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Relative Analysis of Different Technique of MRI Image Segmentation

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Abstract- Image segmentation is a process of partitioning an image into a set of non overlapping regions. The purpose of image segmentation is to decompose an image into parts that are meaningful with respect to a particular application. Although it is difficult to predict by a computer program what constitutes a meaningful segmentation. The medical image segmentation is measured a very complex process due to variability of the composition that is represented in the images. In order to address this challenging process, various segmentation methods have been analysed in the paper. The techniques of medical image segmentation were classified in many ways, according to diverse classification schemes. However, we present here a extensive classification of them into six groups thresholding, region-base, boundary detection, clustering-based, Watershed and hybrid methods.

Keywords - Clustering, Thresholding, Region-base, Boundary Detection.

I. INTRODUCTION

Image segmentation subdivides an image into its constituent regions or objects. The level to which the subdivision is carried depends on the problem being solved. Segmentation of nontrivial images is one of the most difficult tasks in image processing.

Segmentation accuracy determines the eventual success or failure of the computerized analysis procedures [1]. Segmentation algorithms are area oriented instead of pixel-oriented. The result of segmentation is the splitting up of the image into connected areas. Image segmentation is the fundamental step in image analysis, understanding, and interpretation and recognition tasks. There are a number of techniques to segment an image into regions that are homogeneous. Not all the techniques are suitable for medical image analysis because of complexity and inaccuracy. There is no standard image segmentation technique that can produce satisfactory results for all imaging applications like brain MRI, brain cancer diagnosis etc. Optimal selection of features, tissues, brain and non–brain elements are considered as main obstacles for brain image segmentation. Fuzzy logic has shown great potential in this field. With the involvement of soft computing, the pattern matching, classification and detection of algorithms which have direct applications in many medical problems have become easier to be implemented & diagnosed

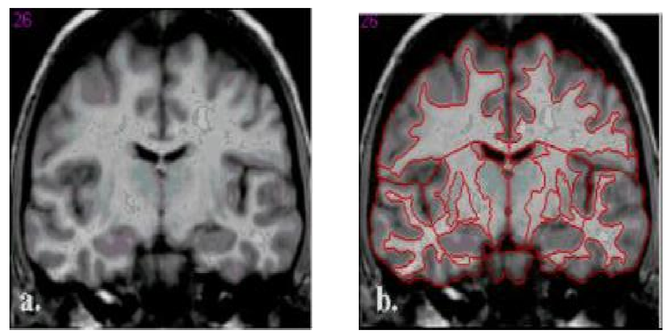


Figure 1.
a. Before Segmentation b. After segmentation

II. SEGMENTATION TECHNIQUES

Image Segmentation partitions an image into set of Regions. The region represents meaningful areas in an image or be the set of border pixels grouped into structures such as line segments, edges etc. The segmentation has two objectives: (i) to decompose an image into regions for further analysis, (ii) to perform a change of representation of an image for faster analysis . Different types of segmentation techniques are used for segmentation[3,4]. Based on the application, a single or a combination of segmentation techniques can be applied to solve the problem effectively. Segmentation algorithm is based on the properties of gray level values of pixels. The different types of segmentation techniques are: (a) Threshold Based Segmentation (b) Region Based Segmentation (c) Clustering (d) Neural network (e) Normalized Cuts (f) Fuzzy Connectedness . In this paper we will overlook of all different segmentation methods.

III. THRESHOLDING

Segmentation methods based on thresholding attempt to determine intensity values, called thresholds, which separate the pixels' intensities into ranges that correspond to the tissue types. One approach to determining an appropriate threshold value is to iteratively try each possible value and evaluate its resulting segmentation for features that indicate the segmentation is satisfactory in [5], both use this approach. Another approach to determining appropriate threshold values is to examine the image's histogram of pixel intensities. Since each tissue type has a characteristic MR signal intensity. It is assumed that the histogram of pixel intensities should display a discernable peak for each tissue type, with the valleys between these peaks occurring at the desired thresholds.

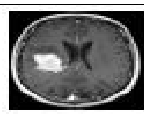
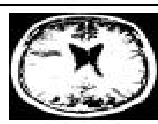
Input Image	
Output Image	

Figure 2. Segmented Image Using Thresholding

IV. REGION-BASED METHODS

Watershed transform and region growing are commonly known examples of region based segmentation approaches. Watershed transform and region growing are shown as examples of region splitting and merging methods, respectively. In the following subsections, watershed transform and region growing methods are explained.

4.1 Watershed Transform

Watershed transform is used to segment gray matter, white matter and cerebrospinal fluid from magnetic resonance (MR) brain images. The method originated from mathematical morphology that deals with the topographic representation of an image. Watersheds are one of the typical regions in the field of topography[6]. A drop of the water falling it flows down until it reaches the bottom of the region. Monochrome image is considered to be a height surface in which high altitude pixels correspond to ridges and low-altitude pixels correspond to valleys. This suggestion says if we have a minima point, by falling water, region and the frontier can be achieved. Watershed uses image gradient to initial point and region can get by region growing. The accretion of water in the neighbourhood of local minima is called a catchment basin. Watershed refers to a ridge that divides areas shattered by different river systems . A catchment basin is the environmental area draining into a river or reservoir. If we consider that bright areas are high and dark areas are low, then it might look like the plane. With planes, it is natural to think in terms of catchment basins and watershed lines. Two approaches are there to find watershed of an image,

1. Rainfall approach

2. Flooding approach

In rainfall approach, local minima are found all through the image, and each local minima is assigned an exclusive tag. An intangible water drop is placed at each untagged pixel. The drop moves to low amplitude neighbour until it reaches a tagged pixel and it assumes tag value. In flooding approach, intangible pixel holes are pierced at each local minima. The water enters the holes and takings to fill each catchment basin. If the basin is about to overflow, a dam is built on its neighbouring ridge line to the height of high altitude ridge point. These dam borders correspond to the watershed lines. Advantages of the watershed transform include the fact that it is a fast, simple and intuitive method. More importantly, it is able to produce a entire division of the image in separated regions even if the contrast is poor, thus there is no need to carry out any post processing work, such as contour joining. Its limitations will include over-segmentation and sensitivity to noise. There has also been an increasing interest in applying soft segmentation algorithms, where a pixel may be classified partially into multiple classes, for MR images segmentation. Actually, instead of the original image, the watershed transform is applied to its gradient. There are several disadvantages of watershed transform:

(1) over segmentation

(2) sensitivity to noise

(3) poor detection of significant boundaries with low contrast .

Oversegmentation: The watershed transform produces plenty of small regions since instead of the original image, catchment basins are computed on its gradient. Number of resultant regions should be minimized to achieve the useful segmentation results. Using marker image, which causes to decrease in the number of minima in the image, is the solution to the minimization of region quantity. Moreover, The usage of a scale space approach to choose the regions of interest with such different filters as morphological operations or nonlinear diffusions is also conducted.

Sensitivity to noise: A local variation of the image causes the results of the transform to change dramatically. This effect deteriorates due to the use of the gradient estimation amplifying the noise. In order to lower the problems stemmed from the local variations, anisotropic filters have been used.

Poor detection of significant boundaries with low contrast: If the region of interest has not high enough contrast boundaries, the watershed transform is not capable of the accurate segmentation. In addition, the detected contours do not always correspond to the contours of interest although the watershed transform intuitively extracts those with higher value between markers.

4.2Region Growing

Region growing is a bottom up technique which extracts an image region connected based on some similarity constraints. Region is iteratively grown from the seed sub region by adding in neighbouring sub regions that are similar based on some predefined criteria, increasing the size of the region, where sub regions usually correspond to pixels or voxels in the image or to catchment basins in watershed transform. The growing procedure is continued until all sub regions belong to some region. The predefined criteria, actually similarity constraints, can be defined based on intensity information, edges in the image, and/or the output of any other segmentation algorithm. In simplest region growing algorithm, a seed point that is manually selected by an operator is required and the extraction of all pixels connected to the initial seed based on any predefined criteria is realized. In order to determine the seed points, user interaction is required, which is its primary drawback. In other words, one must plant a seed for each region to be extracted. Split and merge is a region growing related algorithm which does not need a seed point . Another drawback of the region growing is the sensitivity to noise. This causes the extracted regions to posses holes or become disconnected. In medical image processing, region growing is rarely used on its own. In general, it is used with other image processing operations. Especially, To delineate small and simple structures such as lesions and tumors are common medical applications of region growing.

V. CLUSTERING TECHNIQUE

Clustering is a grouping technique that uses a similarity measure based on which similar items are placed together in the same group and dissimilar items are placed in different groups. The resulting groups are referred to as clusters and the similarity measure by which they were generated is in fact known as a distance measure. This technique is considered to be the most important unsupervised learning technique, it is widely used in the field of computer vision and image processing and as a result has found application in a vast array of domains such as: Marketing, Biology, Libraries, Medical Imaging, etc.

5.1 K-means clustering

We make use of K-means clustering algorithm, which is an unsupervised method, to provide us with a primary segmentation of the Brain tumor in MR image[6,7]. From our previous work, we observed that there are many regions with similar intensities in a MR image of the head, which result in many local minima that increases over segmentation, when we apply the watershed algorithm. The coarse areas are smoothened in the primary segmentation. K-means clustering is used because it is simple and has relatively low computational complexity. In addition, it is suitable for biomedical image segmentation as the number of clusters (K) is usually known for images of particular regions of human anatomy [16]. MR image of the head generally consists of regions representing the bone, soft tissue, fat and background. Hence we select K to be 4. Initial cluster centers are chosen in a first pass of the data. The dataset is partitioned into K clusters and the data points are randomly assigned to the clusters resulting in clusters that have roughly the same number of data points. For each data point, we calculate the Euclidean distance from the data point to the mean of each cluster. If the data point is not closest to its own cluster, it will have to be shifted into the closest cluster. If the data point is already closest to its own cluster, we will not shift it. The process continues until cluster means do not shift more than a given cut-off value or the iteration limit is reached.

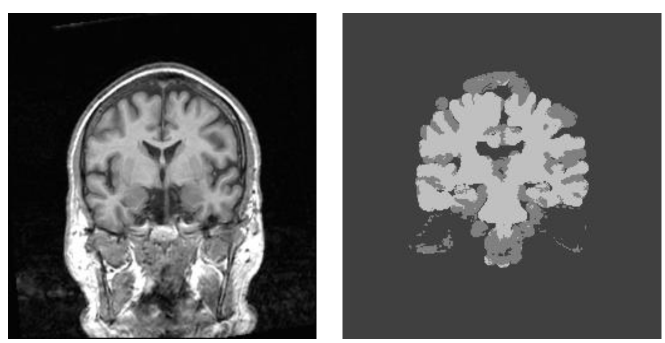


Figure 3. Orignal Image K Means Segmented Image

5.2 Fuzzy C-means clustering

Fuzzy C-means clustering (FCM), also called as ISODATA, is a data clustering method in which each data point belongs to a cluster to a degree specified by a membership value. FCM is used in many applications like pattern recognition classification image segmentation FCM divides a collection of n vectors c fuzzy groups and finds a cluster center in each group such that a cost function of dissimilarity measure is minimized. FCM uses fuzzy partitioning such that a given data point can belong to several groups with the degree of belongingness specified by membership values between 0 and 1.

VI. NEURAL NETWORKS

In a neural network framework for image segmentation, neural network is usually applied with basic segmentation operations, such as thresholding, region growing, or etc, since neural networks requires some features describing the object to be segmented[8]. Some examples of the features are area, circularity, inertial momentum, mean and standard deviation of radial length and intensity, entropy of intensity distribution, fractal index, eccentricity, anisotropy and etc.

Figure 4. Hybrid Artificial Neural Network Segmentation

VII. NORMALIZED CUTS

In the Normalized Cut, segmentation is considered as a graph-partitioning problem: “it maximizes both the total dissimilarity between the different groups and the total similarity within the groups[9] The Normalized Cut segmentation technique has tendency to merge different features, e.g., windowed histograms, position, brightness. Combination of various features expands its application areas using different imaging modalities.

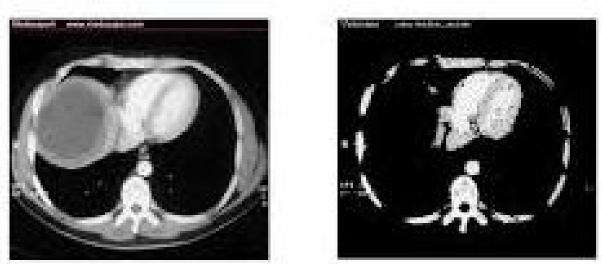


Figure 5.Orignal Image Segmented Image

VIII. FUZZY CONNECTEDNESS

In images, regions belonging to object appear with a variety in intensities due to the actual object material property as well as due to such artifacts as noise, blurring, and variations in background originated from the imaging modalities. Object regions can be recognized easily by observers as a gestalt despite this gradation of intensities. With a fuzzy topological concept called fuzzy connectedness, this scheme intends to mimic what the observer do. Fuzzy connectedness denotes how the image components be connected together spatially. During recongnizing object in an image, the connectedness strength between every pair of the image components and all possible connection paths between the pair is considered. Modern workstations’ computational speed give a chance to extract objects from an image using theoretical advances in fuzzy connectedness via dynamic programming in spite of high combinatorial complexity. Fuzzy connectedness framework are used in several medical applications in the areas of computer tomographic (CT), magnetic resonance (MR), angiography, mammography, and colonography as well as for detection of tumours and multiple sclerosis of the brain and upper airway disorders in children.

IX. CONCLUSION

Future research in the segmentation of medical images will strive towards improving the accuracy, precision, and computational speed of segmentation methods, as well as reducing the amount of manual interaction. Accuracy and precision can be improved by incorporating prior information from atlases and by combining discrete and continuous-based segmentation methods. For increasing computational efficiency, multiscale processing and parallelizable methods such as neural networks appear to be promising approaches[10].

Computational efficiency will be particularly important in real-time processingapplications. Possibly the most important question surrounding the use of image segmentation is its application in clinical settings[11]. Computerized segmentation methods have already demonstrated their utility in research applications and are now garnering increased use for computer aided diagnosis and radiotherapy planning. It is unlikely that automated segmentation methods will ever replace physicians but they will likely become crucial elements of medical image analysis. Segmentation methods will be particularly valuable in areas such as computer integrated surgery, where visualization of the anatomy is a critical component.

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