

# An Effective Segmentation on Gray Scale Images using Iterative Triclass Otsu Thresholding

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**Abstract** -The project presents an automatic gray scale image segmentation using iterative Triclass thresholding technique. This technique was extended from the standard Otsu method for image partitioning into foreground and background region effectively. The iterative method starts with Otsu's threshold and computes the mean values of the two classes as separated by the threshold. Based on the Otsu's threshold and its two mean values, the image can be separated into three classes instead of two regions. The first two classes are determined as the foreground and background and it will not be processed further. The third class is a desired region to be processed at next iteration. In the upcoming iteration, Otsu's method is applied on the desired region to calculate a new threshold and two class means and the desired region is again separated into three classes. The process stops when the Otsu's thresholds calculated between two iterations is less than a predefined threshold. Then, all the intermediate foreground and background regions are combined to create the final segmentation result. After this process, Morphological filtering will be used to smooth the segment the region by removing the back ground noise and false detection. Finally, the target regions are extracted with better accuracy.

**Keywords**- Otsu's method, segmentation, threshold, triclass segmentation.

## I. INTRODUCTION

Image segmentation is the fundamental approach for digital image processing. In image processing, segmentation is the first step to preprocess the images to extract the objects and make it easier to analyze. It is used to separate the foreground from the background to change the representation of an image into meaningful one. The main aim of segmenting an image is to enhance the quality and suitability for presenting the image[1]. It has two objectives. First, is to decompose the image into several parts for further analysis. Second, is to perform a change of representation. And the result of image segmentation is a set of regions that collectively cover the entire image. Segmentation are used in various applications like locate tumors, measure tissue volume, locate objects in satellite images and finger print recognition, study of anatomical structure etc[2]. There are different image segmentation algorithms they are Fuzzy technique, feature based technique, and region based technique. Among them, Otsu method is one of the most successful methods for image

thresholding because of its simple calculation. It is mostly used in pattern recognition.

Thresholding is an important technique in image segmentation applications. Its main aim is to classify the pixels of an image into two classes that is, object and the background. The basic idea is to select an optimal threshold value for separating objects from the background. The gray level histogram of an image is usually considered as efficient tools for development of image thresholding algorithms. Many threshold methods have been proposed to binaries the image. Otsu method is global thresholding selection method, which is widely used because it is simple and effective.

A grayscale Image is digital image in which the value of each pixel is a single sample, that is, it carries only intensity information. Images of this sort, also known as black and white, are composed exclusively of shades of gray (0-255), varying from black (0) at the weakest intensity to white (255) at the strongest. Grayscale images are distinct from one bit black and white images, which in the context of computer imaging are images with only the two colors, black, and white (also called bilevel or binary images). Grayscale images have many shades of gray in between. Grayscale images are also called monochromatic, denoting the absence of any chromatic variation. Grayscale images are often the result of measuring the intensity of light at each pixel in a single band of the electromagnetic spectrum (e.g. infrared, visible light, ultraviolet, etc.), and in such cases they are monochromatic proper when only a given frequency is captured. But also they can be synthesized from a full color image. A (digital) color image is a digital image that includes color information for each pixel. Each pixel has a particular value which determines it's appearing color.

## II. OTSU METHOD

Otsu method was proposed by scholar Otsu in 1979. It is mostly used because of its simplicity. Its main aim is to search across the whole range of pixel values until the between class variance is maximized or within class variance is minimized. To make segmentation more robust

the threshold should be automatically selected by the system. Otsu method is one of the automatic thresholding techniques it mainly works on global thresholding and it requires computing a gray level histogram before running[3]. This algorithm assumes that the image contains two classes of pixels following bimodal histogram that is, foreground pixels and background pixels, then calculates the optimum threshold separating the two classes so that their within class variance is minimal. The two classes are the background and the foreground. If the signal intensity changes, it may affect  $T$ . So, the segmentation result may become less optimal. This is because; due to increase in signal intensity it increases  $T$  in segmentation such that some weak objects are missed by Otsu's method. So, very strong signal objects actually make it difficult for Otsu's method to perform satisfactorily.

### III. ITERATIVE TRICLASS THRESHOLDING UNDER OTSU METHOD

A new iterative method that is based on Otsu's method chooses the threshold that minimizes the intra class variance of threshold black and white pixels. It is one of the applied methods of image segmentation in selecting the threshold automatically for its simple calculation and good adaptation. It is most suitable to segment the images with bimodal histograms. This method can able to segment the image even in the presence of noise and also identify the missed weaker objects after certain iterations.

At the first iteration, Otsu's method on an image to obtain the Otsu's threshold and the means of two classes separated by the threshold. Then, based on the two class means the image is divided into three classes. The three classes are foreground with pixel values are greater than the mean, the background with pixel values are less than the mean, and then the third class is to-be-determined (TBD) region with pixel values between the two means classes. Then at the next iteration, the previous foreground and background will not be considered and the Otsu's method is applied on the TBD region. Again, it separate into three classes in the similar manner. And the iteration stops after meeting a preset criterion, then the last TBD region is then separated as foreground and background, instead of three regions[5],[6]. This method has minimal added computational load. And it can segment weaker objects or fine structures that are missed by the standard Otsu's method.

First principle component analysis is applied on the input image to reduce the dimension of the input image to make computation easier. Then, Otsu method is applied to that image to find the threshold  $T$ . Based on the threshold, image is divided into two classes i.e. foreground and background region and the two mean values are determined based on the threshold. Based on this two mean values triclass partitioning is done that is, region greater than mean value is determined as foreground region and region less than mean value is determined as background region and the region between this two mean values is

TBD. Second iteration, is done on the TBD region than foreground and background region. This iteration continuous until the target object is determined. And at last, Post processing will be used to smooth the region by removing the back ground noise and false detection[10]. This iteration method finds the weaker objects which are missed by the Otsu method.

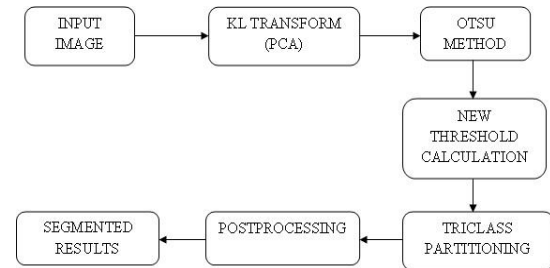


Fig 1: Block Diagram of Proposed System

### IV. PRINCIPLE COMPONENT ANALYSIS (PCA)

Principle component analysis is a technique that is useful for compression and classification of data. The purpose is to reduce the dimension of the data set by finding new set of variables, which is smaller to the original set of variables that retain most of the sample information. The new variables are uncorrelated with one another. The main linear technique for dimensionality reduction is principal component analysis. It converts the high dimensional data to low dimensional data. It performs a linear mapping of the data to a lower dimensional space in such a way that the variance of the data in the low dimensional representation is maximized. It is a way of identifying the patterns of data, and expressing the data in such a way as to highlight their similarities and differences. Since, the patterns of data are hard to find in high dimension, the graphical representation of high dimensional data is difficult. Coordinate system for sample data where the largest variance of a projection of the data exists on the first axis, and so on[12],[15]. Because these axes are orthogonal, this approach allow for reducing the dimensionality of the data set by eliminating those coordinate axes with small variances.

### V. PARTITIONING OBJECT AND BACKGROUND

The image contains only two principle regions that is, object region and the background region. When Otsu segmentation method is applied to input image it automatically calculates the threshold until the intra class variances reach their minimum. Based on the threshold, object and the background region are separated. Object region is represented as white pixels while the background region is represented black pixels.

## VI.PERFORMING ITERATIVE TRICLASS PARTITIONING

Once the image is separated into two regions based on the threshold, two mean values are calculated. In iterative method, the histogram of the image is classified into three classes that is foreground region greater than mean value, the background region smaller than the mean value, and the TBD region between the two mean values. The third region has miss classified pixel that is to be considered for further iterations and the new threshold is calculated[9]. Again the TBD region is divided into three classes. This iteration proceeds until the final threshold is small than the preset threshold.

## VII.IMAGE PARTITIONING USING FINALIZED THRESHOLD

When the iteration stops after meeting a preset criterion, the final TBD region is then separated into two classes, foreground and background. Then, the final foreground is the logical union of all the previously determined foreground regions and the final background is determined similarly. The new method is almost parameter free except for the stopping rule for the iterative process and it has minimal computational load.

## VIII.HIGHLIGHTING THE SEGMENTED OBJECTS

The objects which are segmented are highlighted. The weaker objects are identified from the images which are highlighted. This make easier to identify the objects easily.

## IX.PERFORMANCE VIEWS OF SEGMENTATION

To understand effectively histogram analysis is used. This histogram is a graphical representation showing the number of pixels in an image at each different intensity value found in that image. When the image is suitable for thresholding then the histogram will be bimodal. A suitable threshold will be found in between the two peaks in the histogram. One Peak represents the object pixels and the other one represents the background The histogram of an image represents the relative frequency of occurrence of the various gray levels in the image. Histogram of the black and white images have 256 gray levels ,from 0 up to 255, and the vertical lines in the histogram indicate how many pixels in an image assume a particular gray level. Therefore, histogram of the image is found to be very efficient in terms of computation complexity. If significant peaks and valleys are identified properly and proper threshold is fixed this technique yields good results.

## X.DISTANCE RATIO

To understand quantitatively the factor that determines the performance of Otsu's method is distance ratio. The ratio of the distance in mean between the foreground and background to the full pixel range of an image. It measures a posterior, for an image segmented into two classes by

techniques such as Otsu's method and to determine how far apart the means of the two classes are measured in terms of full pixel range of the image. The farther the two means are separated, and then it is easier for Otsu's method to segment the image. Unless the image has been segmented by an algorithm it is difficult to compute distance ratio ( $\Gamma$ )[16]. A larger  $\Gamma$  indicates that the segmentation process is likely more accurate.

## XI.SIMULATION RESULTS

The simulation results are shown below

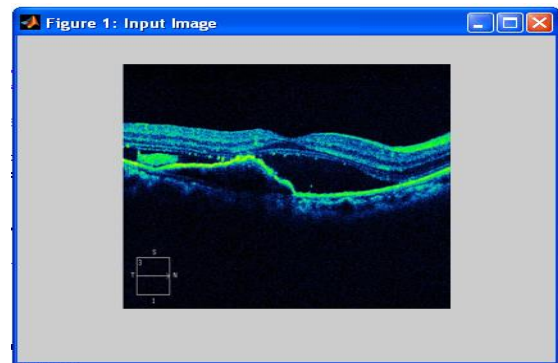


Fig 2 Input Image

The weaker objects are to be identified from the input image as shown in Fig 2.

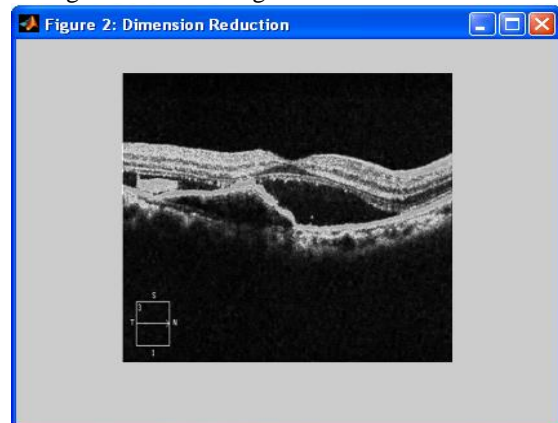


Fig 3 Dimensionality Reduction

Fig 3 shows that principle component analysis is used on the input image. It is a dimension reduction technique to reduce high dimension to low dimension. In this technique Eigen values and Eigen vectors are computed, the Eigen vector which has largest Eigen values is used to derive a new set. Because, largest Eigen value has highest variance and it is called as the first principle components. So, using this technique computational complexity is reduced.

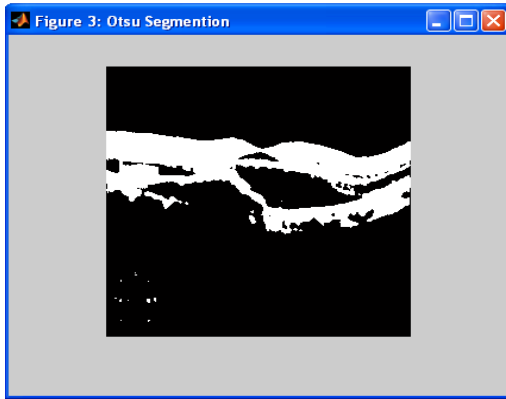


Fig 4 Otsu Segmentation

Fig4 shows that the Otsu segmentation method is applied on the Fig 3 to identify the threshold. Otsu threshold is found by searching across the whole pixel values of the image until the intra class variance reaches their minimum. Based on threshold, image is segmented into two regions that are, object and the background. Since Otsu threshold is biased towards the larger variance, it tends to miss weaker objects.

Table 1 Iterations Vs Threshold values

ITERATIONS	THRESHOLD VALUES
1	81
2	78
3	63
4	56
5	50
6	47
7	45
8	43
9	42
10	42

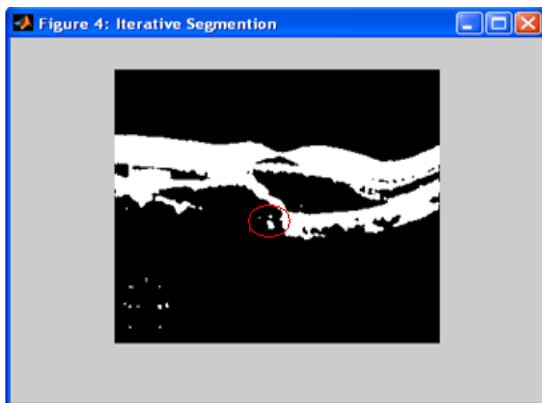


Fig 5 Iterative Segmentation weaker objects

Fig 5 shows that two mean values are calculated based on the mean values the image is divided into three regions that is foreground, background and TBD. The first two regions are not processed further only the TBD region is further segmented because it has miss classified pixels. This iteration process proceeds, on the TBD region until threshold decreases than the preset threshold. This method identifies the weaker objects accurately.

At first iteration threshold value is higher this indicates most of the miss classified pixels present in the TBD region when iteration precedes threshold value decreases and stops until it meet the preset criterion this indicates pixels are classified correctly and weaker objects are identified.

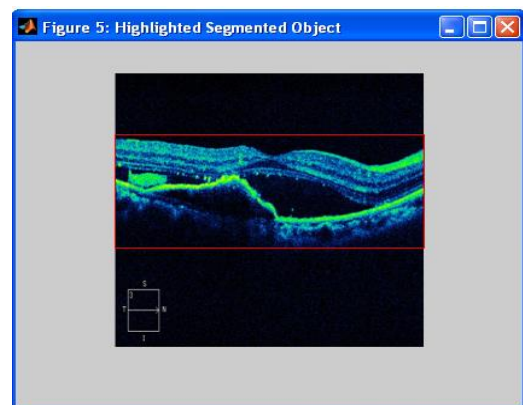


Fig 6 Highlighted the Segmented Objects

Fig 6 shows that the weaker objects are identified from the highlighted images.

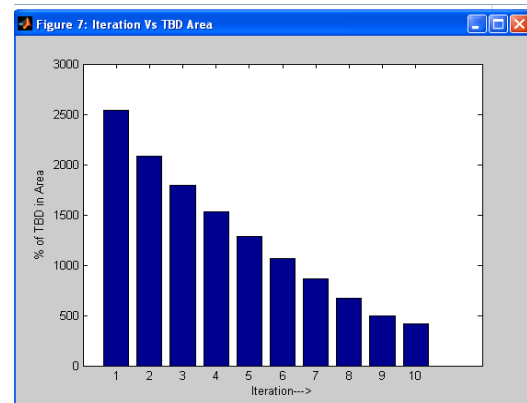


Fig 7 Iteration Vs TBD Region

The Fig 7 shows the percentage of TBD area, when iterative method is applied on the image it is divided into three regions that is foreground, background and TBD region. Again the process is applied on TBD region because it has miss classified pixels. When iteration precedes most of the pixels are classified therefore TBD region gets decreased .



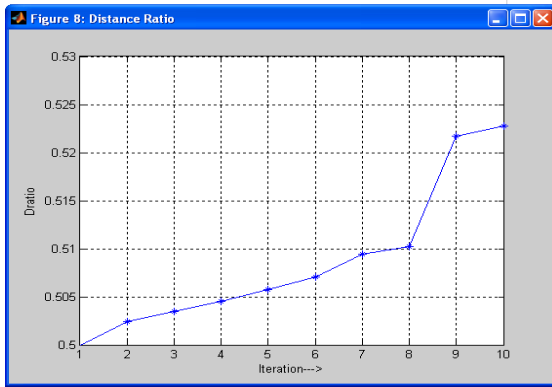


Fig 8 Distance Ratio

The Fig 8 shows that the distance ratio ( $\Gamma$ ), it computes how far the two class means are separated. The farther the two class means are separated then it is easier for the Otsu method to segment the image when iteration increases both the mean values decreases so the distance ratio increases. The increase in  $\Gamma$  indicates good segmentation

## XII. CONCLUSION

The iterative triclass method can able to identify the target region even in the presence of background noise. This method aiming at removal of background noise from images and it has, better adaptability of various kinds of noise at different areas of the same image based on low computational cost. The iterative threshold quickly decreases after first or second iterations, implying it is fast to reach satisfactory results and the weak objects are gradually classified into foreground. Simultaneously, the area of the TBD region reduces as the iterative process proceeds. However, the results of the iterative method show even when the histogram of the image is not bi modal that the new method can perform very well and it can achieve good results in different types of histogram. Results show that the method can achieve better performance in challenging cases.

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