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Review: Existing Image Segmentation Techniques

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Abstract – Image segmentation is the most important part in digital image processing. Segmentation is nothing but a portion of any image and object. In image segmentation, digital image is divided into multiple set of pixels. Image segmentation is generally required to cut out region of interest (ROI) from an image. Currently there are many different algorithms available for image segmentation. Each have their own advantages and purpose. In this paper, different image segmentation algorithms with their prospects are reviewed.

Keywords – Image segmentation, thresholding techniques, edge detection, K-means.

I. INTRODUCTION

Images are primarily used in the field of computer vision for tasks such as navigation of robots, disease identifications from MR images, identification of number plates of moving vehicles, etc [1]. Primary objective of computer vision and digital image processing is to automate different tasks and image segmentation is an important step in it.

Image Segmentation is a process of dividing an image into different parts. This helps to simplify or change the overall presentation of an image into such data which is more meaningful and easier for a system to analyze. In segmentation, value is assigned to every pixel of an image in such a way that the pixels which share certain characteristics, such as color, intensity or texture in a particular region are grouped together. Adjacent regions who are not grouped together must be significantly different with respect to the same characteristics. Purpose of dividing an image is to further analyze each of these subparts or sub-images so that some high level information can be extracted. Sometimes image denoising is done before the segmentation to enhance the image and improve the quality of segmentation process [2].

This paper is arranged in four parts. Part II provides and introduction to image segmentation. Part III explains the current image segmentation techniques. Part IV covers conclusion. Part V shows the future scope of this paper.

II. IMAGE SEGMENTATION

Image segmentation refers to the process of partitioning a digital image into N number of parts. The images are segmented on the basis of set of pixels or pixels in a region that are similar on the basis of some homogeneity criteria such as color, intensity or texture, which helps to locate and identify objects or boundaries in an image [2].

In terms of mathematical formulae, Image segmentation divides a digital image f(x, y) into continuous, disconnect and nonempty subsets$f_1, f_2, f_3, \ldots\ldots\ldots\ldots\ldots\ldots f_n$, from these subsets higher level information can be easily extracted. Practical applications of image segmentation include object identification and recognition, facial recognition, medical image processing, criminal investigation, airport security system, satellite images, quality assurance in factories, etc [3][4]. Due to the importance of the image segmentation, large number of algorithms have been proposed but the selection of the algorithm purely depends upon the image type and the nature of the problem [2].

III. CURRENT IMAGE SEGMENTATION TECHNIQUES

In recent years, a lot of research is done in the field of image segmentation process. There are currently thousands of algorithm, each doing the segmentation process slightly different from another, but still there is no particular algorithm that is applicable for all types of digital image, fulfilling every objective. Thus, algorithm developed for a group of images may not always apply to images of another class [2] [5].

Currently image segmentation approach, based on two properties of an image, is divided into two categories:

- Discontinuities based

In this category, subdivision of images are carried out on the basis of abrupt changes in the intensity of grey levels of an image. Our focus is primarily based on identification of isolated points, lines and edges. This include image segmentation algorithms like edge detection.

- Similarities based

In this category, subdivision of images are carried out on the basis of similarities in intensity or grey levels of an image. Our focus here is on identification of similar points, lines and edges. This includes image segmentation algorithms like thresholding, region growing, region splitting and merging.

A. Segmentation based on edge detection

Edge detection is very important step in digital image processing and computer vision. In an image, edge represent object boundaries and thus help in detection and segmentation of objects in an image [5] [6]. Edge detection refers to algorithms which try to identify points in a digital image where there is an abrupt change in image brightness or there is a difference in intensities. These points are then linked together to form closed object boundaries [6]. The result of segmentation using edge detection is a binary image.

There are many different ways to perform edge detection, however, two most prominent used algorithms are mentioned here:

1) Gray Histogram Technique:

In this technique, segmentation depends upon separation of foreground from background by selecting a threshold value T. The difficulty arises in selecting the threshold values since gray threshold is uneven due to the presence of noise. Thus, we substitute the curves of object and the background with two conic Gaussian curves [7], whose intersection is chosen as the value of threshold T.

2) Gradient Based Method:

Gradient is the first derivative for image f(x, y), when there is an abrupt change in the intensity near edge. Another noise, gradient based method [7] involves convolving gradient operators with the image. High value of gradient magnitude can be points with abrupt change between intensities of the two region. These points are called edge pixels and can be linked together to form closed boundaries.

Normally sobel operator, canny operator, Laplace operator, Laplacian of Gaussian (LOG) operator etc is used as operator in gradient based method. Usually canny operator is used but it takes more time as compared to sobel operator.

In practice edge detection algorithms require a balance between detecting edges accurately and reducing the level of noise. If the level of accuracy is too high, noise will create detection of numerous additional and fake edges. On the other hand, if we try to reduce the level of noise too greatly [7], we might reduce the accuracy of the edges and many of the useful edges might not be detected. Thus, edge detection algorithm are usually suitable for images that are simple and noise free [8].

B. Threshold Method

Image segmentation by using threshold method is quite simple but very powerful approach for segmenting images based on image-space region i.e. characteristics of the image [7]. This method is usually used for images having light object on darker background or vice versa. Thresholding algorithm will choose a proper threshold value T to divide image's pixels into several classes and separate objects from the background. Any pixel (x, y) for which f(x, y)>=T is considered to be foreground while any pixel (x, y) which has value f(x, y) <T is considered to be background.

Based on the selection of threshold value, there are two types of thresholding method that are in existence:

1) Global Thresholding:

Global (single) thresholding method is used when there the intensity distribution between the objects of foreground and background are very distinct. When the difference between foreground and background objects are very distinct, a single value of threshold can simply be used to differentiate both objects apart. Thus, in this type of thresholding, the value of threshold T depends solely on the property of the pixel and the grey level value of the image. Some most common used global thresholding methods are Otsu method, entropy based thresholding, etc [10].

2) Local thresholding

This method divides an image into several sub regions and then choose various thresholds Ts for each sub region respectively. Thus, threshold depends on both f(x, y) and p(x, y). Some common used Local thresholding techniques are simple statistical thresholding, 2-D entropy-based thresholding histogram transformation thresholding etc [7].

C. Region based Segmentation Methods

A As compared to segmentation based on edge detection, segmentation methods based on regions are relatively simple and are more immune to noise. Contrary to edge basedSegmentation techniques who segmenting image based on the abrupt changes in the intensities of neighboring pixel, region based segmentation algorithms segment an image into regions that are similar according to a set of predefined criteria [10]. Region based segmentation include:

1) Region Growing

This method group pixels in an entire image into sub regions or large regions based on predefined criterion. In other words, the basic idea is to group a collection of pixels with similar properties to form a region [10]. Region growing can be processed into four steps:

(i) Select a group of seed particles in original image
(ii) Select a set of criteria for determining similar seeds based on properties such as grey level intensity or color and then set up a stopping rule.
(iii) Grow the region by adding to each seed those neighboring pixels that have predefined properties similar to the seed pixel.
(iv) Stop the region growth when there are no more pixels that match the criterion for inclusion in that region.

2) Region Splitting and Merging

Previous mentioned techniques, region grows by selecting a set of seed points. However, in this technique, the image is subdivided into a set of arbitrary unconnected regions and merge/split the region according to the condition of the

segmentation. This particular splitting technique is usually implemented with theory based on quad tree data. Quad tree is a tree in which each node has exactly four branches [10]. This include following steps:

a) Start splitting the region into four branches.
b) Merge any region when no further splitting is possible.

Stop when no further merging is possible.

D. Theory based Segmentation

This type of image segmentation algorithm include derivatives from different fields and are very important for segmentation approach. They include genetic algorithms, wavelet based algorithms, fuzzy based algorithms, and neural network based algorithms, clustering based algorithms and so on [10].

1) Clustering Techniques

Clustering is an unsupervised learning task, where one needs to identify a finite set of categories known as clusters to classify pixels [11]. A similarity criteria is defined between the pixels and then similar pixels are grouped together to form clusters. Similarity criteria include attribute of an image such as size, color, texture etc. The quality of a cluster depends on both the quality of similarity criteria used and how it is implemented. Clustering methods are classified as hard clustering, k-means clustering, fuzzy clustering, etc.

a)Hard Clustering

Hard clustering assumes that a pixel can only belong to a single cluster and also that there exists sharp boundaries between clusters. One of the most popular and well used hard clustering algorithm is K-means clustering algorithm [11].

K-mean clustering is a clustering technique group n pixels of an image into K number of clusters, where $K < n$ and K is a positive integer. Initially the centroids of the predefined clusters are initialized randomly. Clusters are formed on the basis of some similarity features like gray level intensity of pixels and distance of pixel intensities. The process is as follows:

(i) Randomly choose number of clusters K.
(ii) Randomly choose K pixels of different intensities as Centroids.
(iii) Centroids are finding out by calculating mean of pixel values in a region. Place Centroids as far away from each other as possible.
(iv) Now, compare a pixel to every Centroid and assign pixel to the closest Centroid to form a cluster. When all the pixels have been assigned, initial clustering has been completed
(v) Recalculate the mean of each cluster and recalculate the position of Centroids in K clusters.
(vi) Repeat steps (iv) & (v) until the Centroids no longer move.

b)Fuzzy clustering

Fuzzy clustering can be used in situations when there is no defined boundaries between different objects in an image. Fuzzy clustering divides the input pixels into clusters or groups on the basis of some similarity criterion. Similarity criterion can be distance, connectivity, intensity etc. Fuzzy clustering algorithms include FCM (fuzzy C means) algorithm, GK (Gustafson-Kessel), GMD (Gaussian Mixture Decomposition), FCV (Fuzzy C varieties) etc.

Fuzzy Clustering Mean algorithm [12] is most accepted since it can preserve much more information than other approaches. In this technique, a dataset is grouped into N clusters with every data point in the dataset belonging to every cluster to a certain degree.

2) Neural Network-based segmentation

In this algorithm, an image is firstly mapped into a neural network where every neuron represents a pixel [3] [7]. The neural network is trained with training sample set in order to determine the connection and weights between nodes. Then the new images are segmented with trained neural network. Neural network segmentation includes two important steps:

(i) Feature extraction- This step determines the input data of neural network. Some important features from images are extracted that will help in image segmentation
(ii) Image segmentation- In this step the image is segmented based on the features extracted from the images

Neural network based on segmentation have three basic characteristics:

(i) Fast computing and highly parallel computing ability makes it suitable for real time application.
(ii) Improve segmentation results when the data deviated from a normal situation.
(iii) High robustness makes it immune to noise.

E. Model Based Segmentation

The human eyes has the ability to recognize objects even if they are not completely visible. All the algorithms mentioned above utilize only local information. In this case, we require specific knowledge about the geometrical shape of the object, which can then be compared with the local information to recreate the object. This segmentation technique is applicable only if we know the exact shape of the objects contained in the image.

IV. CONCLUSION

In this paper, we have classified and discussed major image segmentation algorithms. Image segmentation algorithms have a promising future ahead since they are the basis of image processing and computer vision and have become the focus of contemporary research. In spite of several decades of research, there is no universally accepted image segmentation algorithm. Since image segmentation is affected by lots of factors such as type of image, color, intensity,

level of noise, etc. Thus there is no single algorithm that is applicable on all types of images and nature of problem. Due to all above factors, image segmentation still remains a big pending problem in the areas of image processing.

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