An Effective Medical Image Segmentation Based on Triclass Otsu's Tresholding

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Abstract-Image segmentation method typically involves the partitioning of an image into completely different set of heterogeneous pixel groups referred to as segments. We present a novel methodology in image segmentation that's supported Otsu's methodology however iteratively searches for sub regions of the image for segmentation, rather than treating the total image as an entire image for processing. The reiterative methodology starts with Otsu's threshold and computes the mean values of the two categories as separated by the threshold. Based on the Otsu's threshold and also the two mean values, strategy separates the image into three categories rather than two because the normal Otsu's methodology will. The primary two categories area unit the determined as the foreground and background and that they won't be processed any. The third category is denoted as a to-be-determined (TBD) region that's processed at next iteration. At the succeeding iteration, Otsu's methodology is applied on the TBD region to calculate a replacement threshold and two category means that and also the TBD region is once more separated into three categories, namely, foreground, background, and a replacement TBD region, that by definition is smaller than the previous TBD regions. Then, the new TBD region is processed within the similar manner. The process stops once the Otsu's thresholds calculated between two iterations is a smaller amount than actual threshold. Then, all the intermediate foreground and background regions are, severally, combined to form the final segmentation result.

Keywords: Otsu, Image Segmentation, TBD, Iterative Methods.

I. INTRODUCTION

Image segmentation is that the method by that an image is split into regions, or segments, supported varied criteria. Greyscale Image Segmentation may be a kind of image segmentation whereby a two-dimensional image is divided into two segments foreground and background in keeping with some relationship of the pixels' intensity or gray levels. The ensuing segmentation is understood as a monochrome (black and white) image, where either black or white pixels are designated as foreground, and therefore the remainder as background. Foreground pixels can be same to be 'interesting', in this they represent some object or feature that is of interest to study; background pixels square measure 'uninteresting' as they supply no immediate value for analysis. The segmentation method identifies the cluster of pixels having similar properties inside the image. Segmentation may be a valuable tool in several fields in our way of life like business, health care's, Digital image process, remote sensing, Road traffic image, content based retrival, pattern recognition, and computer vision etc. The image segmentation methodology is utilized in applications were the object detection, recognition, and measurement of object space in a image. Three main strategies are there for segmentation Edge based, Region based and Boundary segmentation. As a segmentation technique, Otsu's methodology is wide utilized in pattern recognition, document binarization and computer vision. In several cases Otsu's methodology is employed as a pre-processing technique to phase an image for additional process like feature analysis and quantification. For all of these, the image ought to be regenerate into greyscale images or it ought to be binarized. Binarization is that the methodology of changing the given input greyscale or color image into a bi-level illustration like foreground and background binarization techniques for greyscale documents is sorted into two broad categories: global binarization and local binarization. Global binarization strategies like that of Otsu methodology try and realize one threshold value for the total document. Then every component is assigned to page foreground or background supported its gray value. Global binarization strategies square measure in no time and that they offer smart results for typical scanned documents and medical imaging. However all the tactic ought to be applied to any kind of images for that and rule like K-means ought to be thought of to classify the depth and extension region of the known area.

II. RELATED WORK

Currently varied approaches to image segmentation are used, of that we'll describe a number of the foremost well-established and recognised below. Once categorising image segmentation techniques it's helpful to refer to the underlying method every technique uses. The simplest greyscale segmentation approach to understand is that of thresholding, that involves shaping a particular intensity value as a threshold specified component with an intensity bigger than the edge is labelled 'white', and any lower than or adequate the edge is labeled 'black'. Then, counting on the particular image and context, either 'black' or 'white' pixels are same to be foreground, and also the others background. One usually used and well recognised thresholding technique, projected by Noboyuki Otsu in 1978 [4], explained applied mathematics analysis of the image's grey-level bar chart to determine the optimum threshold. Alternative thresholding techniques are recommended that use completely different objective functions to judge the optimality of a threshold. Let's say, by victimization techniques created accessible through fuzzy pure mathematics, a threshold is also evaluated by some live of fuzziness [5] of the resulting partitioned image, comparable to the linear index of fuzziness [6], fuzzy entropy [7] or fuzzy correlation. All these techniques follow constant basic approach as Otsu's threshold, with variations within the details of implementation, above all the target operate accustomed appraise a threshold. As such, a detailed explanation of Otsu's threshold is going to be provided, together with explanations of wherever the algorithmic program is also altered to include completely different recommended techniques. Many image thresholding techniques are represented thoroughly by Chi et. al., with samples of applications of different techniques.

Another common approach to greyscale image segmentation uses clump techniques to cluster pixels according to common characteristics. One such technique, referred to as k-means clump, is a fixed-class-number variant of the ISODATA technique [9] that uses an algorithmic approach to classify pixels into categories and optimise that classification. In terms of greyscale image segmentation, the quantity of categories used in k-means is fastened at a pair of (foreground and background). A fuzzy generalisation of k-means, proposed initially by Dunn in 1973 then improved upon by Bezdek in 1979, is thought as fuzzy c-means (FCM).

More recently varied completely different approaches to greyscale image segmentation are projected. One such technique, let's say, is region growing, whereby some methodology is employed to decide on a seed purpose within the image, and also the algorithmic program extracts all pixels connected to the initial seeds supported some predefined criteria, comparable to till a footing is detected within the image. Documents discussing region growing, likewise as alternative general approaches to image segmentation (such as victimization classifiers, Andrei Markov random field models, artificial neural networks, deformable models, and atlas-guided approaches) are provided elsewhere.

It has conjointly been recommended that a fuzzy rule-based approach is also employed in image segmentation, by interpreting image options as linguistic variables [19] and victimization fuzzy if-then rules to phase a picture into regions. Descriptions of fuzzy rule-based systems ar provided by Chi et. al., but a study of obtainable literature suggests that this approach isn't usually utilized in modern analysis, and Chi et. al. describe inherent difficulties and issues with the approach[8], and per se fuzzy rule-based systems won't be studied thoroughly during this document.

Itti et al. [1] introduced a biologically-inspired saliency model. They proposed to use a collection of feature maps from three complementary channels as intensity, colour, and orientation. The normalised feature maps from every channel were then sent into a 'Winner-take-all' competition to select the foremost conspicuous image locations because the overall prominence map. Ma and Zhang [2] projected a neighbourhood contrast-based saliency model that is obtained from summing variations of image pixels with their individual encompassing pixels in a very little neighbourhood. A fuzzy-growing technique then segments salient regions from the saliency map. Wu et al. [3] projected to work out the saliency map optimisation low-level features, as well as luminousness, color and region information, then thresholding these feature maps employing a simply noticeable distinction (JND) model and desegregation them into a final saliency map.

III. 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,

$$\mu 1 > \mu 0.$$

The calculation of threshold *T* is as follows：

$$T=\arg\min \sigma_0^2(T) \quad \text{------(1)}$$

Where

$$\sigma_w^2(T) = q_0(T)\,\sigma_0^2(T) + q_1(T)\,\sigma_1^2(T) \quad \text{------(2)}$$

$$q_1(t) = \sum_{i=1}^{t} P(i) \quad \text{and}$$

$$q_2(t) = \sum_{i=t+1}^{I} P(i) \quad \text{------(4)}$$

where the subscript 0 and 1 denote the two classes, background and foreground, respectively, and qi and σi , i = [0, 1] are the estimated class probabilities and class variances, respectively.

These quantities are calculated

as

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.

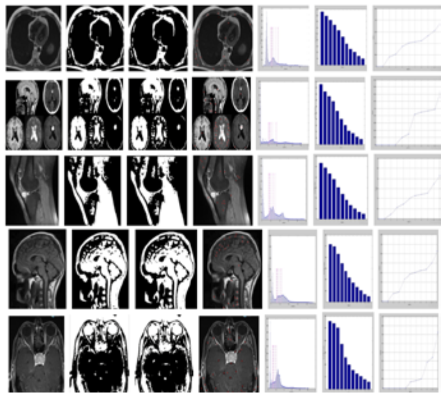
The iteration stops only after meeting a preset criterion, the last TBD region is then separated into two classes, foreground and background, instead of three regions. The final foreground is determined as the logical union of all the previously determined foreground regions and the final background 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 Medical MRI Scan images and found that it can achieve better performance in segmenting images.

- *Algorithm*

The steps involved for this new iterative triclass thresholding is given below:

1. Start
2. Read original image
3. Determine first threshold using Otsu's method
4. While two successive threshold values are not same do
5. Compute pixels with intensity less than specified threshold
6. Compute pixels with intensity more than specified threshold, foreground
7. Calculate mean1 against foreground and mean2 against background for both the regions
8. Set background pixel intensity as 0(black)
9. Set foreground pixel intensity as 255(white)
10. Display the intermediate image
11. compute TBD region as set of pixels with intensity greater than mean1 and less than mean2
12. compute new threshold for the TBD region
13. goto step 4
14. End loop
15. Display the final image
16. End

IV. SIMULATION/EXPERIMENTAL RESULT



(a) (b) (c) (d) (e) (f) (g)

Figure1(a) Input image(b) Otsu's segmentation (c) Iterative segmentation (d) HighlightedSegmented object (e) Histogram with threshold (f) Iteration Vs TBD area (g) Distance ratio

TABLE 1. THRESHOLDING CALCULATIONS

S. No	Name	No of Iterations	Thresholding	
			Min value	Max value
1	Primary cardiac	11	27	47
2	Brain	11	38	64
3	Human leg	11	40	44
4	MRI(all)	11	44	82
5	Pituitary gland	11	50	96

V. CONCLUSION

Otsu's method is one of the pre-processing step in segmenting the images for further analysis. While pre-processing 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 medical images, breakage and tumour 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 medical 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. Experimental results show 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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