Comparison between Otsu's Image Thresholding Technique and Iterative Triclass

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Abstract *- Medical image segmentation is related to the segmentation of known anatomic structures from medical images. Structures consists of organs or parts such as cardiac ventricles or kidneys, abnormalities such as tumors and cysts, as well as other structures such as vessels, brain structures etc. The complete objective of this segmentation is known as computer-aided diagnosis which is used by doctors in evaluating medical images or in recognizing abnormalities in a medical image.*

Segmentation means the process of partitioning a digital image into multiple regions (sets of pixels). The methods of segmentation is used to simplify and change the representation of an image into something that is more meaningful and easy to understand. The result of image segmentation is a set of regions that combine the whole image, or a set of contours extracted from the image. Each of the pixels in a region is same with respect to some characteristic or computed things, such as color, concentration, or texture. Adjacent regions are not similar with each other they differs in some characteristics. A rugged segmentation procedure brings the process a long way towards successful solution of an image difficulty. Outcome of the segmentation stage is raw pixel data, consisting of both the boundary of a region and all the points in the region.

In this paper, we compared two methods of image segmentation OTSU's method and new iterative triclass thresholding technique of image segmentation.

Keywords - *Segmentation, binary, thresholding*

I. INTRODUCTION

Image segmentation technique is used to separate the foreground from the background. Image segmentation is one of the hardest research problems in the computer vision industry and pattern recognition. Thresholding is often used to separate objects from the background. One of the commonly used method, the Otsu method, improves the image segmentation effect considerably.

While segmenting the image, it is pre-processed, which can involve restoration, enhancement, or simply representation of the data. Certain features are extracted from image to segment the image into its key components. The segmented image is passed to a image classifier or an image understanding system. The image classification process maps different regions or it is segmented into one of several objects. Each object is uniquely identified by a label. The image understanding system decides the relationships between various objects in a scene to provide a complete scene description. The different practical applications of image segmentation are: Measure tissue volumes, Computer-guided surgery, Study of anatomical structure etc.

Thresholding is known as a non-linear operation that is used for segmenting the image. Thresholding converts a gray-scale image into a binary image. In the process of thresholding the two levels are assigned to pixels that are below or above the specified threshold value T. So in thresholding pixels that are similar in gray scale or some other feature are grouped together. A thresholded image can be represented by the expression:

$$g(x,y) = 0 \quad f(x,y) < T \qquad \text{OR}$$

$$g(x,y) = 1 \quad f(x,y) >= T$$

Such that the pixels with value 1 is considered as an foreground pixel and pixels with 0 value are considered as background pixels. Hence value of T must be selected very carefully such that there is proper separation between foreground and background pixels. Some images may be bimodal images due to this a single threshold value is used for proper separation. Some other images tends to be multimodal and multiple thresholds are used for segmentation.

II. METHODS

A. *OTSU's METHOD*

From the histogram of an image Otsu's method find a threshold that binarizes the image into two classes, the background with a mean of $\mu 0$ and the foreground with a mean of $\mu 1$. Without loss of generality,we assume that the foreground is brighter than the background, this can be represented as,

$$\boldsymbol{\mu 1 > \mu 0.}$$

The calculation of threshold T is as follows:

$$T = \arg\min_{T} \sigma_w^2(T) \tag{1}$$

where

$$\sigma_w^2(T) = q_0(T)\sigma_0^2(T) + q_1(T)\sigma_1^2(T) \tag{2}$$

where the subscript 0 and 1 denote the two classes, background and foreground, respectively, and q_i and σ_i , i = [0, 1] are the estimated class probabilities and class variances, respectively.
These quantities are calculated as

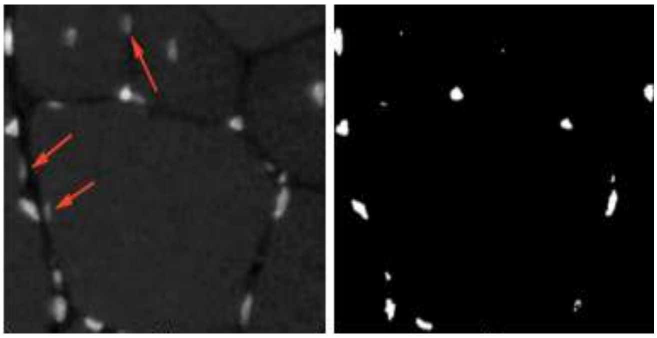
$$q_0 = \sum_{i=1}^{T} P(i) \quad q_1 = \sum_{i=T+1}^{K} P(i) \tag{3}$$

There are many cases in which Otsu's method does not produce satisfactory results even when the foreground has a high signal intensity, i.e., a higher signal-to-background ratio (SBR). In other words, we can say that the performance of Otsu's method is not a function of SBR only. To understand more clearly what factors also affect the performance of Otsu's method and therefore allows us to design a better approach, we should consider notion of "distance ratio" which is defined as the ratio of the distance in mean between the foreground and background to the full pixel range of an image. The distance ratio measures a posteriori, for an image segmented into two classes i.e. foreground and background by techniques such as Otsu's method, how far apart the means of the two classes are measured in terms of full pixel range of the image.

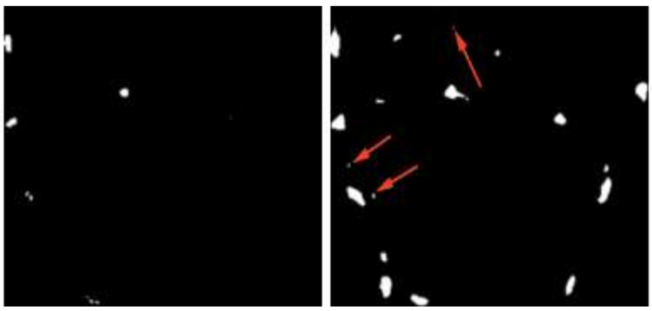
B. ITERATIVE METHOD

A new iterative method is nothing but a extension of standard Otsu's method but differs from the standard application of the method in an important way. At the first iteration, the Otsu's method is applied on an image to obtain the Otsu's threshold and also the means of two classes separated by the threshold are derived as the standard application does. At this stage instead of classifying the image into two classes separated by the Otsu's threshold, this method separates the image into three classes based on the two class means derived. The three classes are defined as the foreground with pixel values are greater than the larger mean, the background with pixel values are less than the smaller mean, and most important, a third class which is known as "to-be-determined" (TBD) region with pixel values fall between the two class means. Then at the next iteration, this method does not change the previous foreground and background regions and re-applies Otsu's method on the third region i.e. TBD region only to, again, separate it into three classes in the similar manner. The iteration stops only after meeting a preset criterion, the last TBD region is then separated into two classes, foreground and background, instead of three regions. The final foreground is determined as the logical union of all the previously determined foreground regions and the final background is determined in similar manner. The new method is almost parameter free method except for the stopping the iterative process and has minimal added computational overhead. We made some experiments using the new iterative method on synthetic and real images and found that it can achieve better performance in segmenting images such as zebrafish and nuclei images acquired by microscopes.

III.RESULT



(a) (b)



(c) (d)

Fig;1 (a) A zoomed-in portion of muscular nuclei, the weak nuclei are denoted by red arrow.
(b) The result after applying Otsu's method, it missed the weak nuclide.
(c) Results after applying the first iteration of the new method.
(d) Results after applying the fourth iteration of the new method. The weak nuclei are now detected by the proposed method.

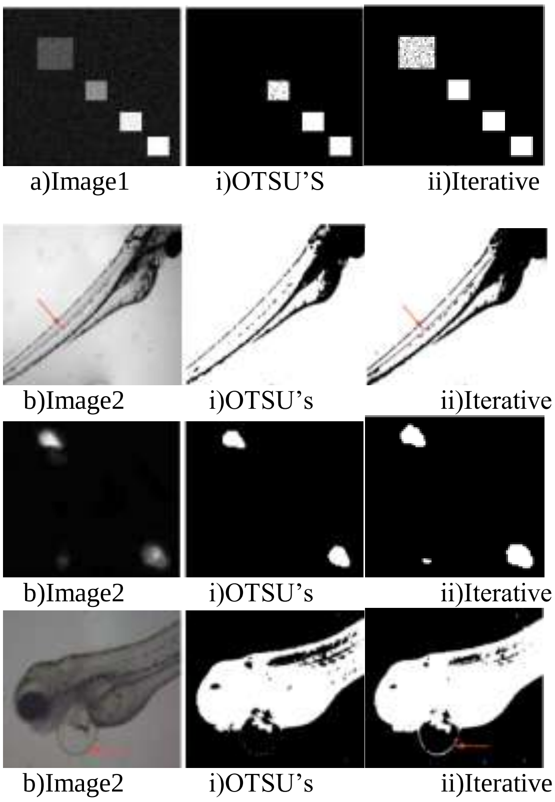


Fig 2:Result applying OTSU'S and iterative method

S.No	Method	Computational Time
Image1	OTSU	1.00
	ITERATIVE	4.00
Image2	OTSU	1.0470
	ITERATIVE	4.188
Image3	OTSU	1.0460
	ITERATIVE	4.184
Image4	OTSU	0.8910
	ITERATIVE	3.564

Table1:Represents computational time required to segment the image using Otsu's and iterative method

IV. CONCLUSION

Otsu's method is one of the preprocessing step in segmenting the images for further analysis. While preprocessing the images it is very important to achieve a high degree of accuracy. Otsu's thresholding technique is diverted towards the class with a larger variance, it tends to miss weak objects or minute details in images. In biomedical images, nuclei and axons may be imaged with very different intensities due to uneven staining or imperfect lightening conditions. It will raise the difficulty for algorithms like Otsu's method to successfully segment them. Due to this, more sophisticated processing which requires fine details in image such as tracking and feature analysis become very challenging. In this paper, we decribed a new technique which is based on Otsu's technique which classifies the image into three tentative classes instead of two.

From the experiment conducted on the different microscopic images , it is clear that the proposed algorithm can achieve superior performance in segmenting weak objects and fine details. The proposed method is also almost parameter-free except for the preset threshold to terminate the iterative process. The computational cost is minimal as the process usually stops in a few iterations. From a statistical analysis perspective. Experimental results shows that the proposed method can achieve better performance in many challenging cases. We note that there are many segmentation methods, but most of them are dependent on carefully selection parameters to achieve satisfactory performance. Because of this, a parameter-free i.e. proposed method may be well suited in many challenging applications.

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