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Quadtree Algorithm for Improving Fuzzy C-Means Method in Image Segmentation

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1.Abstract

Image segmentation is an essential processing step for much image application and there are a large number of segmentation techniques. A new algorithm for image segmentation called Quad tree fuzzy c-means (QFCM) is presented I this work. The key idea in our approach is a Quad tree function combined with fuzzy c-means algorithm. In this article we also discuss the advantages and disadvantages of other image segmenting methods like: k-means, c-means, and blocked fuzzy c-means. Different experimental results on several images in this article show that the proposed method significantly increases the accuracy and speed of image segmentation.

Keyword: *Image Segmentation; Fuzzy Clustering; Quadtree; C-means, K-means*

2. Introduction In today's world, image segmentation has a special effect in image processing. Therefore, it is accounted as one of the primary steps enhancing the image analysis. Image segmentation is defined as a process in which the image is separated into discrete parts. These segments have some properties such as color intensity, etc. in common. There are numerous image segmentation techniques such as Classifier, Clustering Region Growing, Thresholding, Deformable Models, Neural Network-Based Approaches, MRF Model-Based Approaches [1-3].Image segmentation techniques are divided into two major groups of Histogram Based techniques, and clustering based techniques. In Histogram Based methods, efforts are made to find an appropriate threshold level. Threshold is applied when an image has various measurable characteristics (2, 4, 5). In fact the threshold is accounted as a kind of border. For instance, in image binarization the values lower than the defined threshold are equal to zero (black) and the larger values would be equal to one (white). On other hand, Clustering methods, classify the data in some clusters which result in data separation. K-means and C-means are considered as the most important among clustering based methods

3.Materials and Methods

3.1 K-Means Algorithms

The object of this article to discuss different methods of image segmentation methods. Particularly, it focuses K-means, C-means ,blocked Fcm methods . We also and we also propose a new algorithm for image segmentation.

K-means is one of the simplest methods among clustering techniques in which an uncomplicated process is used for clustering the data. Any sample in this method, is dependent to one and only one cluster and could not be a member of any other cluster. In order to segment an image into k parts in the current algorithm, firstly an arbitrary initial value is attributed to cluster centers. The second step is to evaluate the distance of any pixel from the cluster center. Each pixel would then be considered as a member of the cluster which it has the minimum distance from. Euclidean distance is used in order to calculate the pixel distance from the cluster centers [1,6,7] .

$$d_{ik} = \left| x_i - \sim_k \right| \quad (1)$$

In the above equation d_{ik} is Euclidean distance, where x_i is ith pixel and α_k is the center of the kth cluster. K-means is a repetitive algorithm. In this method, the distances from cluster centers are compared to each other. This distance must always be smaller than the minor value of ε (1).

$$\varepsilon\ (1): \left| \sim^{p} - \sim^{p-1} \right| < £ \quad (2)$$

Where α^p is center of pth cluster and α^{p-1} is center of (p-1)th cluster. Satisfying this condition is equivalent to minimizing the following relationship. This relationship defines the amount of error in pixel assignment (S is represents the whole pixels of image).

$$error = \sum_{k=1}^{k} \sum_{i \in s} \left| x_i - \sim_k \right| \quad . (3)$$

3.2 C-Means Algorithm

C-means is one of the most significant and useful algorithms among clustering techniques. Data are divided into c individual clusters in this algorithm. The amount c is pre-defined. The membership possibility of any pixel in each cluster is evaluated. After segmentation each pixel would be assigned to the cluster with maximum membership possibility. Similar to k-means, the main objective of this algorithm is to minimize the error function during image segmentation process. In fuzzy state, error function is defined as follows [1, 8].

$$error = \sum_{k=1}^{K} \sum_{i=1}^{M.N} \left| u_{ik}^{m} d_{ik}^{2} \right| = \sum_{k=1}^{K} \sum_{i=1}^{M.N} u_{ik}^{m} \left\| x_i - \sim_k \right\| \qquad (4)$$

Where indicates the membership possibility of ith pixel in kth cluster, and is the distance of ith pixel from cluster center. M.N shows the total number of pixels in the image. In the above relationship, m parameter is the fuzzy coefficient as a real number is larger than one. Regarding that is a possibility function; the following condition should always be satisfied.

$$\sum_{k=1}^{k} u_k = 1 \qquad i = 1, 2, \ldots . m .n \qquad (5)$$

3.3 Blocked-FCM Method (BFCM)

Since c-means involves the entire pixels of an image in various steps of segmentation, running the algorithm requires continual calculation of M.N.K in possibility function formula (k is the number of classes). This causes the runtime of the algorithm to get long. In order to reduce the runtime of the fuzzy algorithm blocked FCM method would be an appropriate choice. Initially the image is segmented into square blocks in b×b dimensions (these blocks may have various dimensions of 2×2, 3×3 or larger). Instead of using the light intensity of each block, it is possible to utilize the average intensity and standard deviation of blocks for segmentation. These two statistical characteristics increase the similarity of the pixels in a cluster. Running this algorithm, the part of the possibility function would be calculated. In the next step, the average values of the pixels in each block are given to the FCM function as the input matrix. The blocks would then be sub classified considering the pre-defined clusters[1] .

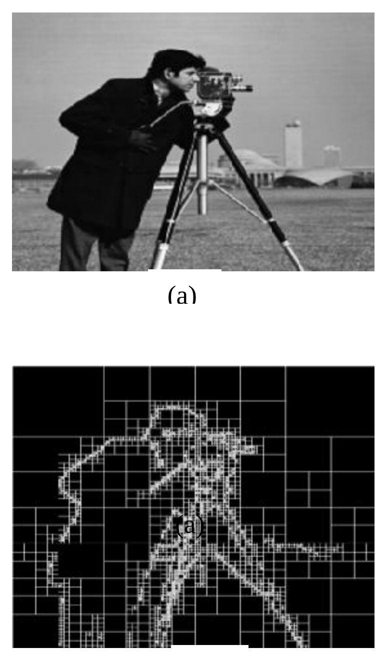
Although blocked-FCM increases the runtime of the algorithm, the error arises from segmenting the entire pixels of a block in a single cluster. Therefore, this method would have inaccuracy in segmentation of border areas, where each block belongs to two separate clusters but is classified in one cluster during.

3.4 Our Proposed QFCM Algorithm

The first step of Quadtree function is to divide the image into four pieces. Then each one of the blocks are again divided into four another and this procedure goes on until the smallest block in size is created, which is then considered as one pixel of the image [8,9].

This function has the ability to divide the picture into different size blocks. The size could vary as in: 1, 2, 4, 8, 16, 32, 64, 128, 256, and 512. Furthermore, the quadtree is a thresholding function in which the sensitivity for creating borders and edges of the image varies with the chosen value. (1, 9, 10)

Quadtree fuzzy c-means method is presented in this article. Quad tree function is able to segment images in various sized blocks.(9, 10) So that the image would be segmented to large blocks in low resolution areas and inversely with small blocks in high resolution areas (figure 2) as in blocked-FCM, rather than using the light intensity of each pixel, the average light intensity of image blocks is used as the input matrix of FCM function.



(a)

(b)

Figure 2: Segmenting an image with Quad tree function 1
(a)original image,(b) segmented image with quad tree function

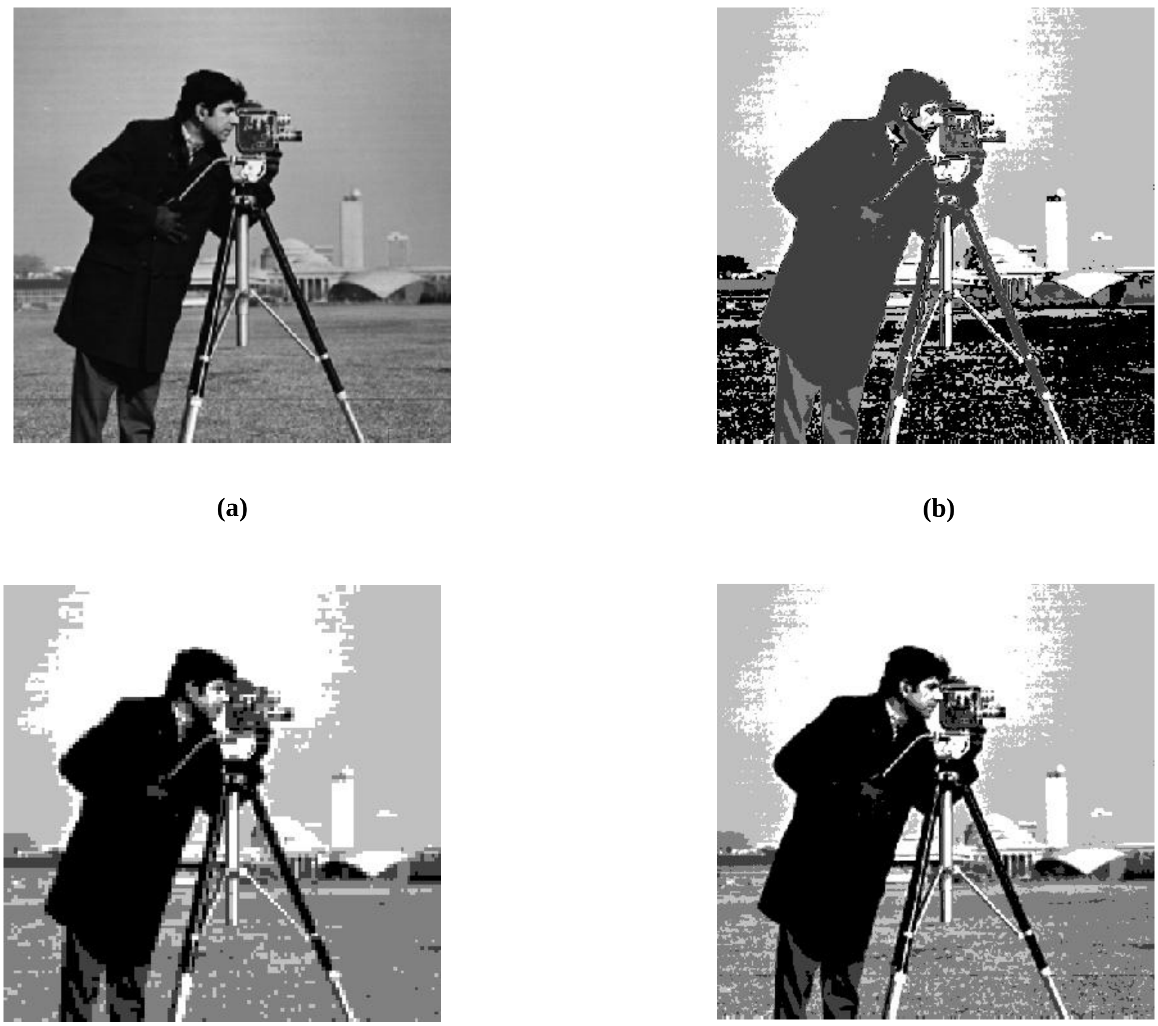
4.RESUL

Using this method not only able to increase the segmentation precision but also enhances the runtime of fuzzy algorithm using quad tree concept. As a result the calculations of this function would decrease. So as to evaluate the suggested algorithm and compare it with FCM and BFCM methods, various experiments are done on reference images which are usually utilized for evaluation of image processing techniques [reprinted from (11)].

The result of implementing such algorithms on a sample image is represented in Figure 3 .As observed, the required implementation times for QFCM algorithm is less than BFCM and FCM that indicates the increase on the speed of c-means.

It is obvious that in order to establish an appropriate sub classification, the pixels in a cluster should be as close as possible to each other and also the clusters should have the same statistical characteristics.

For this purpose, Table 1 is designed to present some statistical characteristics such as mean, variance and standard deviation for each cluster. The less the characteristic value is, the more similarities would exist among the pixels in a cluster.



(a) (b) (c) (d)

Figure 3: (a) The original image, (b) Result of FCM technique on the image, (c) Result of BFCM technique on the image, and (d) Result of QFCM Technique on the Image

approved methods by eyesight. Different clusters based on statically data in table (, it is possible to compare the performance of different methods.

According to this figure, it may be difficult to confirm advantage of proposed method compared the other

Table I. Comparison of Algorithms FCM, BFCM With the Proposed Algorithm QFCM. M,VAR, and C Represent Average, Variance, and Standard Deviation, Respectively

Method	Interaction Count	The Parameter Comparison	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
FCM	**100**	M	14.4092	65.8252	120.3065	179.5905	156.2158
		VAR	47.6706	263.5830	136.9021	143.8173	64.2382
		C, %	47.9165	24.6641	9.7255	6.6776	5.1306
BFCM	**87**	M	13.2087	64.6235	118.0105	178.3021	155.0183
		VAR	46.2034	262.1309	135.4063	142. 4073	63.1385
		C, %	51.4608	25.0535	9.8605	6.6927	5.1258
QFCM	**69**	M	15.0192	66.0352	121.6865	180.1704	157.1021
		VAR	47.9077	263.8840	137.0281	143.9843	64.7385
		C, %	46.0846	24.5997	9.6197	6.6599	5.1215

5. CONCLUSION

This article aims to improve the function of fuzzy c-means algorithm in precision and speed using the quad tree concept. To meet this objective, average block intensity is applied instead of each pixel's intensity. QFCM method divides the image into small blocks in border areas; the classification error in such areas would be much less than BFCM algorithm. The results arised from implementation of this algorithm would be shown on some standard images.

References

[1] F.Yang and T.Jiang , " Pixon-based Image Segmentation with Markov Random Fields" , IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 12, NO. 12, DECEMBER 2003

[2] N. Bonnet, J. Cutrona and M. Herbin. "A 'no-threshold' histogram-based image segmentation method" Pattern Recognition, Vol. 35, (2002), 2319-2322.

[3] G. P. Papamichail and D. P. Papamichail , "The k-means range algorithm for personalized data clustering in e-commerce ",European Journal .

[4] B. Ma and H. S . Wong. "2D clustering based discriminant analysis for 3D head model classification ",Pattern Recognition, Vol 39, (March 2006), 491-494.

[5] S. Chuai-aree, C. Lursinsap, P. Sophatsathit, and S.Siripant, "Fuzzy C-Mean: A Statistical Feature Classification of Text and Image Segmentation Method" International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, Vol. 9, (2001), 661-67.

[6] K. Chuang, H. Tzeng, S.Chen, J. Wu and T. Chen, "Fuzzy c-means clustering with spatial information for image segmentation" ,Computerized Medical Imaging and Graphics, Vol 30, (Jan 2006), 9-15.

[7] H. Hassanpour, E. Nadernejad, and H. Miar "Image Enhancement Using Diffusion Equations", International Symposium on Signal Processing and its Applications (ISSPA 2007), Sharjah, UAE,2007.

[8] J. H. Park , G. S. Lee and S.Y. Park "Color image segmentation using adaptive mean shift and statistical model-based methods" Computers and Mathematics with Applications , vol.57, (2009) 970_980.

[9] G. M. Hunter , k.Steiglitz , " Operation on Images Using Quad Tree" IEEE Transactions on Pattern Analysis and Machine Intelligence , Vol.PAMI-1,No.2,April1979

[10] J. R. Smith and S. F. Chang, "Quad-Tree Segmentation For Texture-Based Image Query" ACM 2nd International Conference on Multimedia, Oct. 1994, San Franciso, CA.
[11] DIPimage Databases. 2012 [updated 2012; cited]; Available from: http://imageprocessingplace.com/DIP/dip_image_dabases/image_databases.htm.