Survey on Otsu Image Segmentation Algorithm

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Abstract— **Image segmentation is the fundamental approach of digital image processing among all the segmentation Methods, Otsu method is one of the most successful Methods for image thresholding because of its simple calculation Otsu is an automatic threshold selection region based segmentation method. This paper studies Various Otsu algorithms.**

Index Terms: **Image processing, Otsu algorithm, Segmentation, Thresholding.**

INTRODUCTION

Image segmentation is one of the most fundamental and difficult problems in image analysis. Image segmentation is an important part in image processing. In computer vision, image segmentation is the process of partitioning an image into meaningful regions or objects. There are various applications of image segmentation like locate tumors or other pathologies, measure tissue volume, computer - guided surgery, treatment planning, study of anatomical structure, locate objects in satellite images and fingerprint recognition etc.

Segmentation subdivides an image into its constituent region or object. Image segmentation methods are categorized on the basis of two properties discontinuity and similarity [1].Based on this property image segmentation is categorized as Edged based segmentation and region based segmentation. The segmentation methods that are based on discontinuity property of pixels are considered as boundary or edges based techniques. Edgebased segmentation method attempts to resolve image segmentation by detecting the edges or pixels between different regions that have rapid transition in intensity and are extracted and linked to form closed object boundaries. The result is a binary image. Based on theory there are two main edge based segmentation methods, gray histogram based and gradient based method [2].Region based segmentation partitions an image into regions that are similar according to a set of Predefined criteria. The region based segmentation is partitioning of an image into similar areas of connected pixels. Each of the pixels in a region is similar with respect to some characteristic or computed property such as color, intensity and/or texture. There are different type of the Region based method like thresholding, region growing and region splitting and merging[2]. Thresholding is an important technique in image segmentation applications. The basic idea of thresholding is to select an optimal gray-level threshold value for separating objects of interest in an image from the background based on their gray-level distribution. While humans can easily differentiable an object from complex background and image thresholding is a difficult task to separate them. The gray-level histogram of an image is usually considered as efficient tools for development of image thresholding algorithms. Thresholding creates binary images from grey-level ones by turning all pixels below some threshold to zero and all pixels about that threshold to one. If

$g(x, y)$ is a threshold version of $f(x, y)$ at some global threshold T,it can be defined as [1],

$$g(x, y) = 1 \text{ if } f(x, y) \geq T$$
$$= 0 \text{ otherwise}$$

Thresholding operation is defined as:
$$T = M [x, y, p(x, y), f(x, y)]$$

In this equation, T stands for the threshold; $f(x,y)$ is the gray value of point (x, y) and $p(x,y)$ denotes some local property of the point such as the average gray value of the neighborhood centered on point (x, y) Based on this, there are two types of thresholding methods.

1) Global thresholding: When T depends only on $f(x, y)$ (in other words, only on gray-level values) and the value of T solely relates to the character of pixels, this thresholding technique is called global thresholding.

2) Local thresholding: If threshold T depends on $f(x, y)$ and $p(x, y)$, this thresholding is called local thresholding. This method divides an original image into several sub regions, and chooses various thresholds T for each sub region reasonably[3].Otsu method is type of global thresholding in which it depend only gray value of the image. Otsu method was proposed by Scholar Otsu in 1979. Otsu method is global thresholding selection method, which is widely used because it is simple and effective [4].The Otsu method requires computing a gray level histogram before running. However, because of the one-dimensional which only consider the gray-level information, it does not give better segmentation result. So, for that two dimensional Otsu algorithms was proposed which works on both gray-level threshold of each pixel as well as its Spatial correlation information within the neighborhood. So Otsu algorithm can obtain satisfactory segmentation results when it is applied to the noisy images[8]. Many techniques thus were proposed to reduce time spent on computation and still maintain reasonable thresholding results. In [9], proposed a fast recursive technique that can efficiently reduce computational time. Otsu's method was one of the better threshold selection methods for general real world images with regard to uniformity and shape measures. However, Otsu's method uses an exhaustive search to evaluate the criterion for maximizing the between-class variance. As the number in classes of an image increases, Otsu's method takes too much time to be practical for multilevel threshold selection [10].

II. VARIOUS OTSU ALGORITHMS

A. Image Segmentation Based on Improved
Otsu Algorithms Here [4], author described 1D Otsu algorithm. This algorithm is widely used because of its simple calculation and stability. Here the algorithm works on only gray value of the image. The 1D Otsu algorithm only consider

the pixel's gray -level information without considering the pixel's spatial neighborhood information , so it is difficult to obtain satisfactory segmentation result. This algorithm fails, when the global distribution of the target and background vary widely. Also it gives good segmentation effect but never work on image when the two classes are very unequal. In this paper authors proposed a new method based on Entropy which gives better result compare to 1D Otsu algorithm.

B. Comparative Research on Image Segmentation Algorithm

Here[5],the main image segmentation algorithm has been reviewed and gives some valuable characteristics of image segmentation algorithm. The authors have classified Otsu algorithm as thresholding region based segmentation algorithm.
Also the complexity rate of Otsu thresholding algorithm is very high and processing rate is very slow. The segmentation result of Otsu segmentation algorithm is stable or good. By concluding here, in order to improve the performance of the Otsu algorithm, combine it with other algorithm.

C. Otsu Thresholding Based on Improved Histogram

Here the authors [6] proposed a fast Otsu algorithm based on improved histogram to reduce the high computation complex it y of 1D and 2D Otsu algorithm. In this algorithm two dimensional histogram is projected onto the diagonal and then applied to2D Otsu on that histogram to find the optimal threshold value. To evaluate the practical performance of proposed algorithm, authors applied salt and pepper noise and Gaussian noise in image. The result of experiment showed that it greatly enhanced the speed of thresholding and has better noise immunity for salt and paper noise images but does not give good result for Gaussian noise images.

D. Otsu and K-Means Method
In this paper [7], it states that the objective function of Otsu method is equivalent to that of K means method in multilevel thresholding. They both are based on the same criteria that minimize the within-class variance. Also the Otsu method works on global thresholding while the K means method work on the local thresholding. The Otsu method requires computing a gray level histogram before running while K means does not require computing a gray level histogram before running .Both methods produce good segmentation result but K means give better results comparatively to Otsu. Otsu method takes comparatively more time and increases the complexity of the algorithm.

III.COMPARATIVE ANALYSIS OF OTSU METHOD

PAPER	Method	SEGMEN TATOIN RESULT	LIMITATION
Otsu Threshloding Based on Improved histogram	Improved histogram	Good	This algorithm gives better result in salt and paper noise but does not give
Comparative Research on Image Segmentation Algorithm	Global thresholding	Good/ stable	High complexity/ low processing rate
Otsu and K-mean	Global optimal threshold	Good	Increased complexity and time
Image Segmentation Based on Improved Otsu Algorith m	Entropy based	Stable	When the global distribution of target image and background vary widely, the performance degrades

on Gaussian noise.

IV. CONCLUSION

This paper studies about various Otsu algorithms for image segmentation. The Otsu algorithm has been widely used because of its simplicity. Here, a comparative analysis regarding different ways of implementing Otsu algorithm with respect to their methods, results and limitations are compared.

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