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PERSPECTIVE DESCRIPTORS OF IMAGE SEGMENTATON IN VARIOUS MODALITIES

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Abstract-Image segmentation refers to the process of partitioning an image into groups of pixels which are homogenous with respect to some criterion. Segmentation of nontrivial images is one of the most difficult tasks in image processing. Segmentation accuracy determines the eventual success or failure of computerized analysis procedures. The main objective of image segmentation is to extract various features of the image which can be merged or split in order to build objects of interest on which analysis & interpretation can be performed. Image segmentation represents the first step in image analysis & pattern recognition. The goal of segmentation is to simplify the representation of an image into something that is more meaningful &easier to analyse. Due to the importance of image segmentation a number of algorithms have been proposed but based on the image that is inputted the algorithm should be chosen to get the best results. This paper discusses the various segmentation techniques which are available.

Keywords-Segmentation; Artificial Intelligence techniques; thresholding; edge models; region oriented images; textual features.

I. Introduction

Segmentation is the process dividing an image into regions with similar properties such as gray level, color, texture, brightness, and contrast. The role of segmentation is to subdivide the objects in an image. Automatic segmentation is a difficult task as images are complex in nature and rarely have any simple linear feature. Further, the output of segmentation algorithm is affected due to

- Partial volume effect.
- intensity inhomogeneity
- presence of artifactscloseness in gray level of different soft tissue

Image segmentation continues to be a complex and challenging problem. Different researchers have done the classification of segmentation techniques in one or another way.

II.ClassificationOf Segmentation Techniques:

Thus, the broad classification of techniques available for segmentation of an image classified into two classes is as follows:

Methods based on gray Level

Features:

- Amplitude segmentation based on histogram features
- Edge based segmentation
- Region based segmentation

II.I.Amplitude segmentation based on histogram features

This includes segmentation of an image based on thresholding of histogram features and gray level thresholding is perhaps the simplest example of this technique. This is particularly suitable for an image with region or object of uniform brightness placed against a back ground of different gray level, athreshold can be applied to segment the object and background. Mathematically the threshold can be defined as follows.

ri,j={1pi,j≥Tpi ,0,pi,j≺T Equation(1)

Where $r_{i,j}$ is the resulting pixel at co-ordinate (i, j), $p_{i,j}$ is the pixel of input image and T is the value of threshold.The equation (1) gives good results for segmentation of image with bi-modal histogram and fails in the case of an image with multi-modal histogram. To overcome this limitation, band thresholding based multiple thresholding operation is applied as follows:

ri,j=1 for T1<pi,j≤T2

=2 for T2<pi,j≤T3

=3 for T3<pi,j≤T4

=k for Tk<pi,j≤Tk

=0 otherwise Equation (2)

Here, the K^{th} band is corresponding to object/region having pixel values in the range of T_k to T_{k+1} where T_k is the lower limit of gray level and T_{k+1} is the upper limit of Gray level band.For application of thresholding based segmentation technique, it is required to apply the correct threshold values in order to achieve proper segmentation results, otherwise results are poor. The histogram of an image is particularly used to determine the value of threshold

For Example: abdomen CT image

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The Histogram of abdomen CT image is shown in Figure 2. There are three peaks (maxima) separated by two minima. The values of these minima are selected as segmentation of image; the original abdominal CT scan image and corresponding segmentation result are shown in figuresrespectively

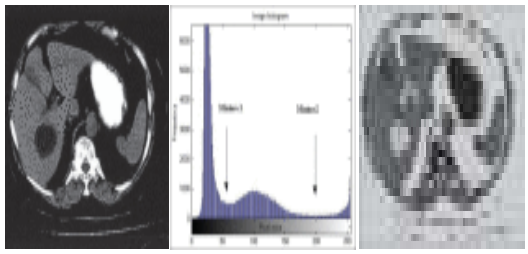

Fig 1(a): Original Abdomen CT Image

Fig 1(b): Image Histogram (three peaks separated by two minima)

Fig 1(c): Segmentation of Abdomen (CT image using threshold technique)

Object 1 belongs (0 to 55)

Object 2 belongs (55 to 200)

Object 3 belongs (200 to 255)

Limitations

Selection of proper values of threshold is quite difficult. Performance is affected in presence of artifacts.

II.II.Edge based segmentation

Edge based segmentation is the most common method based on detection of edges i.e. boundaries which separate distinct regions. Edge detection method is based on marking of discontinuities in gray level, color etc., and often these edges represent boundaries between objects. This method divides an image on the basis of boundaries.Number of edge detecting operators based on gradient (derivative) function are available e.g. Prewitt, Sobel, Roberts (1^{st} derivative type) and Laplacian (2^{nd} derivative type), Canny, Marr-Hildreth edge detector. The different edge based segmentation algorithms are:

- Edge relaxation,
- Border detection method,
- Hough transform based

The generalized algorithm for edge based segmentation has the following steps.

1. Apply the derivative operator to detect edges of the image
2. Measure the strength of edges by measuring amplitude of the gradient
3. Retain all edge having magnitude greater than threshold T (removal of weak edge)
4. Find the position of crack edges; the crack edge is either retained or rejected based on the confidence it receives from its predecessor and successor edges
5. Step 3 and 4 are repeated with different values of threshold so as to find out the closed boundaries; segmentation of an image is achieved.

Fig 2:Result of Edge-based Segmentation of Abdomen (CT image)

The limitations of edge based method are:

- Performance is affected by the presence of noise
- fake edges and weak edges may be present in the detected edge image which may have a negative influence on segmentation results
- Edge detection techniques are required to be used in conjunction with region-based technique for complete segmentation.

II.III.Region based segmentation

Region based methods are based on the principle of homogeneity - pixels with similar properties are clustered together to form a homogenous region. The criteria for homogeneity is most of the time gray level of pixelsand this criteria can be specified by following conditions

$R1 \cup R2 \cup R3 \cup .... \cup Ri=I$

WhereR_1, R_2, R_3,Ri are the region in the image I, Region merging

- In this method some seeding points are required to initialize the process, the segmentation results are dependent on the choice of seeds.Regions are grown iteratively by merging the neighboringpixels depending upon the merging criterion.
- This process is continued until all pixels are assigned to their respective regions as per merging criterion.

2.3.1 Region splitting:

Its principle is just opposite to region merging and whole image is continuously split until no further splitting of a region is possible.

Split and merge method:

This is the combination of splits and merges utilizing the advantage of the two methods. This method is based on quad quadrant tree representation of data whereby image segment is split into four quadrants provided the original segment is non-uniform in properties. After this the four neighboring squares are merged depending on the uniformity of the region (segments). This split and merge process is continued until no further split and merge is possible. And further, R1∩R2∩R3∩...∩Ri=0.This is as per the set theory of homogeneity.Region based segmentation is further divided into three types based on the principle of region growing:

a. Region merging

b. Region splitting

c. Split and merge

2.3.2 Region merging

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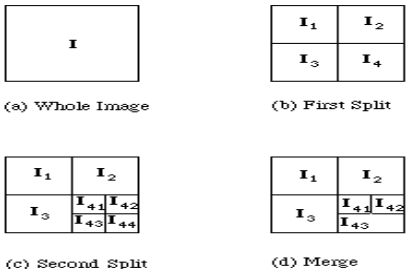

Fig 3:Region Split & Merge

2.3.5 Watershed segmentation

Watershed segmentation based on the concept of topography and hydrography is also a region-based segmentation.

The limitation of region based segmentation is that there are chances of under segmentation and over segmentation of regions in the image. However, this problem can be rectified in two ways

- By optimally selecting the criterion for segmentation, for this several algorithm utilizing artificial intelligence techniques have been developed.
- By combining region based approach with edge based approach

II.IV.Method based on the textural features

Textural features of image are important from image segmentation and classification point of view. The aim of texture based segmentation method is to subdivide the image into region having different texture properties, while in classification the aim is to classify the regions which have already been segmented by one or other method.

Definition of texture:

Texture is defined as something consisting of mutually related elements. A texture may be fine coarse, smooth, or grained depending upon its tone and structure.

Other approaches of segmentation

Apart from the above methods, the following two methodsofimage segmentation are also available.

- Model based segmentation and
- Atlas based segmentation.

Model based segmentation:

The basic approach is that the structure of organs has a repetitive form of geometry and can be modelled probabilistically for variation of shape and geometry. This can be used as constraint while segmenting the image and involves problems.

Disadvantages

1. They require manual interaction to place an initial model and choose appropriate parameters.
2. Standard deformable models can also exhibit poor convergence to concave boundaries.

Atlas based segmentation approaches are the most frequently used and powerful approaches in the field of medical image segmentation. In this, information on anatomy, shape, size, and features of different, organs, soft tissues is compiled in the form of atlas or look up table (LUT).

II.V.Artificial Intelligence Tools for Segmentation and Classification

Automatic segmentationmethods have been based on artificial intelligence (AI) based techniques. AI techniques can be classified as supervised and unsupervised.

2.5.1 Supervised methods

In the supervised category, we can place mostly Artificial Neural Network (ANN) based algorithms. ANN is composed of large number of interconnected processing elements (artificial neurons) working in unison to solve specific problems. The main advantages of ANN are:ability to learn adaptively, using training data to solve complex

2.5.2 Unsupervised methods

Most of the unsupervised algorithms are cluster based and not dependent on training and training data. The two commonly used algorithms for clustering are K-mean or Hard C-mean and Fuzzy C-means.

In clustering, the aim is to construct decision boundaries based on unlabelled training data.Clustering is the process of finding natural grouping clusters in multidimensional feature space. It is difficult because clusters of different shapes and sizes can occur in multidimensional feature space. However, the main limitations of fuzzy clustering algorithm are: (a) sensitivity to initial partition matrix (b) stopping criterion (c) solution may get stuck at local minima. Hence, clustering techniques may not result in optimal solution and there is no best clustering algorithm for a particular application. A number of different algorithms are required to be tried to find the best one.

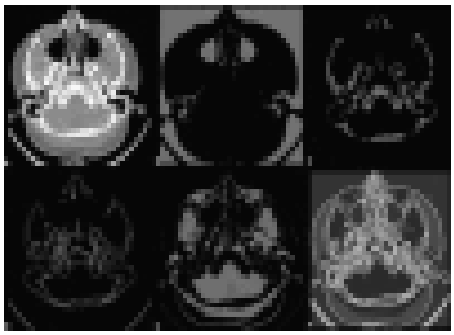

Fig 4: Individual segments of this image obtained using simulated annealing based fuzzy-c-means algorithm

III. Conclusion

The present review provides the basics of segmentation approaches and their respective features. The approaches for image segmentation discussed in this review can be ranked on the basis of applicability, suitability,performance, and computational cost. Computer-aided segmentation is a key step finding application in computer aided diagnosis, clinical studies, and treatment planning. Segmentation techniques based on gray level techniques such as thresholding, and region based techniques are the simplest techniques and find limited applications. However, their performance can be improved by integrating them with artificial intelligence techniques. Techniques based on textural features utilizing atlas or look-up-table have excellent results on medical image segmentation. However, they need expert knowledge in building the atlas. The limitation of atlas based technique is that under certain circumstances it becomes difficult to correctly select and label data; has difficulties in segmenting complex structure with variable shape, size, and properties. In such situations it is better to use unsupervised methods such as fuzzy-c-means algorithm.A variety of different neural network-based algorithms are also available for texture-based segmentation and classification having good accuracy. However, most of these neural network-based algorithms require extensive supervision and training and their performance depends upon the training method and data used in training. Finally, it is desired from medical image segmentation and classification algorithms that they must have the following features: a) accuracy, b) reliability, c) repeatability, d) robustness and e) least dependency on the operator.

IV.Acknowledgment

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