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A Comparative Evaluation of Image Analysis Techniques in Image Segmentation

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Abstract

Segmentation is defined as a technique that entails the division or separation of the image into regions of equal attribute. Clustering and Thresholding is the most commonly used image segmentation methods. Thresholding is termed to be the simplest method of the image segmentation and clustering is a feasible approach for finding similarities in data and putting similar data into groups. This paper proposes a novel framework for the qualitative comparison and evaluation of Otsu thresholding and Fuzzy C-Means (FCM) clustering technique for the segmentation of leukemia infected blood microscope images and standard mat lab images based on full reference pixel-difference -based image quality measures such as PSNR (Peak Signal to Noise Ratio), MSE (Mean Square Error) and Human-Visual system based measure like Similarity Index Measure (SSIM). The elapsed time of the segmentation process by both the methods is also calculated and analyzed.

AMS Subject Classification:

Key Words and Phrases: segmentation, clustering, thresholding, FCM, PSNR, MSE, SSIM

1 Introduction

Image Analysis is defined as extracting meaningful information from an image. Segmentation is an image analysis technique, in which different regions of an image are segregated based upon the pixel intensities available within the image.The segregation of an image into connoting structures, image segmentation, is often viewed as step forward in image analysis, object representation, visualization, and a handful of other image processing tasks[1]. Figure 1.1 illustrates the classification of image segmentation techniques.

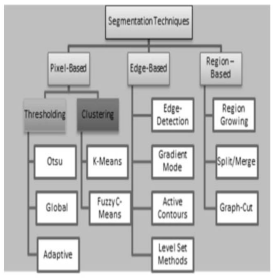


Figure 1.1 Classification of Segmentation Techniques

The primary objective of this paper is to propose a novel framework to compare and evaluate the pixel based segmentation techniques such as thresholding and clustering by applying it on leukemia infected blood microscope images and matlab standard images.

2 Related Works

A large section of researchers applied different segmentation strategies like theresholding strategy, region based methodologies, edge detection approach, clustering approaches, artificial neural network, Fuzzy procedure, watershed algorithms and others for the segmentation of various images in an attempt to arrive at better results. N. H. Harunet. al. [2] proposed three numbers of clustering algorithms such as k-means, fuzzy c-means and moving k-means algorithm, which were applied on the saturation component image. Then the median filter and seeded region growing area extraction algorithms have been applied. The comparison process is carried of the three clustering algorithms in order to evaluate the performance of each clustering algorithm on segmenting the blast area, where the moving k-means clustering algorithm has successfully produced the fully segmented blast region in Acute Leukemia image. J.selvakumaret al.,[4]developed a method that permits these gmentation of tumor tissue precisely and whose reproducibility at par to manual segmentation. In addition, it also enables reduction in the time required for analysis. On the completion of process, the tumor is extracted from the MR image and both its correct position and the shape are determined. The stage of the tumor is produced on the basis of the amount of area calculated from the cluster. The derived experimental results are compared with other algorithms. The proposed method results in more accurate result. J. Poornima et al.,[5] developed a novel image processing technique to detect and count the platelets. It is an efficient and simple technique to identify whether the patient is affected with dengue or not. The One of the morphological operations called flood fill is utilized to detect platelet with platelet size. It is helpful in estimate the count of platelet using image processing technique successfully.Compared with the manual counting of platelets the proposed system is taken less time. This paper intends to propose a novel framework to compare and evaluate the segmentation techniques such as Otsu thresholding and Fuzzy C-Means (FCM) unsupervised clustering techniques.

3 3 Proposed Framework

The performance of the Otsu thresholding and FCM clustering segmentation methods are compared by proposing a novel framework which is illustrated in the Figure 1.2 and evaluated using the full reference pixel based measures namely, PSNR and MSE and the Human-Visual system based measure like Similarity Index Measure (SSIM).The elapsed time of the segmentation is also calculated and analyzed. The above methods are applied on the blood microscope image and also on standard mat lab peppers image.

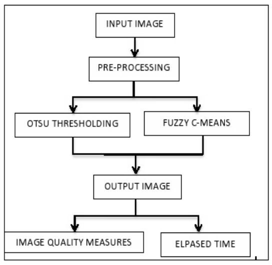


Figure 1.2 Proposed Framework of the Performance Analysis Process The leukemia infected blood microscope images and mat lab peppers image is given as the input image. Initially, a preprocessing of the input image is done using the partial contrast stretching technique and then the image is segmented by applying the Otsu thresholding and Fuzzy C-Means clustering methods separately. The segmented output image is analyzed and evaluated based on the image quality measures and elapsed time.

3.1 Pre-processing

The aim of the pre-processing is to improve the visibility of low contrast features while suppressing noise. Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine. In this framework the preprocessing is done using partial contrast stretching technique to improve the contrast of the image.

1. ***Partial Contrast Stretching Technique***

The contrast stretching technique is a widely used image enhancement techniques that works to improve the contrast in the image by stretching the range of the intensity values it contains to span a desired range of values. Partial contrast is defined as a linear mapping function that is applied to improve the contrast level and brightness level of the image [6].

3.2 Segmentation

2. ***Fuzzy C-Means Method***

Known thresholding and clustering techniques, such as Otsu's threshold and Fuzzy C-Means(FCM), have shown high levels of popularity in the past thirty years, and are very simple algorithms to implement that run quickly compared to other, more complicated procedures.FCM was initially proposed by Bezdek et al., It is the widely used tool for image processing in clustering objects in an image. FCM facilitates the pixels to secure a place with various cluster along with alterable degrees of participation.Owing to this extra adaptability, FCM is also termed as Soft clustering strategy. Fuzzy clustering is a simple methodology which carries out the non-unique partitioning of the data in a collection of clusters [7].The FCM Algorithm is as follows:

Step 1: Randomly initializing the cluster centers, termination criteria α, Maximum no of iterations X.

Step 2: Creating a distance matrix from a point x_j to each of the cluster centers using the following equation.

$$d_{ij} = \| c_i - x_j \| \tag{1}$$

Step 3: Repeat the following steps until reach the total number of iterations.

Step 4: Compute the Membership matrix.

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} [\frac{d_{ij}}{d_{kj}}]^{\frac{2}{(m-1)}}} \tag{2}$$

Step 5: Generating new cluster centers.

$$c_i = \frac{\sum_{j=1}^{n} u_{ij}^m x_j}{\sum_{j=1}^{n} u_{ij}^m} \tag{3}$$

Step 6: Compute the objective function.

$$J = \sum_{j=1}^{N} \sum_{i=1}^{c} (\mu_{ij})^m d_{ij}^2 \tag{4}$$

Step 7: Update cluster heads.

Step 8: If abs value of distance metric of J is $< \alpha$ Stop execution.

Step 9: Otherwise update objective function values and Go to Step 3.

3. *Otsu's Global Thresholding Method*

Thresholding is the most commonly used image segmentation method,it is used to create binary images from a grayscale image. Otsu's thresholding method applies iterative process with all probable threshold values and computing the degree of spread for the pixel levels each side of the threshold, i.e. the pixels that either falls in foreground or background. The aim is to obtain the threshold value where the sum of foreground and background spreads is at its minimum [8].The Figure 1.3 illustrates the process flow of Otsu thresholding technique. The Otsu algorithm is as follows:

1. Compute histogram and probabilities of each intensity level.

2. Set up initial $\omega_i(o)$ and $\mu_i(o)$ and t.
3. Step through all possible thresholds $t = 1...$ maximum intensity. Update ω_i and μ_i.
4. Compute $\sigma^2 b(t)$.
5. Desired threshold corresponds to the maximum $\sigma^2 b(t)$.

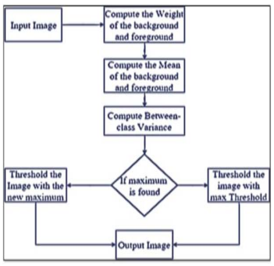


Figure 1.3 Process Flow of the Otsu thresholding Technique

4 Comparison Parameters

4. *Peak Signal to Noise Ratio (PSNR)*

PSNR is the traditional measure commonly used to measures the ratio between the maximum possible power of an image and a power of corrupting noise. The PSNR is provided in decibel units (dB), it is defined as in Equation 5 [9].

$$PSNR = 10\log((L-1^2)|MSE) \quad (5)$$

where L is the largest possible value of the signal (typically 255), Higher PSNR means more noise removed.

5. *Mean Square Error(MSE)*

MSE is the cumulative squared error value between the input image A(i, j) and the segmented image B(i, j) is given in equation 6 [9].

$$MSE = \frac{1}{MN}\sum_{I=0}^{N-1}[A(I,J)-B(I,J)]^2 \quad (6)$$

6. *Structural Similarity Index(SSIM)*

This measure is based on the perception of what human eyes would do. Image quality is measured by contrast, colour and frequency change. SSIM serves as a quantitative measurement of the quality of the second signal. It is maximal if it is 1.It separates the task of similarity measurement into three comparisons- Luminance, Contrast and Structure which is shown in the equation 7.

$$SSIM(x,y) = [l(x,y)]^{\alpha}.[c(x,y)]^{\beta}.[s(x,y)]^{\gamma} \quad (7)$$

7. *Elapsed Time*

The elapsed time is the time required for the accomplishment of segmentation process is denoted in terms of seconds [9].

5 Results and Discussion

This section evaluates the performance of the proposed novel framew.The above proposed framework is actualized utilizing Image Processing Tools of MATLAB R2013a. The accompanying figures represents to the outcomes acquired from the proposed structure calculation. The sample images are collected from the data set [10]. The results are determined based on full reference pixel based measures PSNR and MSE and Human- visual system based measure SSIM are given in the table I,II, III and IV for leukemia infected blood microscope image and matlab peppers image. The initial random cluster centers and the cluster heads generated by the FCM is given in the Table V and VI. FCM is exhibiting better results for PSNR, MSE and SSIM by producing the high PSNR and low MSE which in turn indicates the better reconstruction of images. The input image and the segmented output images are shownin the figure 1.4and 1.5. The segmentation of the blood microscopy image is performed by segmenting the White Blood Cell(WBC) from Red Blood Cell (RBC) and cytoplasm. The image segmented by the FCM method is exhibiting better results for PSNR, MSE and SSIM by producing high PSNR and low MSE which in turn indicates the better reconstruction of images. FCM algorithm has greater data handling capacity and has better operability upon diversified data range. On the other hand, the convergence rate gets affected if the number iterations are subsequently increased. Diminishing the number of iterations and to obtain faster convergence rate has an adverse effect upon the segmentation accuracy. The graphical representation of the performance analysis is given in the Figure 1.6, 1.7, 1.8 and 1.9.

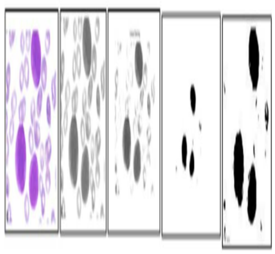
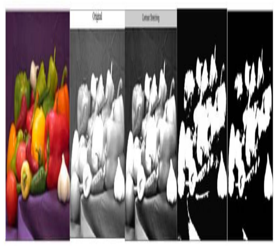


Figure 1.4. Results of Proposed Framework for Leukemia image (i)Original RGB image (ii) Grayscale Image (iii)Pre-Processed Image (iii)FCMsegmented Image(iv) Otsu segmented Image Figure 1.5. Results of Proposed Framework for mat labpep-



pers image (i)Original RGB image (ii) Grayscale Image (ii) Pre-Processed Image (iii) FCM segmented (iv) Otsu segmented Image

Table I Results for Image Quality Measures [Ideal values: PSNR-High MSE-Low]

IMAGE	METHOD	PSNR(decibels)	MSE(Pixels)
Leukemia Blood Microscopy Input Image	Original Image	30.63	21.23
Peppers Input Image	Original Image	35.68	17.55
WBC Segmented Blood Microscopy Image	Otsu	28.52	31.14
	FCM	26.42	29.68
Peppers Image	Otsu	36.62	14.14
	FCM	36.80	13.58

Table II Results for Image Quality Measures [Ideal values: Elapsed Time-Low SSIM≈1]

IMAGE	METHOD	ELAPSED TIME (seconds)	SSIM(Pixels)
WBC Segmented Blood Microscopy Image	Otsu	3.8522	0.8852
	FCM	4.1495	0.9154
Peppers Image	Otsu	2.5487	0.8547
	FCM	2.9374	0.9054

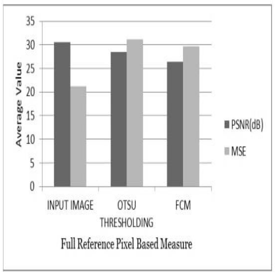


Figure 1.6 Performance Analysis of Leukemia Blood Microscopy image

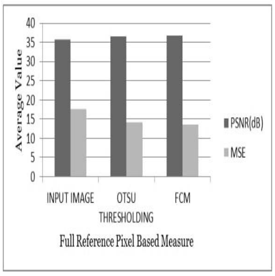


Figure 1.7 Performance Analysis on mat lab peppers image

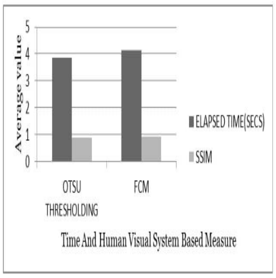


Figure 1.8 Performance Analysis of Leukemia infected Blood Microscopy image

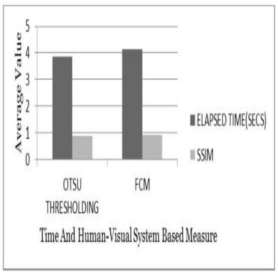


Figure 1.9 Performance Analysis ofmat lab peppers image

Table VCluster Heads of FCM for Peppers Image Initial Random cluster centers C1=55 C2=217

No of iterations	Cluster Head 1 (C1)	Cluster Head 2 (C2)
1	86.6089855866177	232.572337600067
2	100.079767521873	240.175384183937
3	107.324665180242	243.640468043003
4	111.1464707169	245.202443612435
5	113.102428876511	245.924700815753
6	114.085268665011	246.266893763386
7	114.574246067812	246.431790539909
8	114.816266523678	246.512061978362
9	114.935741503688	246.551355939943
10	114.994643749536	246.57064672978
11	115.023664160115	246.580131198653
12	115.037957547368	246.584797742757
13	115.044996331156	246.587094611552

Table VICluster Heads of FCM for Leukemia Image Initial Random cluster centers C1=86 C2=232

No of Iterations	Cluster Head 1 (C1)	Cluster Head (C2)
1	55.2628584358533	217.610606412288
2	57.6335490728318	220.098893581724
3	58.2904865947913	221.511651498317
4	58.5523687843714	222.137443848914
5	58.6638963977682	222.405108030104
6	58.7115916688018	222.518982993066
7	58.731938436305	222.567397735448
8	58.7406031065328	222.587981430016
9	58.7442897652545	222.596733033372

6 Conclusion

The effectiveness of the proposed framework is compared and evaluated by applying the thresholding and clustering techniques on blood microscope image and matlab peppers images. Based on the image measures and elapsed time FCM is performing well in segmenting the images than the Otsu thresholding by showing high PSNR and low MSE values. Considering the elapsed time, Otsu technique is performing the image segmentation in a reduced time than the FCM. Because of the delayed convergence rate the numbers of iterations are subsequently increased which leads to increase in the elapsed time of the segmentation process. To reduce the number of iterations and to obtain faster convergence rate, the method can be hybridised with any effective optimal algorithm such as Particle Swarm Optimization (PSO) which may automatically useful in improving the elapsed time.

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