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Survey on Medical Image Segmentation Methods

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Abstract*—Segmentation is conceptually very simple idea. Simply looking at an image, one can tell what regions are contained in a picture. The main goal of image segmentation is domain independent partitioning of an image into a set of disjoint regions that are visually different, homogeneous and meaningful. In the last decades, medical imaging techniques have been applied to scan human body for clinical purposes (diagnoses and surgical planning) and medical science studies like anatomy and physiology. The area incorporates imaging technology based on radiography, nuclear medicine, endoscopy, microscopy, tomography, magnetic resonance imaging, among others. This survey addresses the basics of segmentation methods used in medical field.

***Keywords*— Cluster, Image Processing, MRI, Texture, Threshold**

I. INTRODUCTION

Image analysis is being adopted extensively in many applications such as digital forensics, medical treatment, industrial inspection, etc. primarily for diagnostic purposes. Hence, there is a growing interest among researches in developing new segmentation techniques to aid the diagnosis process. Manual segmentation of images is labour intensive, extremely time consuming and prone to human errors and hence an automated real-time technique is warranted in such applications. There is no universally applicable automated segmentation technique that will work for all images as the image segmentation is quite complex and unique depending upon the domain application [4].

Medical image segmentation is one of the most challenging problems in healthcare industry and has been studied extensively in the last few decades. Segmentation of vessel like structures in medical images includes image driven techniques, such as edge-based and region-based approaches; pattern recognition techniques, model-based approaches, tracking-based approaches and neural network based approaches [8].One of the common behaviors of medical images is that they are inherently fuzzy in most of the cases and do not exhibit discrete boundaries posing major challenge for clear segmentation of desired structure within the image. As medical imaging technology has grown tremendously, there are a number of modalities available and terabytes of images are generated everyday in healthcare environment. Difference in these images due to different body parts scanned through varied modalities for different pathological needs make the development of intelligent and efficient unsupervised image segmentation techniques necessary as well as challenging. Segmentation of medical images in 2D or 3D domain has several advantages and applications in healthcare industry. Key application areas include visualization, volume estimation of objects of interest, detection of abnormalities like tumors, tissue quantification, classification and elimination of unnecessary structures in the areas of interest within an image [7].

This part provides an overview of what is segmentation and problems during medical image segmentation method. Rest of the paper organized as follows: In section 2 describes the study of different segmentation methods with some advantages and disadvantages. Section 3 concludes the study.

II. DIFFERENT METHODS

Segmentation methods help to segment the image. Different image segmentation methods are as follows:

A. Thresholding Method

Simple thresholding based methods [6] relies on the brightness constant called threshold value and segment the pixels in the original image according to chosen threshold value.

Thresholding is used to separate foreground from background by selecting a threshold value T, any pixel(x, y) is selected as a part of foreground if its intensity is higher than or equal to threshold value i.e $f(x, y) \geq T$, else pixel points to background.Method used to select T is by observing histograms of particular image considered for segmentation. Selection of T automatically for each image by system without human involvement is termed as automatic threshold. Threshold technique can be viewed as:

$$T=T[x, y, p(x, y), f(x, y)]$$

Where: T is a threshold value, (x, y) are the coordinates of threshold point, p(x, y), f(x, y) are points the grey level image pixels, threshold image g(x, y) can be defined as:

$$g(x, y)= \begin{cases} 1 & \text{if } f(x,y)>T \\ 0 & \text{if } f(x,y)<T \end{cases}$$

when T depends only on f(x ,y) it refers to as global threshold, if T depends on f(x ,y) and p(x ,y) then it is called as local threshold and if T depends on x ,y along with p(x ,y) and f(x ,y) then it is called as adaptive threshold .Automatic thresholding can be done using an iterative thresholding scheme.

1. Select an initial value of threshold T.
2. Threshold the image using T, get two sets C1 and C2.
3. Find the mean intensity m1 and m2 for the pixels in two sets.
4. Find new threshold T=1/2(m1+m2).
5. Repeat the whole process till the value of T converges

Thresholding method [1] works well in images which has a bimodal distribution. Therefore algorithm can perform well on simple images with bimodal intensity distribution but fails on medical images which do not have bimodal distribution of intensity. In this case, thresholding result cannot partition the images into various anatomical structures correctly. Also this kind of segmentation neglects all spatial information of the image and is quite sensitive to noise.

B. Boundary-based Method

Boundary-based methods rely on the pixel characteristic which changes rapidly at the boundary between two regions. In this process, in the initial phase, edge detector operators are used for detecting the edge pixels and later these edges are modified to produce the close curves representing the boundaries between adjacent regions.

In those rare cases where an edge image already shows perfect closed object boundaries, edge-based segmentation can be achieved by the following algorithm:

1. Compute an edgeness image ∇f from f. Any preferred gradient operator can be used for this
2. Threshold ∇f to an image $(\nabla f)t$, so we have a binary image showing edge pixels.
3. Compute a Laplacian image Δf from f. Any preferred discrete or continuous Laplacian operator may be used.
4. Compute the image $g = (\nabla f)t \cdot \mathrm{sgn}(\Delta f)$.

The sgn operator returns the sign of its argument. The result image g will therefore contain only three values: 0 at non-edge pixels of f, 1 at edge pixels on the bright side of an edge, and −1 at edge pixels on the dark side of an edge. The image g contains the boundaries of the objects to be segmented. The Laplacian is used to facilitate the final steps of the algorithm: turning the boundary image into a segmented image h containing solid objects. If we traverse the image g from left to right, two adjacent pixels with values −1 and 1 means we move into an object, and the values 1 and −1 means we move out of one. The image h can therefore be created by setting all pixel values to zero, except for those pixels that are between the transitions $1 \rightarrow -1$ and $-1 \rightarrow 1$ in each line of g, which are set to 1. If unique values are desired for each separate segment, a labelling algorithm can be run on h.

Disadvantage of this method is the difficulty in converting the edge pixels into the close boundary in medical images.

C. Active Counter Method

Active contour or Snack techniques [4] are a special category of segmentation, they mainly work based on energy minimization principles. This kind of method is suitable for finding regions with high frequency variation with dominant edges whose gray scale intensities are significantly different from the surrounding region into the images. The user needs to interact with the segmentation process by placing an initial contour around the expected region and active contour techniques will deform these contours to fit the exact region boundaries.

D. Clustering Method

Clustering is an approach in which pixels are classified to a cluster, which is closest among all clusters. Pixels having homogeneous characteristics belong to the same cluster and different with respect to pixels of other clusters. The pixels must follow the homogeneity criteria in the same cluster. To perform clustering based segmentation, present *K*-mean, use LVQ efficiently. Fuzzy logic based Fuzzy *C*-Mean clustering method introduces fuzzy membership to pixels with respect to every cluster. Both supervised and unsupervised clustering techniques are used in image segmentation. Commonly used techniques are:

Log Based Clustering**:** Images can be clustered based on the retrieval system log maintained by an information retrieval process. This technique is difficult to perform in case of multidimensional images.

Fuzzy Clustering [3]*:* In this technique pixel values are divided into clusters on the basis of some similarity criteria and classify pixels values with great extent of accuracy and suitable for decision oriented applications i.e tumor detection.

In cluster based image segmentation techniques, it is necessary to choose a certain number of clusters initially which eventually reduces the dynamicity of the technique.

E. Live Wire Method

Live-wire [7] segmentation is an interactive tool for efficient, accurate boundary extraction which requires minimal user input with a mouse. Optimal boundaries are computed and selected at interactive rates (ie the time between two mouse clicks) as the user moves the mouse starting from a manually specified seed point. When the mouse position comes in proximity to an object edge, a “live-wire” boundary snaps to, and wraps around the object of interest. Input of a new seed point “freezes” the selected boundary segment, and the process is repeated until the boundary is complete.

F. Region Growing

The basic idea of region growing method [2] is a collection of pixels with similar properties to form a region. The steps are as follows: First, find a seed pixel as a started point for each of needed segmentation. And then merge the same or similar property of pixel (Based on a pre-determined growing or similar formula to determine) with the seed pixel around the seed pixel domain into the domain of seed pixel. These new pixels as a new seed pixel to continue the above process until no more pixels that satisfy the condition can be included [5].

III. CONCLUSION

In this survey, the aim has been to investigate and compare different image segmentation techniques. 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.

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