the author has provided an efficient fitness function to ABC to increase quality of segmentation. Advantage of this method over the other nature inspired algorithm is the low noise content.

Its result shows that this method not only detects the tumor from the images, but also gives its intensity.

2. Pixel Classification

This paper, "Pixel Classification based Brain MR Image segmentation"[2] presents the segmentation of brain MR images into four classes namely background, Cerebra spinal fluid, grey and white matter. This method also accomplishes an accurate segmentation of tumor in brain. The inter class distances are compared for classifying the pixelin various different classes. The author have ensured average Jaccord Index and dice co-efficient of 0.8173 and 0.8952 respectively.

The result of this proposed method has proven that the segmentation accuracy is good for images which have no noise or in-homogeneity.

3. K-means Clustering and SVM

In this paper, "A New Brain MRI image segmentation strategy based on K-means Clustering andSVM"[3] the authors have proposed a new strategy that uses K-means Clustering and SVM to segment brain MR images for the problem of noise and no reference image during MRI image segmentation. In this work MRI images are segmented using K-means clustering algorithm which gives us the initial classification result as class label then the feature vectors of each pixel of brain tissue are selected as training sample and test sample, and also SVM is used to segment brain MRI image. Experimental results of this proposed method produces better segmentation and good suppression of noise with low signal-noise-ratio (SNR) for brain images.

The outcome of this proposed method has given better segmentation effect for low SNR brain MRI.

4. Cellular Automata based Fuzzy C-means

This paper, "Brain Tumor Segmentation using Cellular Automata based Fuzzy C-means"[4], proposes a combined algorithm using features obtained from Gray Level Co-occurrence Matrix (GLCM) which is a hybrid of FCM clustering algorithm and Cellular automata model. The drawback found in traditional segmentation algorithm on seed growing problem using similarity function in which distance of pairwise pixels faced robustness in their function as growing pixels are moving away from the seeds. To overcome this drawback the author makes use of Fuzzy membership function obtained by FCM. BraTS2013 dataset is been used throughout in comparison for performance evaluation using dice similarity matrices.

This proposed method results on average dice similarity matrix of 84% and significantly performs better than other semi-automatic methods. This is achieved by establishing connections between FCM and Cellular Automata where GLCM feature space is applied to extract vector feature from MRI. FCM clusters these features for tumor region that is identified. Similarity function is replaced by Fuzzy membership function.

5. Hybrid Intelligent algorithm

In this work, "Brain tumor detection and segmentation using hybrid intelligent algorithm"[5]the author has proposed a Hopfield Neural Network which is an automatic brain tumor detection and segmentation technique that includes various techniques from skull stripping to detection and segmentation of brain tumor. This approach begins with pre-processing, image fusion and initial tumorous slice classification, segmentation using Hopfield Neural network and tumor region detection and extraction is done. The performance analysis is evaluated for simulated and real, normal and tumorous images.

This work produces final segmentation mean and standard deviation result in Jaccard Similarity Index of 0.8569+/-0.0896, Dice Similarity Score of 0.9186+/-0.0638, Sensitivity and Specificity are 0.9480+/-0.0402 and 0.9917+/-0.0387 respectively.

Four advantages mentioned in this approach:

1. Training data is not needed.
2. This approach is able to segment normal tissues and both enhanced and non-enhanced tumor by fusing T1-weighted and T2 weighted images.
3. Due to its high speed segmentation capabilities of fuzzy Hopfield Neural Network it can be used in real time application.
4. The proposed technique has little or no user intervention required to produce normal tissues and tumor segmentation results in limited time.

6. Improved Fuzzy C-Means clustering and Watershed Algorithm

The most commonly used algorithm for extracting Brain tumor is Fuzzy C-Means clustering and Watershed algorithm. This work, "Brain Tumor Segmentation from MR Brain Images usingImproved Fuzzy C-Means clustering and Watershed Algorithm"[6] combines these two algorithms and it also presents an improved version of Fuzzy C-Means for clustering which includes an effective method to select the initial centroid based on histogram calculation.

To avoid over segmentation problem often found in Watershed algorithm Atlas based Marker detection method is used.

Before segmentation process, this work includes a preprocessing stage that contains 3 operations: Noise removal, Skull stripping and Contrast enhancement. They have achieved an improved accuracy for Fuzzy C-Means of 88.91 and 81.56 for Dice and Tanimoto coefficients and for Watershed 93.13 and 88.64 of Dice and Tanimoto coefficients. They have compared accuracy of normal Fuzzy C-Means and Watershed algorithm accuracy with the proposed method.

7. Bacteria Foraging Optimization algorithm

The proposed system, "MR Brain Image Segmentation using Bacteria Foraging Optimizationalgorithm"[7] presents a unique population based image segmentation method that combines MRF with Bacteria Foraging Optimization algorithm which is a biologically inspired technique.

It works on pixel data of image and to form a content in which they can merge, it uses neighborhood/region map. The result of this is compared with traditional Genetic algorithm and proves that it performs better. Better characterization of natural brain structure has resulted in better accuracy.

8. Deep Learning Based Segmentation

The framework of hierarchical image segmentation consists of image preprocessing, deep learning network based classification and post-processing.

In preprocessing the image patches are extracted and gray level sequence of image patches are obtained which is considered as input to deep learning network. Deep learning based classification is implemented using a stacked auto encoder network that extracts the high level abstract feature from the input. Post-processing is implemented after the classification result is mapped to binary image, by a morphological filter to get the final segmentation outcome. The experiment is applied on to segment real patient's brain tumor dataset.

The proposed method, "A Deep Learning Based Segmentation method for Brain Tumor in MRImages"[8]automatically segments brain tumor, learns a deep non-linear network, realizes approximation of complex function and describes input data distribution. Segmentation results have increased by integrating stacked denoising auto encoder into segmentation procedure.

It gives higher classification accuracy, good matching rate and more stabled result.

9. Convolution Neural Network

This paper, "Brain Tumor Image Segmentation based on Convolution Neural Network"[9] provides a new method for automatic brain tumor segmentation combining Multimodality Images and Convolution Neural Network. Early diagnosis and automatic brain tumor segmentation reduces the problem of low accurateness and time consumption compared to that in manual segmentation.

This model extracts the natural and important features from Multimodality brain tumor images and then combines it with Multimodality information. Later to obtain comprehensive and quantitative evaluation, Convolution Neural Network results is compared with Menze 2010 and Bauer 2011, and is found that it evaluates better than the two.

10. Cuckoo Search Optimization

This paper, "Brain Tumor Segmentation using Cuckoo Search Optimization for MagneticResonance Images"[10]proposes a unique and efficient optimization algorithm which is based on swarm intelligence nature inspired, Cuckoo Search Optimization algorithm. Preprocessing of the acquired image is performed using modified tracking algorithm and Hybrid Center Weighted Median Filter. In the next phase MAP values are identified by applying the Markov Random Field and later MAP values are optimized by applying the Cuckoo Search Algorithm by considering the center pixel intensity.

Finally the obtained result has been compared with the Artificial Bee Colony and Bacteria Foraging Optimization algorithms and is concluded that Cuckoo

Search Optimization algorithm performs better than the two.

SUMMARY OF THE REVIEW TECHNIQUES

Techniques	Results
Artificial Bee Colony and FCM clustering	Fast segmentation, Low noise content, Detection of tumor along with its intensity.
Pixel Classification based Segmentation	Better accuracy for images having no noise or in-homogeneity, future expansion-estimating Mean and Variance by assuming Rician distribution.
K-means clustering and SVM	Better segmentation effect for Low SNR brain MR images
Cellular Automata based Fuzzy C-means	Dice similarity metrics reports 84% efficiency, To reduce computational time images in 2D data is used, Future expansion-applying same algorithm on 3D images.
Hybrid Intelligent algorithm	Does not need training data, Capable of segmenting normal tissues and both enhanced and non-enhanced tumor, high speed segmentation, highly automatic with little or no user intervention.
Improved Fuzzy C-means clustering and Watershed algorithm	Fuzzy C-means clustering Dice Co-efficient-88.91 Tanimoto Co-efficient-81.56 Watershed algorithm Dice Co-efficient-93.13 Tanimoto Co-efficient-88.64
Bacteria Foraging optimization algorithm	Improved accuracy rate due to better characterization of natural brain structure.
Deep Learning based Segmentation	Automatically segment brain tumor, can learn deep non-linear network, realizes the approximation of complex function and describes input data distribution.
Convolution Neural Network	More accurate results than the traditional methods and also provide reliable information for clinic treatments.
Cuckoo Search optimization	Performs superior segmentation of tumor compared to ABC and BFO algorithms.

CONCLUSION

This paper comprises ofa brief introduction on Image processing, Brain tumor, Brain tumor segmentation and review on different brain tumor segmentation techniques. The summary of each of the techniques reviewed is listed in the form of table. After performing a survey on different Segmentation techniques we have come to a conclusion that K-means clustering and SVM, Cellular Automata based Fuzzy C-means, Hybrid Intelligent algorithm, Improved Fuzzy C-means clustering and Watershed algorithm, Deep Learning based Segmentation, Convolution Neural Network, Cuckoo Search optimization algorithm's performances are efficient.

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BIOGRAPHY

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