International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 4 Issue 3, March 2015

A New Tri Class Otsu Segmentation With K-Means Clustering In Brain Image Segmentation

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Abstract— **Abstract: Image segmentation process usually involves the partitioning of an image into different set of heterogeneous pixel groups called segments. Among the various methods otsu threshold segmentation is found to be the best. Instead of classifying the image into foreground and background region as the standard otsu method does , the new method iteratively divides the image into foreground background and a region called TBD (To Be Determined region) on the basis of mean calculated and the chosen otsu's threshold. Next iteration continues with the TBD region to identify mean threshold and again repeats the similar tri class segmentation. The process stops when the Otsu's thresholds calculated between two iterations is less than the previously determined threshold. Then, all the remaining foreground and background regions are, respectively, collected and combined to create the final segmentation result. Here a k-means algorithm can be used to classify the homogeneous pixel regions of the brain to identify the severity of the tumor or affected cell regions. Medical segmentation based on this triclass otsu segmentation is found to be very efficient and fast.**

Index Terms— **Binarization, Brain tumor detection, Otsu segmentation, Threshold, Tri class segmentation.**

I. INTRODUCTION

The segmentation process identifies the group of pixels having similar properties within the image.Segmentation is a valuable tool in many fields in our daily life like industry, health cares, Digital image processing, remote sensing, Road traffic image, content based retrival, pattern recognition, and computer vision etc. The image segmentation method can be used in applications were the object detection, recognition, and measurement of object space in an image. Three main methods are there for segmentation Edge based, Region based and Boundary segmentation.As a segmentation technique, Otsu's method is widely used in pattern recognition ,document binarization and computervision[2] . In many cases Otsu's method is used as a pre-processing technique to segment an image for further processing such as feature analysis and quantification. For all these , the image have to be converted into grayscale images or it should be binarized. Binarization is the method of converting the given input greyscale or color document into a bi-level representation such as foreground and background[11].The binarization techniques for greyscale documents can be grouped into two broad categories: global binarization and local binarization. Global binarization methods like that of Otsu method try to find a single threshold value for the whole document. Then each pixel is assigned to page foreground or background based on its grey value. Global binarization methods are very fast and they give good results for typical scanned documents and medical imaging. But all the method should be applied to all the type of images for that an algorithm like K-means should be considered to classify the depth and extension region of the identified area[13].

II. RELATED WORKS

The segmentation techniques are broadly classified into diferent categories Edge based methods which focuses on the pixels that are lying within the change in intensity value of an image. Edge area had either a steep portion were the intensity value changes or discontinuity is identified[1]-[3]. Region Growing is an approach to image segmentation in which neighboring pixels are examined and added to a region class if no edges are detected. This process is iterated for each boundary pixel in the region. If adjacent regions are found, a region-merging algorithm is used in which weak edges are dissolved and strong edges are left intact. Region Growing offers several advantages over conventional segmentation techniques Histogram thresholding comes under this category. The histogram provides a convenient summary of the intensities in an image. It partitioned the image into different equal sized bins called classes , then number of pixels in each class is identified [7]. Different thresholding techniques are also there ,Other techniques focuses on finding a global threshold which suits for the entire region within the image. K-means clustering method will helps to
identify the dimensions of the required object .

A. OTSU METHOD

Otsu method is a threshold segmentation method binarized the image broadly into two classes based on Pre determined threshold .The pixels in the image are now divided into c1 and c0 classes based on this threshold value. The pixels with value greater than threshold comes under foreground region c0 and the pixels with value lower than threshold comes under background region c1[6]-[10]. The optimal threshold value can be found out by considering the variances of different types within-class variance, between -class and total variances as σ^2_W, σ^2_B ,σ^2_T respectively. Usually an optimal threshold can be found by minimizing the value of any of the ratio between these class variances.

Manuscript received March, 2015.

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ISSN: 2278 – 1323

$$\eta = \frac{\sigma^2_B}{\sigma^2_T}, \quad \lambda = \frac{\sigma^2_B}{\sigma^2_W}, \quad \kappa = \frac{\sigma^2_T}{\sigma^2_W} \qquad (1)$$

From the above criteria it is found that η is minimum ,the optimum threshold value can be defined as

$$T = \underset{T}{\operatorname{argmin}} \; \eta \qquad (2)$$

If the signal intensity changes, it may affect Threshold value and the segmentation result may become less optimal. In all the cases it is assumed that pixels are greater than background.

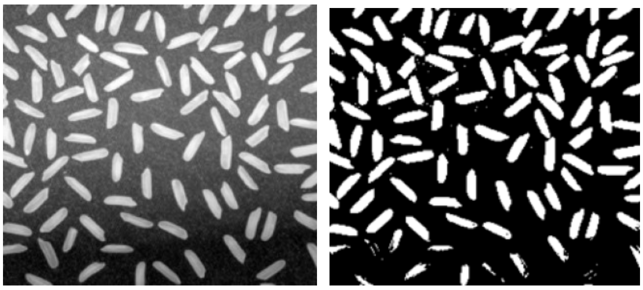

Fig 1 (a): shows the test image, Fig 1(b) :shows the result of standard otsu method.

In the given Fig. 1(a) shows an original image consist of multiple gray scale object. The result of segmentation of the standard Otsu's method is shown in Fig. 1(b), from which we can observe that most objects are correctly segmented or marked. In the given Fig. 1(a) shows an original image consist of multiple gray scale object. The result of segmentation of the standard Otsu's method is shown in Fig. 1(b), from which we can observe that most objects are correctly segmented or marked.

Fig. 2(a) have an added rectangular region, the corresponding Otsu's result is shown in Fig. 2(b). Though one would expect that with added signal intensity the segmentation result should be equally good or better, the result of Fig. 2(b) shows that some weak objects are actually missed now by Otsu's method.

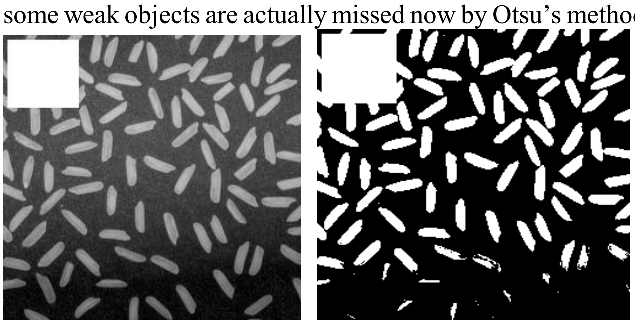

Fig 2 (a) purposely adds a white object to (a) increase its distance ratio . Result is given in Fig 2(b) as the weak objects at the bottom are failed to be segmented.

The reason is that the increased signal intensity resulted in raised T in segmentation, results the method to ignore the weak objects. From the results it is clear that otsu method do not provide better result when foreground has higher pixel intensity than the background, but it is not only the function of Signal-to-Background (SBR).

Another criteria called distance ratio have to be considered for segmentation , it is the ratio between foreground and the background pixels which measures a *posteriori* ,measures how far apart the mean of pixels are arranged in terms of full pixel ranges. Consider an image *u,* such that pixel values at location (x, y) and image is represents *u* (x, y). Then distance ratio can be mathematically expressed as,

$$\gamma = \frac{|\mu 1 - \mu 0|}{Max\{u(x, y)\} - Min\{u(x, y)\}} \qquad (3)$$

Where $0 \leq \gamma \leq 1$,for special cases $\gamma=0$ when image has constant value and $\gamma=1$ when image has two pixel values one for foreground and other for background, larger the value of γ segmentation is found to be more accurate[1].

B. K-MEANS METHOD

One of the best method for clustering is the k-means method which will create the temporary and individual clusters in order to find the optimal threshold value. K-means clustering algorithm is used to find the suitable clusters in such a way that pixels that belongs to the same cluster must be similar and pixels which are lying in the different clusters should be different from each other.

In the initialization stage a set of pixels in the image to be partitioned into number of similar pixel groups are selected and a centroid for each group are defined. Then Classification will done for object ,its distance to each of the centroid is calculated, the closest centroid is determined, and the pixels are assigned to the group related to this centroid.

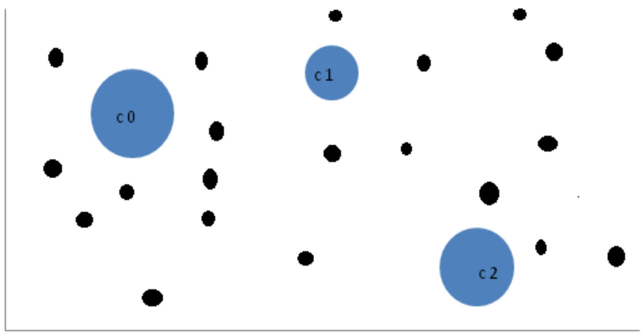

Fig 3. Data sets and cluster centers

Centroid calculation is done for each group generated in the previous step, its centroid is recalculated. Finally , the several convergence conditions have been used from which the most utilized are the following stopped when there is no exchange of objects among groups, or stopping when the difference among centroids at two consecutive iterations is smaller than a given threshold[13]-[14]. If the convergence condition is not satisfied previous steps are repeated. This technique can be used with our method to find the dimension of the affected tumor area of brain.

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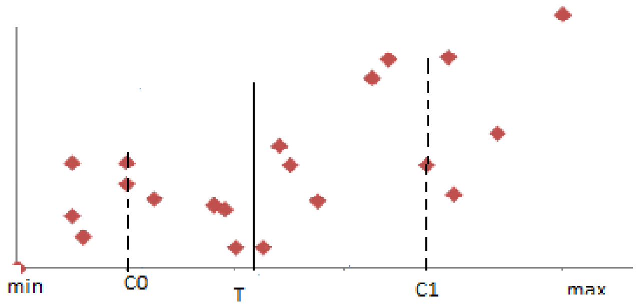
III. PROPOSED SYSTEM

From the different literatures it is found that the otsu threshold segmentation is found to be in accurate if the distance ratio between foreground and background region increases.



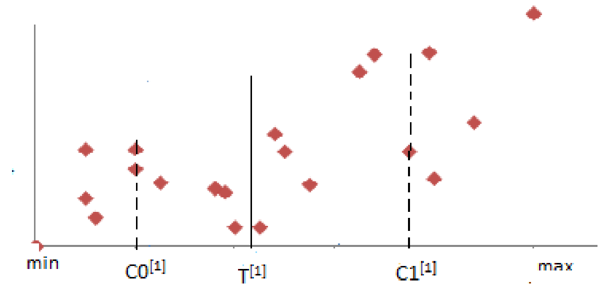


Fig 4(a) otsu method separates image into three regions in the first iteration. Fig 4(b) shows the application of otsu segmentation in the TBD region.

In the improved iterative otsu method the threshold is found by searching across the image to obtain segment with a minimum intra-class variance. This new method is quite similar to the previous otsu method ,in the first iteration otsu method is applied to obtain a threshold fig 4(a). Based on this a mean is calculated for the two regions c0 and c1 as $\mu0^{[1]}$ and $\mu1^{[2]}$ respectively. The pixels with value less than the threshold falls under background $B^{[1]}$ and larger values falls under foreground region $F^{[1]}$. The pixel values that are not lying in these both classes are named as TBD region, represented as Ω were $\mu_0^{[1]} \leq \Omega \leq .\mu_1^{[1]}$ ie the pixel values lying between the middle of foreground and background region.

$$U= F^{[1]} \cup B^{[1]} \cup \Omega^{[1]} \qquad (4)$$

Where U is the logical union operator .In the successive iterations [12] the process is again repeated on $\Omega^{[1]}$ region to obtain a new threshold $T^{[2]}$ by calculating the mean of set of foreground $\mu_0^{[2]}$ background $\mu_1^{[2]}$ and TBD region $\Omega^{[2]}$.

$$\Omega^{[1]} = F^{[2]} \cup B^{[2]} \cup \Omega^{[2]} \qquad (5)$$

Where $F^{[2]}$ is the foreground region , $B^{[2]}$ is the background region and $\Omega^{[2]}$ is the TBD region respectively in the second iteration fig 4(b).

The otsu method is applied on the assumption that found foreground region has the higher pixel intensity than the background .When this concept is extended to the medical imaging like brain tumor detection the affected tissues are assumed to be lying in the mid intensity region that are always rejected by the standard thresholding method The iteration stops when $T^{[n+1]}$-$T^{[n]}$ threshold calculated between the successive iterations is less than a preset threshold[1].

IV . EXPERIMENTAL RESULTS

The improved otsu segmentation shows better performance compared to the different previous otsu methods .The image of the rice grain (fig 5a) is first converted into normalized grey level values, then identifies the TBD region (fig 5b) to process the iterative segmentation.

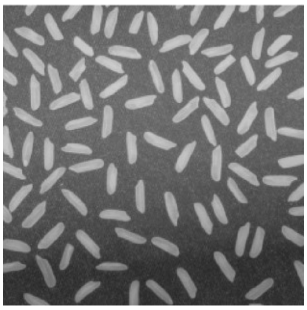
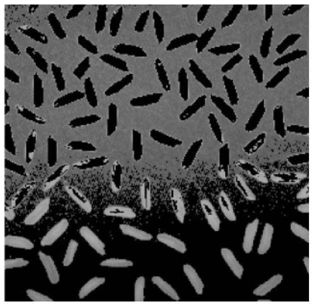



Fig 5(a).Normalized input image ,Fig 5(b).Image with TBD region identified .

This obtained TBD region have pixel values ranging in a middle range that is always ignored by all other methods of threshold segmentation. Finally the clear segmented rice grain images can be identified (fig 5c).

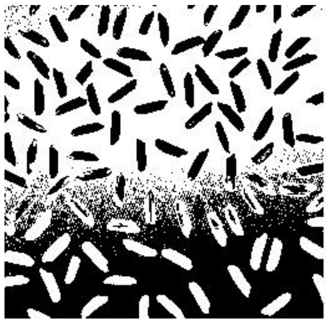


Fig 5(c).Final segmented image

Here almost all the rice grains are clearly segmented and the region of maximum similar pixels are grouped using the k-means method.If this segmentation is applied to brain images we can easily identify the weak areas were the unwanted growth may resides.

By the effective classification of the pixels in the to be determined region we can identify the size or dimensions of the tumor detected. Fig 6 (a) shows the scanned image of the brain were it is identified that near the brain stem an extra growth can be detected near the curved boundary which is clearly defined in TBD region of fig 6 (b) the proposed method will clearly identified this tumor region exactly.

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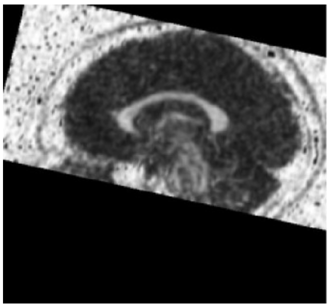
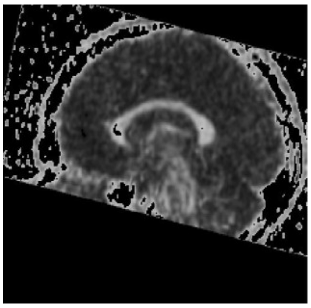

Fig 6(a). Normalized input brain image, Fig 6(b).Image with TBD region identified.

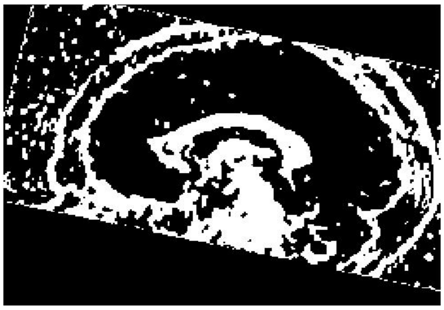

Fig 6(c).Final segmented image tumor detected

V. CONCLUSION

An Otsu method usually classify the image into a group of pixels. But in most of the cases it will failed to recognize the required portions or much brighter or lighter objects particularly for image with large variences . The otsu can be used as a preprocessing step in many cases like document binarization and medical imaging.

In order to overcome the limitations of the otsu segmentation the proposed method classify the image pixels into three groups foreground, background and a TBD region based on a threshold selected randomly. Then the successive iterartions will proceeded with the TBD region until the threshold calculated will be less than a preset threshold value. The added advantage of using k-means clustering will help to classify the regions clearly. The method works well with brain images were we can identify the malicious cell regions with in the scan image.The iterative processing using the TBD region will help to identify even a small cell growth. From the statistical prespective the method works well with images of bi modal histograms and the test result shows that the method shows better performance than the other segmentation methods.

ACKNOWLEDGMENT

The first author would like to thank to all the faculties for their support and guidance. Without their valuable support this task was not possible. And also like to thank the colleagues for their discussions and suggestions.

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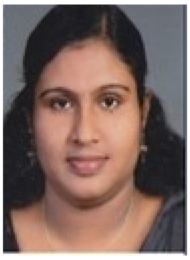
ISSN: 2278 – 1323



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ISSN: 2278 – 1323