A Comparative Analysis of Iterative and Ostu's Thresholding Techniques

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ABSTRACT

Image segmentation is a process of dividing an image into a number of meaningful regions. Each pixel of an image carries a certain measure which is used for segmentation .An image is divided into different regions based on a certain characteristic such as an intensity value. The different regions differ to each other with respect to some characteristic .In this paper ,two different thresholding methods, for partitioning images into different regions are analyzed and compared. The different methods for thresholding for image segmentation have been simulated using MATLAB 7.0. This paper discusses two thresholding methods-Iterative method and Ostu's method. It has been observed that the Ostu's method works better as compared to the Iterative thresholding method as it tends to minimize the inter class variance. The results of this study are quiet promising.

General Terms

Thresholding methods

Keywords

Thresholding, variance, image ,image segmentation

1. INTRODUCTION

Image segmentation techniques are generally either discontinuity detection (edge based) or similarity detection(region based)[1].In discontinuity detection, the approach followed is to partition an image based on sudden changes near the edges whereas in similarity detection technique, the image is partitioned into regions depending on a similar characteristic of pixels in that region [2]. This paper is majorly concerned with methods in second category using thresholding techniques. The thresholding technique is based on partitioning an image directly into regions based on intensity values and their properties. This method is based on selecting a threshold value T for a region. If a pixel value is greater than T, the pixel is included in that particular region as foreground else it is made background[3].Thresholding is a technique following a test function T and the threshold value function T is computed as:

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

where f(x,y) is the pixel value at the point (x,y) and p(x,y) is the local property of the point.

A thresholded image is defined in mathematical terms as : Pixel is labeled as 1 if it corresponds to object and 0 if it correspond to background[4].

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

A thresholding method is basically to determine this value of T to segment an image into different regions. This paper is divided into a number of sections. Section 2 discusses the general thresholding concept. Section 2.1 and 2.2 is to describe the two methods of thresholding. Section 3 deals with experiments and results that have been simulated by implementation of the two methods in MATLAB 7.0.

2. THRESHOLDING

Thresholding is the process of converting a gray scale image to a bi-level image using an optimum threshold value T. It is a process of partitioning an image into object pixels and background pixels. An individual pixel is made an object pixel if the pixel value is greater than a certain threshold value and a background pixel otherwise.

There are two types of thresholding algorithms:

1. global thresholding method

2. local or adaptive thresholding method

Global thresholding methods uses a single global value of threshold to partition an image into distinct regions where as a local method uses different local value of threshold for different areas.

2.1 ITERATIVE THRESHOLDING

This method is based upon assuming an initial value of threshold .The best way for selecting a threshold value according to this algorithm follows these steps [5]:

1. An initial estimate T has to be taken which can be assumed to be the average of minimum and maximum intensity value(though this is not fixed ,any value can be chosen as initial T).
2. Using this value T ,an image is divided into two pixels regions,T1 (with all pixel values<T)and T2(with all pixel values>T).
3. Compute the average intensity values m1 and m2 of regions T1 and T2 respectively.
4. Compute a new value of T as

   $$T=(m1+m2)/2$$

5. Repeat the above steps from 2 to 4 till difference between two successive values of T is minimal.

Iterative method is best suited for an image that has a bimodal histogram (i.e. an image which has two data peaks). Its success is dependent on how well the histogram of an image can be partitioned.

2.2 OSTU'S METHOD:

This method is considered as a variation of iterative thresholding method. It is a clustering method based upon maximizing the between class variance. It is based upon defining well defined threshold classes as clusters with clusters lying tightly adjacent to each other and there is a minimal overlap [6].

The within class variance can be defined as summation of variance of each class as :

$$\sigma^2_{within}(T) = n_B(T)\sigma^2_B(T) + n_O(T)\sigma^2_O(T)$$

$n_B(T)$ = sum of pixel values in background

$n_O(T)$ = sum of pixel values in foreground

$\sigma^2_B(T)$ = variance of pixels in background

$\sigma^2_O(T)$ =variance of pixels in foreground

From the proved methods ,the between class variance is given as:

$$\sigma^2_{between}(T) = n_B(T)n_O(T)[\mu_B(T) - \mu_O(T)]^2$$

where μ_B and μ_O are cluster means[6] .

To find an optimal threshold value is to maximize the between class variance and this is relatively an easier calculation than calculation within class variance which would be minimized by maximizing between class variance. This method also works by assuming an image with a bimodal histogram [7].

3. EXPERIMENTS AND RESULTS

The iterative thresholding method and ostu's method have been simulated in MATLAB 7.0.Iterative thresholding method assumes an initial value of threshold while in the Ostu's method we determine a global threshold that lies in the range [0,1].This sections deals with the results that have been inferred from the simulation of the above two methods in MATLAB 7.0.The paper represent it objectively with the help of different types of images(smooth ,linear, medical, synthetic, sharp etc.).

In a 1d smooth image as below we find that the segments are clearly depicted by ostu's method than iterative method which do not clearly link all the regions of rocks in case of the image below (fig. a). Ostu's method tends to maximize the interclass variance (fig a.)[8].

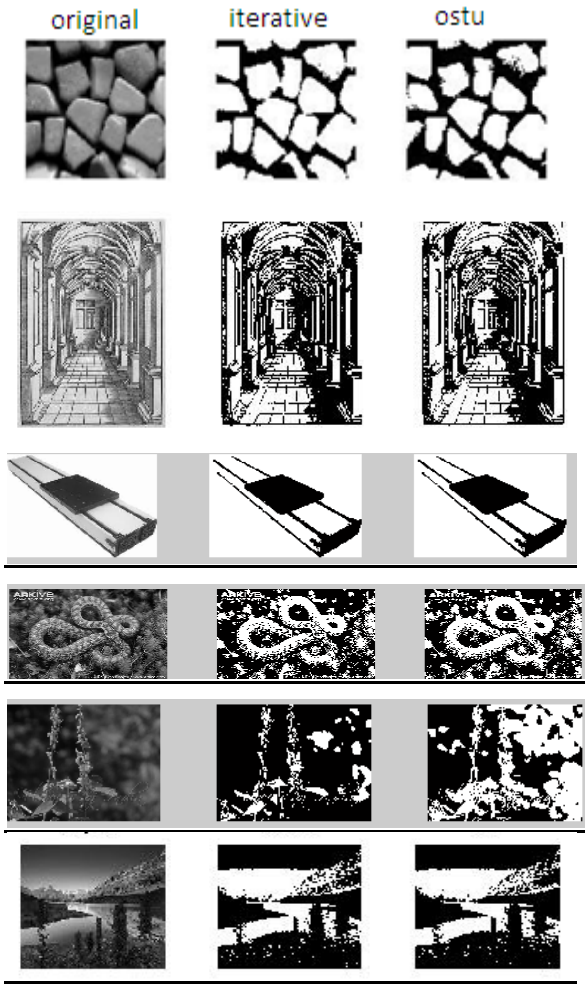

Fig. a,b,c,d,e,f : Implementation of various methods in MATLAB (Picture courtesy: http://thegreenape.blogspot.in)

Another variation of a linear image is presented in the above figures which are also a type of sharp images(fig b and c). In the medical images, the ostu's method segments the images with relevant and effective segments (fig. d).We can also determine that ostu's method works well with images with variable illumination(fig d and e). The automatic or iterative method divides an image into non overlapping blocks with a different threshold value whereas ostu's method is based upon a global threshold value called the optimum threshold.

Original Image	Threshold yielded by iterative method	Threshold yielded by ostu's method
a.	85.59	.4353
b.	158.16	.6000
c.	94.637	.3690
d.	157.1	.6157
e.	69.74	.2353
f.	63.688	.2510

Table. listing all the values of threshold obtained by simulating both the methods in the above images.

4. CONCLUSIONS

This paper presents the major iterative method of thresholding for edge detection along with its variation that is Ostu's method. There is also an attempt made to compare the results of two methods by their implementation in MATLAB 7.0 .From the methods as implemented, image segmented by Ostu's method yields correct and accurate clusters compared to those detected by iterative method . The Ostu's method shows a greater performance when used for the segmentation of linear and sharp images as compared to iterative thresholding. The iterative thresholding method works on initially assuming a threshold value, dividing the image in two regions and recalculating the new threshold by averaging the grey mean values of regions obtained and continuing this till the variation between two values becomes insignificant whereas ostu's method does not initially assume any threshold. It is a global thresholding method of edge detection which finds a global threshold value ranging between [0,1] which is also a normalized intensity value [9]. From the results it can be inferred that, the ostu's method is a better method as it works on finding the best optimum threshold value minimizing the intra-class variance among the different region pixels. Ostu's method works for images with variable illumination but iterative method performance decreases in such images. The combined spread of the image segments in ostu's method is minimal as compared to iterative method. So in comparison to iterative method, Ostu's method is best in segmentation with respect to uniformity and shape features[10].

5. REFERENCES

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