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Comparative Analysis between Iterative Threshold Technique and Otsu's Method

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Abstract: This paper compares and examines the two image segmentation techniques, traditional Otsu method and the iterative Otsu method which includes the new technique called the iterative tri-class threshold technique. The iterative method selects the first threshold value using the Otsu's threshold and then computes the mean values of the two classes as separated by this threshold. Using this threshold value and the two mean values as calculated, this method separates the image into three classes instead of dividing into two classes as is done in the standard Otsu's method. The first class is the background and the second class is the foreground. The third class is the region that needs to be processed in the next iteration. This paper focuses on two parts, at first on stopping criteria and number of iteration in iterative method. Second, comparison between these two methods based on results.

Keywords: Otsu's method [6], segmentation, threshold, tri-class threshold technique [1].

I. INTRODUCTION

Image segmentation is the process of logical segregation a digital image into multiple segments (sets of pixels, also known as super pixels). Image segmentation simplifies and changes the representation of an image into more meaningful form which easier to analyse. Segmentation techniques can be generally categorized into two frameworks, edge-based and region based approaches.

The most popular method used for image segmentation is the threshold technique. In this technique an optimal threshold is selected based on certain criterion, namely, so as to maximize the separation between the resultant classes in gray levels. This procedure is very simple and easy to implement, which uses only the zero and the first-order cumulative values of the gray-level histogram. This method can directly be extended to solve the multi threshold problems. Several experimental results are also presented to support the validity of this method.

As a segmentation technique, Otsu's method [6] is one of the most popular among other techniques, which is based on the threshold method. Otsu's method is also used as a pre-processing technique to segment an image for further processing such as feature analysis and quantification etc. The Otsu's method produces good results when the histogram of the original image has only two distinct peaks, i.e. the background, and the foreground.

The Iterative method [1] starts with Otsu's threshold and computes the mean values of the two classes as separated by the threshold. The Otsu's threshold and the two mean values, separate the image into three classes instead of two classes like the Otsu's method does. The two classes are determined as the foreground and background and they will not be included any further computation. The third class is denoted as to-be-determined (TBD) [1] region that is reprocessed at next iteration. In the next iteration the Otsu's method will again be applied on the TBD region in order to calculate the new threshold value and the two means for this class and the TBD region of this successive class is again separated into following three classes: foreground, background, and a new TBD region, which covers a smaller region than the previous TBD region. The same method is again followed for this new TBD region. Processing of the image stops when the threshold value calculated between two iterations is less than a preset threshold value. Now, all the intermediate foreground and background regions are combined in the same order as calculated to generate the final segmentation result.

II. RELATED WORK

Over the years, many new techniques have been proposed by researchers to improve the result obtained by the Otsu's method. For example, Jun Zhang and Jinglu Hu [4] proposed 2D histogram projection is used to correct the Otsu threshold. Cheriet et al. [7] proposed a recursive approach based on Otsu's technique to focus on the brightest homogeneous object in an image. Salem Saleh et al. [3] attempted to undertake the study of segmentation image techniques by using different threshold methods but It makes comparisons only between segmentation methods based on same criteria. Beside all a new method proposed after long years towards the enhancement of Otsu method by Hongmin Cai, Zhong Yang, Xinhua Cao, Weiming Xia, and Xiaoyin Xu [1]. The new method for image segmentation is based on Otsu's method but iteratively searches for sub regions of the image for segmentation which are discussed later sections.

III. PROBLEM DEFINATION & PROPOSED SOLUTION STRATEGY

An analytical comparison between above stated methods depends on proper implementation of methods sated above. Otsu's method can be implement by applying standard function but the implementation of iterative threshold method became a very challengeable task, because in the iterative methods iterations stop when the difference between two successive thresholds is less than a preset value. This preset value has to be assumed. The

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problem with preset value is: the vale should be dynamic and should depend on respective images. The stopping criteria of an image completely based on this value. If the stopping criterion is not reached, then infinite iterations may occur. Again the numbers of iterations vary from image to image in iterative methods. The main challenge is compare these Otsu's method and iterative threshold methods based on segmented images.
To solve the above stated problem the detail implementation of Otsu method and iterative method are required. The first step of iterative method uses the same technique applied in Otsu's method. The output after each iteration of iterative method returns image which compared with output of Otsu's method. After implementation only comparison can be identified.
The below mention Fig. 1 represents the block diagram solution strategy.

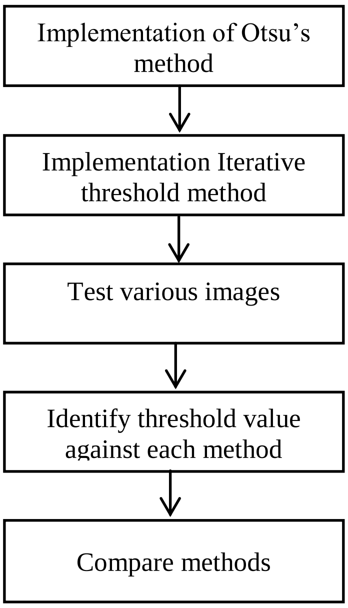

Fig 1: Block diagram of proposed solution strategy

The following algorithms are sated how methods are working. Though the algorithms are established and standard algorithm, some portions are modified only for better implementation.

A. Otsu algorithm[6]

- Start
- Read original image
- Determine threshold using Otsu's method
- Set the intensity values less than threshold as 0(black)
- Set the intensity values greater than threshold as 255(white)
- Display the final image
- End

Description of the Algorithm:-
The main objective of the algorithm is to perform these operations:

- First select the threshold based on the Otsu's method then sets the intensities as 0 and 255 for the respective regions.
- Display the segmented image.

B. Algorithm for Iterative Otsu methods :

- Start
- Read original image
- Determine first threshold using Otsu's method
- While two successive threshold values are not same do
    - Compute pixels with intensity less than specified threshold
    - Compute pixels with intensity more than specified threshold, foreground
    - calculate mean1 against foreground and mean2 against background for both the regions
    - Set background pixel intensity as 0(black)
    - Set foreground pixel intensity as 255(white)
    - Display the intermediate image
    - compute TBD region as set of pixels with intensity greater than mean1 and less than mean2
    - compute new threshold for the TBD region
    - goto step 4
- End loop
- Display the final image
- End

Description of the Algorithm:-
The main objective of the algorithm is to perform these operations:

- First select the threshold based on the Otsu's method by using any function what we have used in Otsu's method.
- Based on the threshold method three classes are identified (foreground, background, TBD)
- Next iteration performed on TBD region based on new calculated threshold value.
- Display the segmented image in each iteration based on threshold value of that iteration.
- Iteration will stop when it matches the threshold criteria.
- The final iteration gives the best segmented image.

IV. RESULT AND DISCUSSION

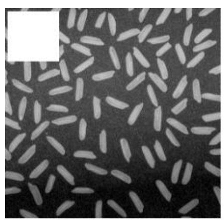

Figure 2.1(a) Input image 1

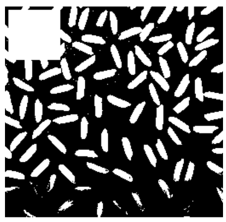

Figure 2.1(b) Otsu's result

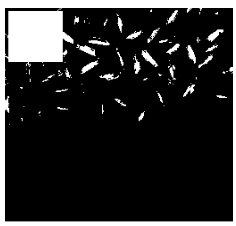

Figure 2.1(c) 1st iteration

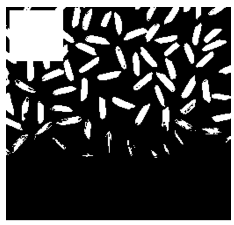

Figure 2.1(d) 2nd iteration

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Figure 2.1(e) 3rd iteration

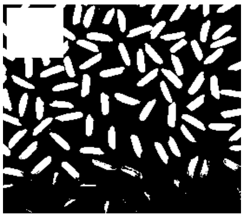

Figure 2.1(f) 4th iteration

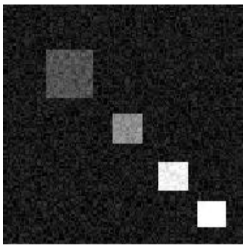

Figure 2.2(a) Input image 2

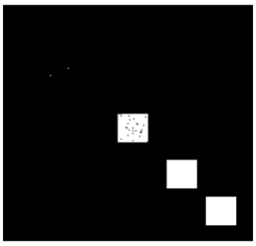

Figure 2.2(b) Otsu's result

Figure 2.2(c) 1st iteration

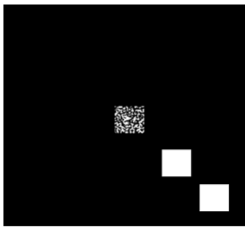

Figure 2.2(d) 2nd iteration

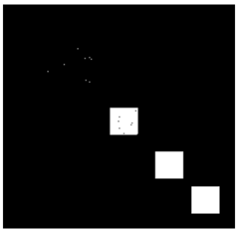

Figure 2.2(e) 3rd iteration

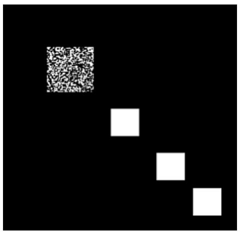

Figure 2.2(f) 5th iteration

Figure 2.3(a) Input image 3

Figure 2.3(b) Otsu's result

Figure 2.3(c) 1st iteration

Figure 2.3(d) 2nd iteration

Figure 2.3(e) 3rd iteration

Figure 2.3(f) 5th iteration

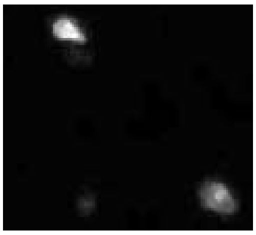

Figure 2.4(a) Input image 4

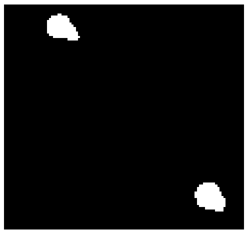

Figure 2.4(b) Otsu's result

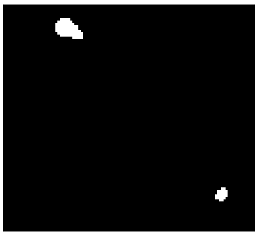

Figure 2.4(c) 1st iteration

Figure 2.4(d) 2nd iteration

Figure 2.4(e) 4th iteration

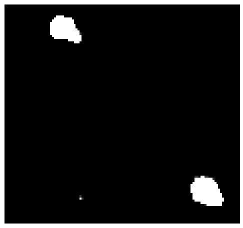

Figure 2.4(f) 6th iteration

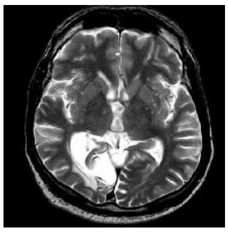

Figure 2.5(a) Input image 5

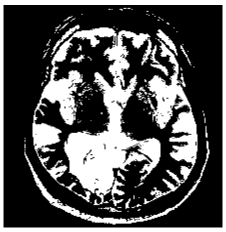

Figure 2.5(b) Otsu's result

Figure 2.5(c) 1st iteration

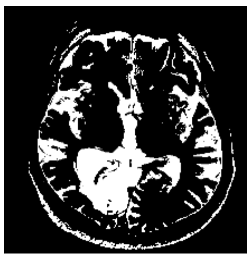

Figure 2.5(d) 2nd iteration

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Figure 2.5(e) 3rd iteration

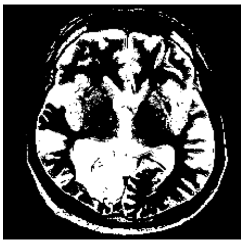

Figure 6.5(f) 4th iteration

Figure 2.6(a) Input image 6

Figure 2.6(b) Otsu's result

Figure 2.6(c) 1st iteration

Figure 2.6(d) 2nd iteration

Two methods are tested and the result against Otsu's methods (refer figure 2.1(b), 2.2(b), 2.3(b), 2.4(b), 2.5(b) and 2.6(b)) and iteration wise result of iterative threshold method (refer 2.1(c) to 2.1(f), 2.2(c) to 2.2(f), 2.3(c) to 2.3(f), 2.4(c) to 2.4(f), 2.5(c) to 2.5(f) and 2.6(c) to 2.6(d)) are shown above. It is observed that the number of iteration in case iterative method is not fixed. The number of iteration may vary through image by image. The following table shows some interesting results.

TABLE I NUMBER OF ITERATION TO FIND THE BEST IMAGE BY ITERATIVE METHOD

SL No.	**Iterative method**	
	Image No.	**No. Of Iteration**
1	2.1	4
2	2.2	5
3	2.3	5
4	2.4	6
5	2.5	4
6	2.6	2

The First the table (TABLE I) shows the number of iteration required in iterative methods. The below mention second table (TABLE II) shows the threshold values for various images segmented using Otsu's method and Iterative technique. The results of the experiments show that the threshold values for Iterative method slightly shift towards the foreground region thereby identifying the weak objects more clearly than Otsu's method for each of the images. Also, from the above outputs it is seen that the segmentation using Iterative method have more accuracy than that of Otsu's method. The image is segmented better and is more precise using Iterative Otsu. Therefore, the conclusion drawn is that Iterative method is a better threshold based segmenting algorithm as compared to Otsu's method in terms of time complexity, accuracy.

TABLE III COMPARISON OF THRESHOLD VALUES FOR OTSU'S AND ITERATIVE METHOD

SL No.	**Threshold value**		
	Image No.	**Otsu Method**	**Iterative Otsu Method**
1	2.1((b),(f))	120	115
2	2.2((b),(f))	119	82
3	2.3((b),(f))	100	98
4	2.4((b),(f))	70	54
5	2.5((b),(f))	91	89
6	2.6((b),(d))	170	171

V. CONCLUSION

However if the histogram has more than two peaks then the Otsu's method may not generate the best output as desired. In such cases the Otsu's method may create suboptimal results. This Iterative Tri-class method is capable of identifying weak objects more clearly than Otsu's method. This method starts with Otsu's threshold and computes the mean values of the two classes as separated by the threshold. Using this threshold value and the two mean values as calculated, this method separates the image into three classes instead of dividing into two classes as is done in the standard Otsu's method. The first class is the background and the second class is the foreground. The third class is denoted by the to-be-determined (TBD) region that needs to be processed in the next iteration. In the next iteration the Otsu's method will again be applied on the TBD region in order to calculate the new threshold value and the two means for this class and the TBD region of this successive class is again separated into three classes, namely, foreground, background, and a new TBD region. Also, after testing various images it can be said that segmentation using Iterative method has more accuracy than that of Otsu's method. Thus, the image is segmented better and is more precise using Iterative threshold method.

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BIOGRAPHY

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