IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 10, Issue 1, Ver. II (Jan - Feb. 2015), PP 80-86
www.iosrjournals.org

Literature Survey on Detection of Brain Tumor from MRI Images

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Abstract: *Today's recent medical imaging research faces the challenge of detecting brain tumor through Magnetic Resonance Images (MRI). Broadly, to produce images of soft tissue of human body, MRI images are used by experts. For brain tumor detection, image segmentation is required. Mechanizing this process is a tricky task because of the high diversity in the appearance of tumor tissues among different patients and in many cases similarity with the usual tissues.Physical segmentation of medical image by the radiologist is a monotonous and prolonged process. MRI is a highly developed medical imaging method providing rich information about the person soft-tissue structure. There are varied brain tumor recognition and segmentation methods to detect and segment a brain tumor from MRI images. This is well thought-out to be one of the most significant but tricky part of the process of detecting brain tumor. A variety of algorithms were developed for segmentation of MRI images by using different tools and methods. Alternatively this paper presents a comprehensive review of the methods and techniques used to detect brain tumor through MRI image.*
Keywords: *Brain Tumor, Magnetic Resonance Image (MRI), Segmentation, Clustering*

I. Introduction

In brain tumor diagnosis, doctors integrate their medical knowledge and brain magnetic resonance imaging (MRI) scans to obtain the nature and pathological characteristics of brain tumors and to decide on treatment options. However, in brain MRI, where a great number of MRI scans taken for every patient, physically detecting and segmenting brain tumors is monotonous. Therefore, there is a need for computer aided brain tumor detection and segmentation from brain MR images to overcome the problems involved in the manual segmentation. Number of methods has been proposed in recent years to seal this break, but still there is no generally customary automated technique by doctors to be used in clinical floor due to accuracy and robustness issues. Artificial Intelligence methods such as Digital Image Processing when cooperative with others like machine knowledge, fuzzy logic and pattern recognition are so valuable in Image techniques. The prime objective of this paper is to develop methodologies for an automated brain MR image segmentation scheme.

The paper is organized as follows the details of related work are given in section II. In section III methods of Pre Processing and Enhancement are discussed. Section IV describes the Segmentation methods. And later on Clustering Techniques are given in section V.

II. Related Work

Ivana Despotovi (2013), presented a new FCM-based method for spatially coherent and noise-robust image segmentation. The contribution was
1) The spatial information of local image features is integrated into both the similarity measure and the membership function to compensate for the effect of noise and
2) An anisotropic neighborhood, based on phase congruency features, is introduced to allow more accurate segmentation without image smoothing. The segmentation results, for both synthetic and real images, demonstrate that our method efficiently preserves the homogeneity of the regions and is more robust to noise than related FCM-based methods.

Maoguo Gong (2013), presented an improved fuzzy C-means (FCM) algorithm for image segmentation by introducing a tradeoff weighted fuzzy factor and a kernel metric. The tradeoff weighted fuzzy factor depends on the space distance of all neighboring pixels and their gray-level difference simultaneously. The new algorithm adaptively determined the kernel parameter by using a fast bandwidth selection rule based on the distance variance of all data points in the collection. Furthermore, the tradeoff weighted fuzzy factor and the kernel distance measure are both parameter free. Experimental results on synthetic and real images show that the new algorithm is effective and efficient, and is relatively independent of this type of noise.

Bhagwat et al (2013) they showed that DICOM images produce better results as compared to non medical images. They found that time requirement of hierarchical clustering was least of three and that for

Fuzzy C means it was highest for detection of brain tumor. K-means algorithm produces more accurate result compared to Fuzzy c-means and hierarchical clustering.[13]

A.Sivaramakrishnan and Dr.M.Karnan(2013) proposed a novel and an efficient detection of the brain tumor region from cerebral image was done using Fuzzy C-means clustering and histogram. The histogram equalization was used to calculate the intensity values of the grey level images. The decomposition of images was done using principle component analysis which was used to reduce dimensionality of the wavelet co - efficient. The results of the proposed Fuzzy C-means (FCM) clustering algorithm successfully and accurately extracted the tumor region from brain MRI brain images[11]

Jaskirat kaur et al (2012), described clustering algorithms for image segmentation and did a review on different tyapes of image segmentation techniques. They also proposed a methodology to classify and quantify different clustering algorithms based on their consistency in different applications. They described the various performance parameters on which consistency will be measured.

Roy et al (2012) calculated the tumor affected area for symmetrical analysis. They showed its application with several data sets with different tumor size, intensity and location. They proved that their algorithm can automatically detect and segment the brain tumor. MR images gives better result compare to other techniques like CT images and X-rays.. Image pre-processing includes conversion of RGB image into grayscale image and then passing that image to the high pass filter in order to remove noise present in image.[14]

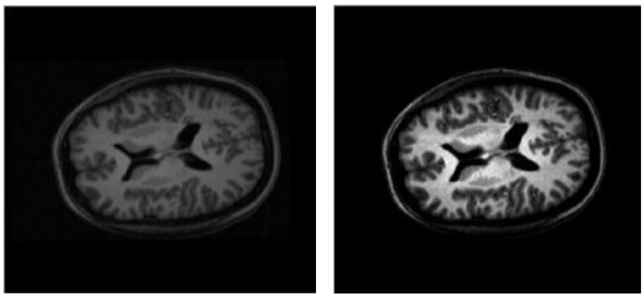
B. Sathya et al (2011), proposed four clustering algorithm; k mean, improved k mean, c mean and improved c mean algorithm. They did an experimental analysis for large database consisting of various images. They analyzed the results using various parameters

Hui Zhang et al (2008), compared subjective and supervised evaluation methodology for image segmentation. Subjective evaluation and supervised evaluation, are infeasible in many vision applications, so unsupervised methods are necessary. Unsupervised evaluation enables the objective comparison of both different segmentation methods and different parameterizations of a single method.[6]

Martial Heber et al (2005), presented an evaluation of two popular segmentation algorithms, the mean shift-based segmentation algorithm and a graph-based segmentation scheme.

III. Preprocessing And Enhancement

Preprocessing and enhancement techniques are used to improve the detection of the suspicious region from Magnetic Resonance Image (MRI).This section presents the gradient-based image enhancement method for brain MR images which is based on the first derivative and local statistics. The preprocessing and enhancement method consists of two steps; first the removal of film artifacts such as labels and X-ray marks are removed from the MRI using tracking algorithm. [12]Second, the removal of high frequency components using weighted median filtering technique. It gives high resolution MRI compare than median filter, Adaptive filter and spatial filter. The performance of the proposed method is also evaluated by means of peak single-to noise-ratio (PSNR), Average Signal-to-Noise Ratio (ASNR).[14]



Original image **Enhanced image**

Fig. 1 Pre-processing and Enhancement [17]

IV. Segmentation Methods

Image segmentation is the primary step and the most critical tasks of image analysis. Its purpose is that of extracting from an image by means of image segmentation. The mechanization of medical image segmentation has established wide application in diverse areas such as verdict for patients, treatment management planning, and computer-integrated surgery.

There are three broad approaches to segmentation, termed, Boundary approach (thresholding), Edge-based approach, Region-based approach.

1. **Boundary Approach (Thresholding)**

In thresholding, pixels are allocated to categories according to the range of values in which a pixel lies. Thresholding is the simplest and most commonly used method of segmentation. Given a single threshold, t, the pixel located at lattice position (i, j), with greyscale value fij , is allocated to category 1 if

$fij \leq t$

or else, the pixel is allocated to category 2.

2. Edge-Based Approach

In edge-based segmentation, an edge filter is applied to the image, pixels are categorized as edge or non-edge depending on the filter output, and pixels which are not divided by an edge are owed to the same category. Edge-based segmentation is based on the fact that the position of an edge is given by an extreme of the first-order derivative or a zero crossing in the second-order derivative. There a pixel is classified as an object pixel judging solely on its gray value independently of the context. To improve the results, feature computation and segmentation can be repeated until the procedure converges into a stable result.

3. Region-Based Approach

Region-based segmentation algorithms operate iteratively by grouping together pixels which are neighbors and have similar values and splitting groups of pixels which are dissimilar in value. Segmentation may be regarded as spatial clustering. Clustering in the sense that pixels with similar values are grouped together whereas spatial in that pixels in the same category also form a single connected component. Clustering algorithms may be agglomerative, conflict-ridden or iterative.

Clustering is the group of a collected works of patterns into clusters based on similarity. [16]Patterns within a valid cluster are more analogous to each one other than they are to a pattern belonging to a dissimilar cluster. Clustering is useful in pattern-analysis, grouping, decision-making, and machine-learning situations, data mining, document recovery, image segmentation, and pattern organization. On the other hand, many such problems, there is little prior information existing about the statistics, and the decision -maker must make as few suppositions about the data as probable [4][6]

V. Clustering Techniques

Clustering is a learning task, where one needs to identify a finite set of categories known as clusters to categorize pixels. Clustering is primarily used when module are known in progress. A resemblance criteria is defined between pixels [2] and then similar pixels are grouped together to form clusters. A good quality clustering method will produce high quality clusters with high intra-class similarity – similar to one another within the same cluster low inter-class similarity and dissimilarity to the objects in further clusters. [9]The superiority of a clustering result depends on both the similarity measure used by the method and its achievement. The eminence of a clustering method is also calculated by its ability to discover. Clustering refers to the classification of objects into groups according to criteria of these objects. In the clustering techniques, an attempt is made to extract a vector from local areas in the image. A standard procedure for clustering is to assign each pixel to the nearest cluster mean. Clustering algorithms are classified as hard clustering (k- means clustering) fuzzy clustering, etc.

1. The K-Means Algorithm

K-means algorithm is the most well-known and widely-used unsupervised clustering technique in partitioned clustering algorithms. Purpose of this algorithm is to minimize the distances of all the elements to their cluster centres.

Most of the algorithms in this field are developed by inspiring or improving k-means. The algorithm upgrades the clusters iteratively and runs in a loop until it reaches to optimal solution.[14] Pseudo-code of the K-means clustering algorithm is shown.

Performance of K-means algorithm depends on initial values of cluster centers. Therefore the algorithm should be tested for different outcomes with different initial cluster centers by multi-running.[15]

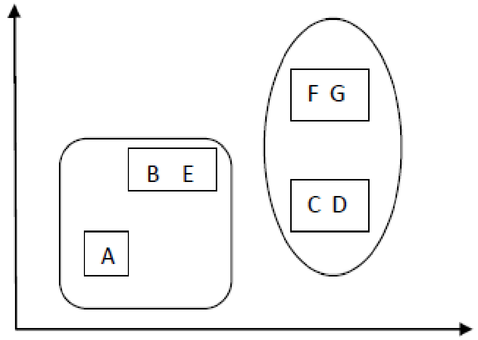


Figure 2. The k-means algorithm

Input:
// gray values of image pixels
dataset = { zp1, zp2, … , zpn }
Nc // number of clusters

Start:
- Generate (m1, m2, … ,mk) centroids randomly

Repeat:
- Assign each pixel to the class with the closest centroid
- Recalculate the Nc centroids, using

$$m_j = \frac{1}{n_j}\sum_{\forall zp \in C_j} z_p \qquad (1)$$

Where n_j is the number of pixels that belongs to cluster j, and C_j is the subset of pixel vectors that form cluster j

Until:
the cluster labels of the image does not change anymore OR fixed number of iterations.

Output:
Nc pieces of clusters

Figure 3. Pseudo code of the K-means

2.Fuzzy Clustering

It is effectively used in pattern recognition and fuzzy modelling. There are various similarity measures used to identify classes depended on the data and the application. Similarity measures for example distance, connectivity, and intensity are used. Its application is in data analysis, pattern recognition and image segments. Fuzzy clustering method can be considered to be superior since they can represent the relationship between the input pattern data and clusters more naturally [14]. Fuzzy c-means is a popular softclustering method. Fuzzy c-means is one of the most promising fuzzy clustering methods. In most cases, it is more flexible that the corresponding hard-clustering algorithm. Traditional clustering approaches generate partition, each pattern belongs to one and merely single cluster. That’s why; the clusters in a hard clustering technique are dislodged. Fuzzy clustering enlarges this notion to connect each pattern with every cluster by means of a membership function. The outcome of such algorithms is a clustering, although not a partition.

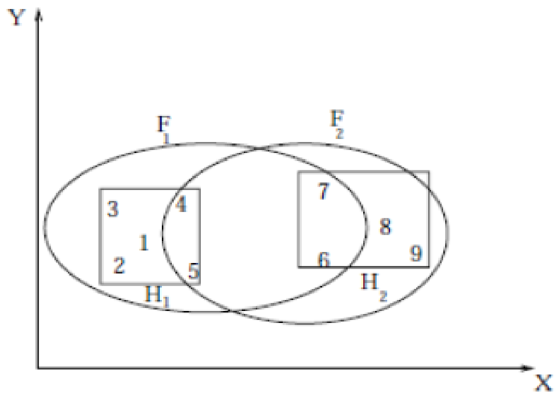


Figure 4. Fuzzy clusters

Step1 : Initialize $U=[u_{ij}]$ matrix, $U^{(0)}$
Step2: At k-step: calculate the centers vectors $C^{(k)}=[c_j]$ with $U^{(k)}$

$$c_j = \frac{\sum_{i-1}^{N} u_{ij}^{m} \cdot xi}{\sum_{i-1}^{N} u_{ij}^{m}}$$

Step:3 Update $U^{(k)}$, $U^{(k+1)}$

$$u_{ij} = \frac{1}{\sum_{k-1}^{c} \left(\frac{||xi-cj||}{||xi-cj||} \right)^{2/m-1}}$$

Step4: If $|| U^{(k+1)} - U^{(k)} || < \epsilon$ then STOP; otherwise return to step 2.

Figure 5. Pseudo code of the FCM[11]

S.NO	K-NN		FCM	
	PSNR	RMSE	PSNR	RMSE
1.	22.1659	102.206	32.1041	115.2132
2.	27.3142	107.241	35.6745	117.2143
3.	30.6634	125.253	37.6745	132.5871

Table 1: PSNR and RMSE values for different MRI[11]

3.Segmentation Using ACO

Ant colony optimization (ACO) is a population-based meta heuristic that can be used to find approximate solutions to difficult optimization troubles. In ACO, a set of software agents named artificial ants look for for excellent solutions to a given optimization problem. [12]To apply ACO, the optimization problem is changed into the problem of finding the best path on a weighted graph. The artificial ants incrementally build solutions by moving on the graph. The solution construction process is stochastic and is biased by a pheromone model, that is, a set of parameters related with graph components whose values are customized at runtime by the ants.

4.Segmentation Using Genetic Algorithm (GA)

Thangavel and Karnan(2005) said a genetic algorithm (GA) is an optimization technique for obtaining the best possible solution in a vast solution space. Genetic algorithms operate on populations of strings, with the string coded to represent the parameter set. The intensity values of the tumor pixels are considered as initial population for the genetic algorithm. The intensity values of the suspicious regions are then converted as 8 bit binary strings and these values are then converted as population strings and intensity values are considered as fitness value for genetic algorithm. [12]Now the genetic operator‘s reproduction, crossover and mutation are applied to get new population of strings

5.PSO-Based Clustering Algorithm

The algorithm based on swarm intelligence has been developed by adapting the collective behavior which is shown for searching food sources. Each solution in PSO algorithm is a bird in the search space and it is called as a “particle”. All particles have a fitness value evaluated by a fitness function and a velocity data that orients their fights. In the problem space, the particles move by following the existing most favourable solutions [12]. PSO algorithm starts with a group of random generated solutions (particles) and optimal solution is investigated iteratively. In each iteration, all particles are updated according to two best values. The first of these best values is that a particle found so far and is called “pbest”. The other one is the best value found so far by any particles in the population. This value is the global best value for the population and called as “gbest”.

PSO is a numeric optimization algorithm in nature. However Omran proposed a PSO-based clustering algorithm in 2004 and he applied this method for image segmentation. In this approach, optimal cluster centers are determined by PSO which is a population-based search technique. Thus the effects of initial conditions are reduced, compared with classic methods (k-means, fcm).

Features	Normal Image	Manual	ACO	PSO
Angular Second moment	0.1762	0.1002	0.1225	0.1225
Contrast	0.0476	0.0439	0.0440	0.0440
Correlation	0.0667	0.0577	0.0575	0.0575
Variance	0.0628	0.0579	0.0590	0.0596
Inverse distant moment	0.3575	0.1734	0.1927	0.1927
Sum average	0.0938	0.0780	0.0776	0.0776
Sum Variance	0.0556	0.0416	0.0424	0.0425
Features	Normal Image	Manual	ACO	PSO
Sum entropy	0.1734	0.1202	0.1235	0.1245
Entropy	0.2828	0.1202	0.1235	0.1245
Difference variance	0.5211	0.1550	0.1729	0.1735
Difference entropy	0.1660	0.1178	0.1190	0.1197
Information measures of correlation	0.2784	0.1295	0.1472	0.1477

Table 2: Comparison Between Manual, Aco, Pso And Gd Segmentation[12]

VI. Conclusion

In this study, the overview of various segmentation methodologies is explained. In spite of huge research, there is no universally accepted method for image segmentation, as of the result of image segmentation is affected by lots of factors. Thus there is no single method which can be considered good. All methods are equally good for a particular type of image. Due to this, image segmentation remains a challenging problem in image processing.

The medical image segmentation has difficulties in segmenting complex structure with uneven shape, size, and properties. In such condition it is better to use unsupervised methods such as fuzzy-c-means algorithm. For accurate diagnosis of tumor patients, appropriate segmentation method is required to be used for MR images to carry out an improved diagnosis and treatment. Through examination of the literature, we found that the Fuzzy C--means algorithm should be used because of its simplicity and it is also preferred for faster clustering. The Intelligent segmentation of brain tumor from Magnetic Resonance Images (MRI) described a gradient-based brain image segmentation using Ant colony optimization (ACO), Particle Swarm Optimization (PSO) and Genetic Algorithm (GA). Initially the preprocessing stages are finished through tracking algorithms generalizing this algorithm to suit for the brain MRI from any database and the statistical result shows the proposed PSO algorithm can perform better than ACO and GA algorithm for tumor detection and detection.

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