International Journal of Trend in Research and Development, Volume 2(1), ISSN: 2394-9333
www.ijtrd.com

Survey on Various Image Segmentation Techniques

Pooja R. Upadhyay
ME Student, Computer Science and Engineering
Parul Institute of Engineering and Technology
Vadodara, India

Mr. Shashwat Kumar
Assistant Professor, Computer Science and Engineering
Parul Institute of Engineering and Technology
Vadodara, India

Abstract— Image segmentation is one of the fundamental approaches of digital image processing. Segmentation can be done for extracting useful information from the image. It is most important for feature extraction and pattern recognition. This paper enumerates various image segmentation techniques. Some valuable characteristics of image segmentation come out after a large number of comparative experiments. Assessing the performance of different algorithms is a complex task. Segmentation can be done based on various parameters and also we can merge the techniques for better understanding of any image. There is a lot of information in any image. There are different algorithms for image segmentation for feature extraction and pattern recognition. The classification of segmentation algorithm is given here. Each of them has their different advantages and limitations.

Keywords —Image segmentation, thresholding, Edge maximization technique, canny operator, Region splitting, fuzzy clustering, object extraction.

I. INTRODUCTION

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. In image processing image segmentation comes under the computer vision field which includes image processing and machine vision. Computer vision is the construction of explicit, meaningful descriptions of objects from their image. Image segmentation and its classification are difficult but very important in computer vision. The main objective of image segmentation is to extract various objects and features of the image that are used for analyzing, interpretation and understanding of images. Purpose of this paper is to determine various segmentation algorithms for extracting meaningful information from any image. And among them recognize the appropriate algorithm of segmentation for any image. Result of object extraction is depending on segmentation algorithm so that it is necessary to select efficient segmentation algorithm. In image segmentation the image is divided into different partitions according to segmentation method used [9]. It is done according to discontinuity of image like edge, color texture etc. We can foresee the trend of image segmentation in three ways: Combination of multi-algorithms, the application of artificial intelligence and the rise of manual alternating segmentation [1]. The image contains lots of information. The object extraction can be done using different methods of image segmentation. In extraction method, the required object is separated from its complex surrounding. But there are several difficulties to extract object from entire image because there can be lot of information in the single image [6]. There are many uncertainties in foreground image edges. Image foreground and background are not smooth because there are many edges in image. There are several methods by which required object can be extracted, but there are some drawbacks of the existing methods. In this paper, classification of main image segmentation algorithms is given and they are reviewed.

II. IMAGE SEGMENTATION METHODS

There are different types of image segmentation algorithms. Each has their own advantages and limitations. The image segmentation algorithm is divided mainly into four types. First is Thresholding techniques, second is Edge-Based Segmentation, third is region based segmentation, forth is clustering techniques.

A. Thresholding Techniques

Thresholding is an important technique for image segmentation and many researchers pay a lot of attention to the methods of how to select reasonable thresholds. The fundamental principle of thresholding techniques is based on the characteristics of the image. It chooses proper thresholds *T* to divide image pixels into several classes and separate the objects from background. T can be calculated by using following equation:

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

Where, T is Threshold, f(x, y) is gray value of point (x, y) and p(x, y) is local property of point i.e.: average gray value of neighbored center on point (x, y).

The fundamental principle of thresholding techniques is based on the characteristics of the image which chooses proper thresholds T_n to divide image pixels into several classes and separate the objects from background. I there is a single threshold T then for any point (x, y), if f(x, y) > T then point (x, y) is an object point otherwise point (x, y) is a background point [4]. Thresholding techniques can be mainly divided into three types global, local, and dynamic thresholding techniques.

i)Global Thresholding- In this threshold T depend only on gray value f(x, y) & relates to character of pixels. The example of this technique is Otsu. Otsu is based on the variance of

pixel intensity. It calculates a measure of pixel levels (graylevel) i.e.; pixels that either fall in foreground or in background. In this method, search for threshold that Minimize intraclass (within class) variance and Maximize interclass variance and at last from this total variance is calculated. There is several limitation of Otsu method. The complexity of Otsu method is very high, processing rate is very slow and suitable images in which gray histogram have three crests[8]. Because of this reason Otsu is not very much useful for image extraction.

ii)Local Thresholding- In this method threshold T depends on both f(x, y) & p(x, y). This method divides an original image into several sub regions and chooses various thresholds T_s for each sub region reasonably. Example of this method is K-means. The K-means method is proposed by MacQueen. This method partition N data points into k disjoint subsets (C_1, C_2... C_k). K-means method has some advantage over Otsu method. It doesn't require calculating gray level as in Otsu. It is more efficient, less computing time and faster especially in 3D thresholding.

iii) Dynamic Thresholding- In this method several objects taking up different gray level regions. The image should be partitioned with vary dynamic thresholds (T1, T2… Tn) [7]. Dynamic thresholding techniques include thresholding image, Watershed, interpolatory thresholding and so on.

There are four techniques for deciding threshold value:

i) Mean Technique- This technique used the mean value of the pixels as the threshold value and works well in strict cases of the images that have approximately half to the pixels belonging to the objects and the other half to background. This technique case rarely happens.

ii) P-Tile Technique- The p-tile technique uses knowledge about the area size of the desired object to the threshold an image. The P-tile method is one of the earliest threshold methods based on the gray level histogram. It assumes the objects in an image are brighter than the background, and occupy a fixed percentage of the picture area. This fixed percentage of picture area is also known as P%. The threshold is defined as the gray level that mostly corresponds to mapping at least P% of the gray level into the object [7]. Let n be the maximum gray level value, H (i) be the histogram of image (i = 0. n), and P be the object area ratio. The algorithm of the P-tile method is as follows:
S=sum (H(i)) (3)
Let f=s
For k=1 to n
f=f-H(k-1)
If (f/t) <p then stop
T=k
Where,
S total area of image f is the initialize all area as object area,
T is the final threshold value

This method is simple and suitable for all sizes of objects. It yields good anti-noise capabilities; however, it is obviously not applicable if the object area ratio is unknown or varies from picture to picture.

iii) EMT Technique- The threshold image by using edge maximization technique (EMT) is used when there are more than one homogenous region in image or where there is a change on illumination between the object and its background. In this case portion of the object may be merged with the background or portions of the background may as an object. To this reason any of the automatic threshold selection techniques performance becomes much better in images with large homogenous and well separated regions. This techniques segmentation depend on the research about the maximum edge threshold in the image to start segmentation that image with help the edge detection techniques operators.

iv) Visual Technique- These techniques improve people's ability to accurately search for target items. These techniques are similar to one another P-Tile technique in that they all use the component segments of original images in novel ways to improve visual search performance but it is different from p-tile don't active when the noise is present in the image.

B .Edge based segmentation

This segmentation algorithm partition an image through detecting edge among different regions. Image can be segmented by detecting discontinuities in image such as gray change, color distinctness, texture variety and so on. There are many methods for edge detection, but most of them can be grouped into two categories, search based and zero-crossing based. The search-based methods detect edges by first computing a measure of edge strength, usually a first-order derivative expression. The zero-crossing based methods search for zero crossings in a second-order derivative expression computed from the image in order to find edges.

Search based

i) Prewitt operator- it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt operator is either the corresponding gradient vector or the norm of this vector. The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical directions and is therefore relatively inexpensive in terms of computations. The prewitt operator uses the same equations as the Sobel operator, except that the constant c = 1. Therefore: Note that unlike the Sobel operator, this operator does not place any emphasis on pixels that are closer to the centre of the masks. The Prewitt operator measures two components. The vertical edge component is calculated with kernel Gx and the horizontal edge component is calculated with kernel Gy. |Gx| + |Gy| give an indication of the intensity of the gradient

in the current pixel.

-1	0	1
-1	0	1
-1	0	1

Gx

1	1	1
0	0	0
-1	-1	-1

Gy

Fig. Prewitt Mask

ii) Sobel operator- It is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding gradient vector or the norm of this vector. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. The computation of the partial derivation in gradient may be approximated in digital images by using the Sobel operators which are shown in the masks below:

-1	o	1
-2	0	2
-1	0	1

1	2	1
0	0	0
-1	-2	1

Fig. The Sobel masks

iii) Canny operator- The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images [2]. It was developed by John F. Canny in 1986. Canny also produced a computational theory of edge detection explaining why the technique works. Canny technique is very important method to find edges by isolating noise from the image before find edges of image, without affecting the features of the edges in the image and then applying the tendency to find the edges and the critical value for threshold. The algorithmic steps for canny edge detection technique are follows:

1. Convolve image f(r, c) with a Gaussian function to get smooth image.

2. Apply first difference gradient operator to compute edge strength then edge magnitude and direction are obtain as before.

3. Apply non-maximal or critical suppression to the gradient magnitude.

4. Apply threshold to the non-maximal suppression image.

Zero crossing

i) Laplacian operator- There must exist a point where there is a zero crossing. That point is the edge's location. Edge detectors that are based on this idea are called Laplacian edge detectors.

ii) Zero-crossings- In the field of Digital Image Processing, great emphasis is placed on operators which seek out edges within an image. They are called 'Edge Detection' or 'Gradient filters'. A gradient filter is a filter which seeks out areas of rapid change in pixel value. These points usually mark an edge or a boundary. A Laplace filter is a filter which fits in this family, though it sets about the task in a different way. It seeks out points in the signal stream where the digital signal of an image passes through a pre-set '0' value, and marks this out as a potential edge point. Because the signal has crossed through the point of zero, it is called a zero-crossing.

C. Region based segmentation

In this we examine neighbouring pixels and detect whether the neighbour pixel should be added or not. Region based segmentation technique attempts to group the pixels with similar characteristics (such as approximate Gray level equality) into regions. Approaches of region-based methods are followed:

i) Region growing- In the region growing process the Seed region is expanded to include all homogeneous Neighbours and the process is repeated [10]. The process ends when there is no pixel to be classified. In region Splitting method the process starts with the entire image as a seed. If the seed is inhomogeneous then it splits into predetermined number of sub regions, typically four.

ii) Region splitting and merging- The region splitting process is then repeated using each sub region as a seed. The process ends when all sub regions are homogeneous. In Region Merging Method, Merge any adjacent regions that are similar enough.

D. Clustering techniques

i) K-mean Clustering- K-Means algorithm is an unsupervised clustering algorithm that classifies the input data points into multiple classes based on their inherent distance from each other. In K-means algorithm data vectors are grouped into predefined number of clusters [11]. At the beginning the centroids of the predefined clusters are initialized randomly. The dimensions of the centroids are same as the dimension of the data vectors. Each pixel is assigned to the cluster based on the closeness, which is determined by the Euclidian distance measure. After all the pixels are clustered, the mean of each cluster is recalculated [3]. This process is repeated until no significant changes result for each cluster mean or for some fixed number of iterations.

ii) Fuzzy Clustering- Fuzzy c-means is that clustering technique in which a dataset is grouped into n clusters with every data point in the dataset belonging to every cluster to a certain degree. Fuzzy clustering method can be considered to be superior to those of their hard counterparts since they can represent the relationship between the input pattern data and clusters more naturally. Fuzzy c-means is a popular soft clustering method, its effectiveness is largely limited spherical clusters [5]. Fuzzy c-means is one of the most promising fuzzy clustering methods. In most cases, it is more flexible than the corresponding hard-clustering algorithm.

III. ANALYSIS OF DIFFERENT METHODS

Here in this subsection we analyze the various algorithms and determine their benefits and drawback based on above discussions which is explained below. Among all techniques Thresholding does not need prior information of the image and has less computational complexity but May be difficult to identify significant peaks and valleys in the image [5]. It does not take into account the spatial detail so the segmented regions may not be contiguous. edge maximization technique is the best for thresholding. It is used in the field of medical imaging to detect or locate the tumors and also useful in other pathologies. Edge based segmentation algorithms locate points with more or less abrupt changes in gray level works well for images having good contrast between regions and produces less immune to noise than other techniques. But it does not work well with images which have too many edges. Mostly it is used for face detection. Among all edge detection techniques canny operator provide most efficient edge detection. In the region based approach the benefit is that we could split the image using the criteria we decide, such as mean or variance of segment pixel value. In addition, the merging criteria could be different to the splitting criteria. But it may It may produce the blocky segments and it is quite expensive technique in computational time and memory. It often used for 3D construction of the any shape. As we shown above Clustering technique is straight forward classification and easy to implement. It is more popular technique of image segmentation. But it does not utilize spatial information and it is used for neural network edge pattern and to measure volume of tissues.

IV. CONCLUSION

There is different segmentation algorithms are used to separate required object image from the background. They all have their related limitations which are described throughout this paper. From above all techniques it can be conclude that not a single algorithm is completely efficient for all type of images. It is based on type of images. Different algorithms are useful for different images. Segmentation can be done in three ways: Combination of multi-algorithms, the application of artificial intelligence and the rise of manual alternating segmentation. These all are the research aspects to be further explored in order to extract required object effectively from an image. The result of image segmentation is affected by lots of factors, such as: homogeneity of images, spatial structure character of the image, continuity, texture, image content, physical visual character and so on. A good image segmentation algorithm should take all-sided consideration on those factors.

Acknowledgment

I heartily thank Prof Shashwat Kumar to guide me regarding the study and analysis of such a wide area and confining me with the basics.

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