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An Edge Exposure using Caliber Fuzzy C-means With Canny Algorithm

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Abstract

Edge exposure or edge detection is an important and classical study of the medical field and computer vision. Caliber Fuzzy C-means (CFCM) clustering Algorithm for edge detection depends on the selection of initial cluster center value. This endeavor to put in order a collection of pixels into a cluster, such that a pixel within the cluster must be more comparable to every other pixel. Using CFCM techniques first cluster the BSDS image, next the clustered image is given as an input to the basic canny edge detection algorithm. The application of new parameters with fewer operations for CFCM is fruitful. According to the calculation, a result acquired by using CFCM clustering function divides the image into four clusters in common. The proposed method is evidently robust into the modification of fuzzy c-means and canny algorithm. The convergence of this algorithm is very speedy compare to the entire edge detection algorithms. The consequences of this proposed algorithm make enhanced edge detection and better result than any other traditional image edge detection techniques.

Keywords: Fuzzy C-means clustering, image segmentation, canny edge detection, Self-Organized Map

1. Introduction

The purpose of edge exposure is for Object Detection. There are numerous edge detection algorithms available to compute the segregation of boundaries in an image. There are three fundamental types of discontinuities in an image, which are points, lines and edges. Edges portray object boundaries and their useful features for segmentation. Edge detection is used to extract salient features of an image. There are some applications of edge detection in real life, which are:

a) Face detection–nowadays this is used in social media apps for example Facebook.
b) People Counting-it is brought into play in analyzing store performance during carnivals.
c) Vehicle detection-used to detect a type of ship entering a port or tracking the speed of a car.
d) Security-used to recognize anomalies in a bomb explosive.

Edge detection of an image is carried out using gradient and Laplacian operation. The boundary is represented by its length and regularity. The boundary descriptor is classified into Fourier descriptor and polynomial approximation methods. Both methods are used in clustering. Clustering is a subdivision of unsupervised learning processes [1]. It is a method for classifying data in an image and to find clusters with the most likeness in the identical cluster and most unlikeness among diverse clusters [2].

Segmentation by clustering is done by three steps which are:-the initial step is to define the color features; the second step is to transform the pixels into color feature space and finally cluster the pixels in color feature space. Fuzzy logic provides a technique to make official reasoning. The coding of input image data is called as fuzzification. The decoding of the output image is known as defuzzification in fuzzy techniques. The modification of membership values is the important step in fuzzy clustering. Fuzzy set declares gradation of all tones in between black and white. Fuzzy sets deal with graduality of concepts and fuzzy membership functions (See Figure 1).
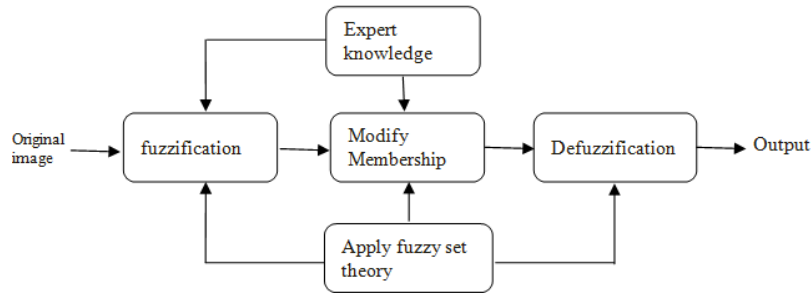
Figure 1. Fuzzy clustering

Fuzzy clustering techniques have a feature of the fuzzy set theory. In image segmentation, Fuzzy C-Means (FCM) technique is one of the generally applied techniques. FCM algorithm is an extension of the k-means clustering technique with a fuzzy set. The selection of a particular technique will depend on which type of output is desired and how much performance, the process required. FCM has been used in medicine imaging and pattern recognition. This paper is planned as follows:-In division 1.1, the FCM is analyzed and the parameter selections are talked about. In division 2, a comprehensive debate of proposed algorithm is presented. This confers the strong properties of cluster algorithm. In division 3, the final outcome of the proposed system is listed out.

1.1. Related Works

Clustering performs dividing pixel points into homogeneous clusters, in which the pixels in the same class are related and the pixels in different classes are unrelated. In various steps clustering is performed:-1) Feature selection or extraction is done using the input image and the result is a pattern representation. 2) This pattern is given as input for inter-pattern similarity operation and the output is given to grouping operation. The final result is a clustered image.

This section discusses the influence of Fuzzy C-means on edge exposure in image processing. Boon-Seng Chew et al. [3] built a fuzzy clustering algorithm which uses the data resemblance within the framework structure of a virtual character (VC) model and is together considered with the temporal coherence in the movement data. Jaferzadeh, K. et al. [4] explained the domain and range blocks categorized by a fuzzy c-mean-clustering method and compared with the use discrete cosine transform coefficient.

Evans A. N et al. [5] proposed a new color edge detector based on vector dissimilarity and its performance get better in the presence of noise. S.Krinidis et al. [6] proposed algorithm that incorporates the local spatial details and gray level details in a new fuzzy method and which uses a fuzzy local similarity measure and planned to guarantee noise insensitiveness, information preservation. To calculate the color difference properly, the digital picture colors are symbolized in a modified L*u*v color space [7], the color reduction is expected into a set of models using self-organizing map (SOM) learning. The weighted fuzzy factor uses the space distance of all adjacent pixels and their gray-level dissimilarity simultaneously. By using this issue in [8], the new method can accurately calculate the damping amount of adjacent pixels.

Fuzzy Conditional Clustering based Modeling method [9], which produces fuzzy rules repeatedly using the conditional Fuzzy C-Means algorithm, and it proposes the use of a new approach for attributes grouping on the context definition step, using heuristic search based on the best recital. Dziuk, M.A. et al.[10] implemented the fuzzy logic control for autopilots which is attained by two sets of fuzzy rules, one for controlling the transformation in heading and the other for scheming the revolutionize in elevation in the aircraft. The basic thoughts of fuzzy set and the theories of fuzzy C-mean clustering technique are discussed in [11]. The Fuzzy C-Mean algorithm was used to cluster data first, then the Fuzzy Inference System had been created based on these clusters by various rules, maximum numbers of inputs and flooded hydraulic conductivity as a result in [12]. Kiani, S. et al. [13] proposed a method which uses a special type of fractal coding. Its constraints are contrasted scaling and the average range of block. Also, it employs the fuzzy C-mean clustering to talk to the watermark bits. Medical imaging technique included fuzzy C-means (FCM) tissue classification and image acquirement has been begun as

a feasible approach for edge detection of the bone from soft tissue [14-15]. The Generalized Fuzzy C-Means deals with the deviation of FCM algorithms and can effortlessly lead to innovative and stimulating clustering algorithms [16]. Alternative Fuzzy C-Means are used in cluster analysis which replaces the Euclidean model [17].

1.1.1. Fuzzy C-Means
Fuzzy C-means is the extension of K-means. Fuzzy C-means allows pixels points to be assigned to multiple clusters and each pixel point has a degree of membership in a cluster to which it belongs. This algorithm uses membership function and cluster center values which are updated iteratively. The FCM involves following steps:
1. Consider M X N dimensional pixels represented by xi.
2. Suppose the number of clusters C, where 2≤ C ≤ N.
3. Select the level of cluster fuzziness f > 1
4. Set the Initial value for membership matrix U.
5. Compute the fuzzy centroid for j=1,.., C.

$$c_j = \frac{\sum_{i=1}^{n} (u_{ij})^m x_i}{\sum_{i=1}^{n} (u_{ij})^m}$$

where m is the fuzzy parameter and n is the number of pixel points.
6. Determine the Euclidean distance between pixel and cluster centroid.
7. Modify the fuzzy membership matrix U.
Repeat the steps 5 to 7 until the cutoff membership is obtained.

1.1.2. Parameters of FCM
The Fuzzy C-means looks to be very simple and easy to understand but it consists of various parameters or factors, which affect the efficiency of this algorithm. The factors, which cause serious damage to this algorithm, are followed:
a. The assumption of starting cluster centroid: the efficiency of FCM full and fully depends on this factor, the centroid value selection must be nearer to the ending centroid value. If it is a good center value, then it is converged speedily and performance time will be very less.
b. The number of clusters C: the next important parameter is cluster number, which decides the key steps in fuzzy c-means algorithm. Usually, the number ranges from 2 to amount of pixels in an image. The selection of cluster number produces a different result for a different number of clusters.
Fuzzy parameter m: this fuzzy parameter m presents in fuzzy membership matrix U. By default, m value must be greater than one and also it is a real number.

2. Caliber Fuzzy C-Means (CFCM)
2.1. Fuzzy C-means clustering with Modification
This paper projected a simple but a very well-organized Fuzzy C-means and canny edge detection algorithm which convey the views of digital image processing. Compare to all fuzzy clustering methods, the fuzzy c-means (FCM) algorithm is the most famous technique, since it has the benefit of robustness for vagueness and maintains a great deal of information than every hard clustering technique. It is extensively used and concerned in image segmentation and image clustering. The Caliber fuzzy c-means consist of various modifications in traditional fuzzy C-means which are as follows:
 a) The number of cluster selection is done using Self-Organized Map (SOM) in neural network concept.
 b) The starting cluster centroid value is fixed using the procedure: select centroid from n-pixels in such a way that the Correlation distance of that pixel is high from other pixels Equation (1).
 c) Fuzzy parameter m selection is done using the random selection method which takes the value in the range 1.5 to 2.5. If the maximum value of the fuzzifier m is outside the upper boundary value, then the unwanted noise information is included in the resultant image.

The SOM uses the training which exploits competitive learning is a feed forward network. This SOM calculates the Euclidean distance all weight vectors. Neurons weight vector is similar to the input value which is identified as the best matching unit. This unit is used to find out the cluster count of this proposed algorithm.

$$\mathbf{W}(s+1)=\mathbf{W}(s)+\Theta(u, v, s)\alpha(s)(\mathbf{D}(t)-\mathbf{W}(s))$$

In the above formula, W is weight vector, D(t) is the original input vector, Θ(u, v, s) is the neighborhood function, 's' is step index, 'u' is index of best matching unit for D(t), 't' is index into the training sample and α(s) is a learning coefficient.

There are various distance calculation formulas are available such as Euclidean distance, Manhattan distance, Minkowski distance, and Correlation distance. Among all, the correlation distance is selected for initial centroid value setting process because of its efficiency.

The correlation distance r_{xy} is calculated using the formula Equation (1)

$$r_{xy} = \frac{Cov(X,Y)}{\sqrt{(Var(X) \cdot Var(Y))}} \tag{1}$$

where X and Y are the pixel value, Cov(X,Y) means covariance of X and Y, Var(X) represents the variance of X and Var(Y) represents the variance of Y. The covariance and variance formulas are listed below Equation (2) to (4):

$$Cov(X,Y) = \frac{\sum_{i=1}^{m}(x_i - \overline{X})(y_i - \overline{Y})}{m-1} \tag{2}$$

$$Var(X) = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{X})^2}{n-1}} \tag{3}$$

$$Var(Y) = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \overline{Y})^2}{n-1}} \tag{4}$$

(a)   (b)

Figure 2. (a) Original image (b) clustered image

The above-clustered image is derived after applying Caliber Fuzzy C-means (CFCM) to the original image (See Figures. 2). The progress of next step is shown in the next division.

2.2. Canny Edge Detection
The Canny edge detector is a good detection and good localization operator. The high-quality detection means optimal detector diminish the probability of false positives and false negatives. The high-quality localization means the edges detected are close to the true edges. Canny edge detector satisfies Single Response Constraint and returns one point only for every edge point. Also, this has the features such as Convolution (Smoothing) with a derivative of Gaussian, Non-maximum Suppression, and Hysteresis Thresholding.
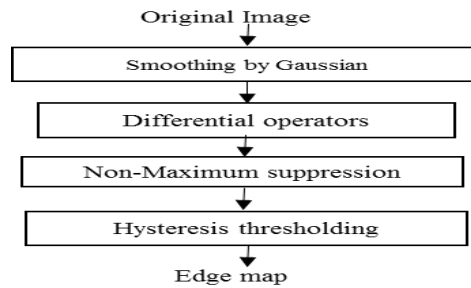
Figure 3. Canny Edge detection steps

In Canny edge detection, the first step is to destroy noise by edge smoothing using the Gaussian. If the mask is oversized, then some edges information will be lost. The second step is a directional transformation in the intensity of a digital image. The third step is used to make a thin edge. Also, non-maximum suppression helped to suppress entire gradient values to zero except sharpest intensity value. The last step is used to create connected-component. That is hysteresis thresholding complete the edges (Figure 3). The basic canny edge detection operation is performed by using the above-clustered image (Figure 2) which is derived by using Caliber fuzzy c-means clustering algorithm. After applying canny edge detection, the resultant image is an edge detected image. In Figure 4, without clustering image is derived by applying canny edge detector to the original image and with clustering image derived by applying canny edge detector to a caliber fuzzy c-means clustered image.

(a)   (b)
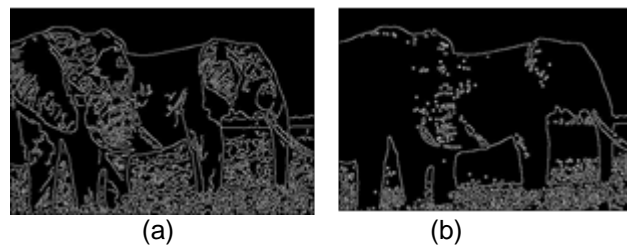
Figures 4. (a) Without Clustering (b) with Clustering

3. Experiment and Results
This division illustrates the details about the experiments conducted using proposed algorithm. The proposed algorithm is implemented on the MatlabR2012b with the Berkeley Segmentation Dataset (BSDS) image. BSDS consists of 100 test images and 200 training images which are used for this proposed work. For all experiments, the maximum amount of iterations is set to 50, the termination condition is 0.0001 (Figure 5). The experiment results are visualized one.
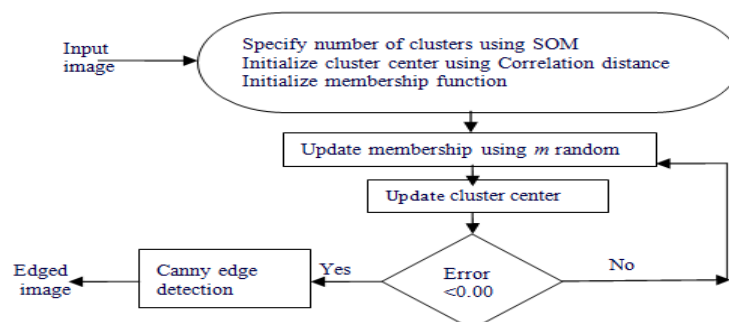

Figure 5. Functional diagrams for a proposed method

(i)   (ii)   (iii)   (iv)
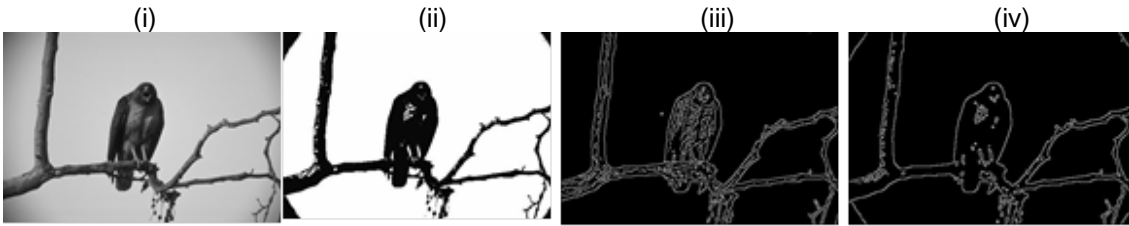
Figure 6. -Plane (3096)

(i)   (ii)   (iii)   (iv)

Figure 7. -Eagle (42049)

(i)   (ii)   (iii)   (iv)
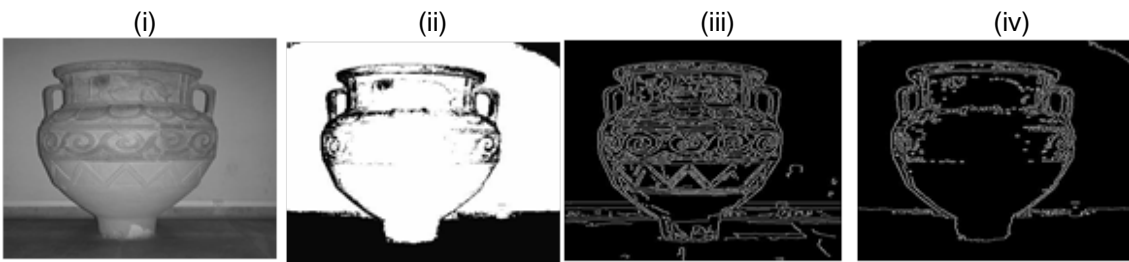
Figure 8.-Vessel (227092)

(i)   (ii)   (iii)   (iv)

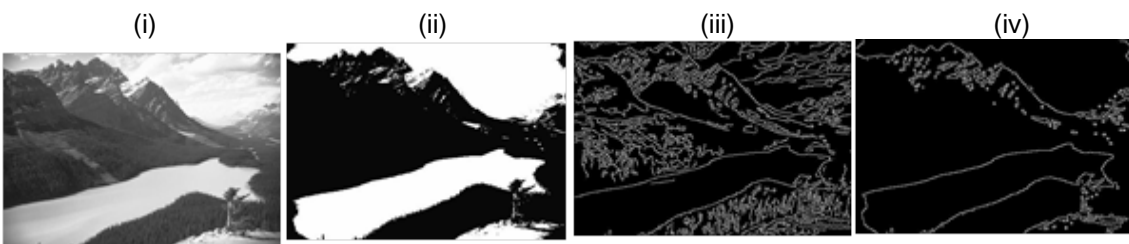Figure 9.-Human (189080)

(i)   (ii)   (iii)   (iv)

Figure 10. Nature (176035)

Edge detection: (i) Input image, (ii) Caliber Fuzzy C-means Clustered image, (iii) Canny image, (iv) Both Caliber Fuzzy C-means Clustering and Canny

Some sample outputs generated by this technique are shown above (Figure 6-10). By seeing that, anyone can understand an over edge detected is avoided in proposed algorithm. Compare to canny algorithm, the proposed algorithm detects fewer edges.

The performance evaluation is done using PSNR and MSE. The peak signal to noise ratio (PSNR) is the proportion between the maximum possible value of a pixel and the influence of altering noise that changes the value of its representation. It is usually measured in terms of the logarithmic decibel scale. The mean squared error (MSE) is used to evaluate the performance of a predictor.

Even though experiment result is the visual one, here MSE and PSNR values for the proposed algorithm are listed in Table 1. PSNR and MSE value of proposed method are significantly better than traditional canny and Log algorithms. And also the comparison results for traditional canny and log algorithms are listed below (Table 2 and Figure 11).

Table 1. Proposed Algorithm Result Comparison

Image	PSNR	MSE	Time
Plane	66.305	0.02	24.554
Eagle	62.9578	0.03	13.915
Vessel	61.521	0.05	234.24
Human	63.0686	0.03	15.334
Nature	62.6492	0.04	11.731
Elephant	59.7611	0.07	17.269

Table 2. Comparison with Canny and Log Result

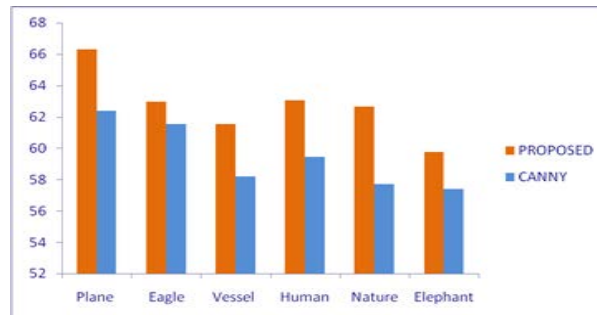| Edge Detection comparison with other Techniques				
Image	Canny		Log	
	PSNR	MSE	PSNR	MSE
Plane	62.364	0.04	65.7959	0.02
Eagle	61.5277	0.05	62.661	0.04
Vessel	58.2106	0.10	59.4014	0.08
Human	59.423	0.07	61.795	0.04
Nature	57.6902	0.11	60.3688	0.06
Elephant	57.385	0.12	59.489	0.07

Figure 11. PSNR value

The cluster centroid value estimation is based on correlation distance calculation, and that value converges to the fixed point until the error value is less than 0.0001. The below table denotes the convergence of cluster centroid values during iteration and finally it reached saturation point. The cluster centroid value convergence is listed out in Table 3 and the number of clusters changes that affected the PSNR value is shown in Figure 12.

Table 3. Proposed Algorithm Cluster Centroid Result Convergence

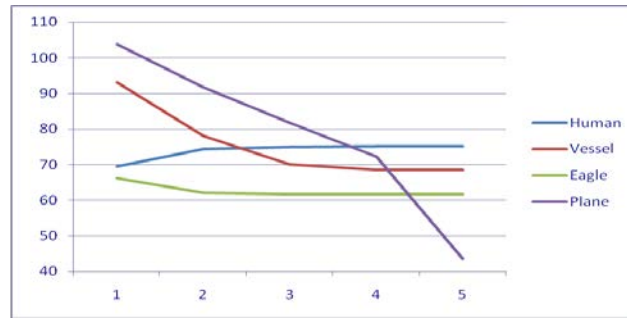| Image	Cluster centroid value variation in every iteration				
Plane	103.871	91.6634	81.8104	72.2520	43.5809
Eagle	66.2412	62.1441	61.7362	61.6949	61.6917
Vessel	93.0232	78.0792	70.1599	68.5935	68.5896
Human	69.4017	74.3634	75.0307	75.1312	75.1345
Nature	67.3549	70.2766	70.3861	70.4128	70.4194
Elephant	73.6764	69.9866	68.2896	67.9683	67.9403

Figure 12. Number of Cluster versus PSNR value

In edge exposure, precision is used to retrieve the pixels that are related Equation (5). The Recall is the relevant pixels that are retrieved Equation (6). A calculation that merges precision and recall are known as an F-measure Equation (7).

$$\text{Precision} = \frac{True\ positive}{True\ positive + False\ positive} \tag{5}$$

$$\text{Recall} = \frac{True\ positive}{True\ positive + False\ negative} \tag{6}$$

$$\text{F measure} = \frac{2*Precision*Recall}{Precision + Recall} \tag{7}$$

Precision, recall and F-measure are used to measure the performance of understanding in an image based on color value. For a sample of three images, performances are listed below in Table 4. Precision versus recall graphical representation for various algorithms is shown in Figure 13.

Table 4. Performance (Precision, Recall, and F-measure) for Proposed and Sobel Algorithm

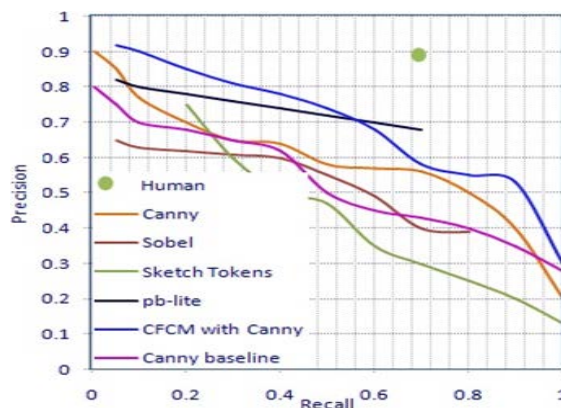| ID	Method	Precision	Recall	F-measure
Eagle	Proposed	0.2545	0.40246	0.47
	Sobel	0.2497	0.29625	0.46
Human	Proposed	0.1134	0.17285	0.28
	Sobel	0.3038	0.29487	0.50
Nature	Proposed	0.1252	0.17761	0.23
	Sobel	0.4743	0.48740	0.20

Figure 13. Precision versus recall

For this experiment totally 100 BSDS images were selected which were based on their segments and color counts. In each and every category, two images were taken for experiment purpose. Those results are shown in Table 5.

Table 5. Performance on 100 BSDS Tests Images for Proposed Method

Method	Precision	Recall	F-measure
Proposed	0.1734 ± 0.002	0.3761 ± 0.0015	0.2418 ± 0.00155
Sobel	0.1736	0.3576	0.2337

4. Conclusion

The proposed unique edge exposure approach in BSDS images using Caliber Fuzzy c-means with canny algorithm can make up the component of soft computing which are appropriate for gripping the issues related to the understandability of information. It can provide approximate solutions faster than any other methods. Berkeley data sets were used to compare the performance of traditional and the proposed algorithms. Experimental results show that the computation cost is reduced and got better performance by discovering a superior set of early cluster centers. In this paper, Caliber fuzzy c-means algorithms were measured up within the context of color quantization. In future, the noise will be added in images boundary and will be further analyzed.

References

[1] Li Zhengzhou, Liu Mei, Wang Huigai, Yang Yang, Chen Jin, Jin Gang. Gray-scale Edge Detection and Image Segmentation Algorithm Based on Mean Shift. *TELKOMNIKA*. 2013; 11(3): 1414-1421.

[2] Xiao Feng, Guo Li, Guo Lina. A New Sub-pixel Edge Detection Method of Color Images. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2014; 12(5): 3609-3615.

[3] Boon-Seng Chew, Chau L-P, Kim-Hui Yap. A Fuzzy Clustering Algorithm for Virtual Character Animation Representation. *IEEE Transactions on Multimedia*. 2011; 13(1): 40-49, DOI: 10.1109/TMM.2010.2082512.

[4] Jaferzadeh K, Kiani K, Mozaffari S. Acceleration of Fractal Image Compression Using Fuzzy Clustering and Discrete-cosine-transform-based Metric. *IET Image Processing*. 2012; 6(7): 1024-1030, DOI: 10.1049/ iet-ipr.2011.0181.

[5] Evans AN, Liu XU. *A Morphologicalgradient Approach to Color Edge Detection*. IEEE Transactions on Image Processing. 2006; 15(6):1454-1463.

[6] Krinidis S, Chatzis V. *A Robust Fuzzy Local Information C-means Clustering Algorithm*. IEEE Trans. Image Processing, May 2010; 19(5):1328-1337.

[7] Dong G, Xie M. Color Clustering and Learning for Image Segmentation.Based on Neural Networks. *IEEE Transactions on Neural Networks*. 2005; 16(40): 925–936.

[8] Maoguo Gong, Yan Liang, Jiao Shi, Wenping Ma, Jingjing Ma. *Fuzzy C-Means Clustering with Local Information and Kernel Metric for Image segmentation*. IEEE Transactions on Image Processing, 2013; 22(2):573-584, DOI: 10.1109/TIP.2012.2219547.

[9] Nogueira TM, de Arruda Camargo H. Fuzzy Rules Generation using Conditional Clustering. Latin America Transactions, *IEEE (Revista IEEE America Latina),* 2009; 7(4): 463-471, DOI: 10.1109/TLA.2009.5349046.

[10] Dziuk MA, Jamshidi M. *Fuzzy Logic Controlled UAV Autopilot Using C-Mean Clustering*. 6th International Conference on System of Systems Engineering (SoSE), 2011; 305–310.

[11] Chen Yu-Mei. Research on the Income of Rural Residents of Sichuan Province Based on Fuzzy C-mean Clustering. FSKD '09. Sixth International Conference on Fuzzy Systems and Knowledge Discovery, 2009; 3: 151-155, DOI: 10.1109/FSKD.2009.235

[12] Taraghi B, Jalali VR. *Fuzzy c-mean (FCM) Clustering and Genetic Algorithm Capability in Predicting Saturated Hydraulic Conductivity*. International Congress on Technology, Communication and Knowledge (ICTCK), 2014; 1-6, DOI: 10.1109/ICTCK.2014.7033521

[13] Kiani S, Moghaddam ME. *Fractal Based Digital Image Watermarking Using Fuzzy C-Mean Clustering*. International Conference on Information Management and Engineering, ICIME '09, 2009; 638-642, DOI: 10.1109/ICIME.2009.72

[14] Mohammad Hadi Aarabi, Anahita Fathi Kazerooni, Parisa Khateri, Mohammad Reza Ay and Hamidreza Saligheh Rad. A Robust MR Based Attenuation Map Generation in short-TE MR images of the Head Employing Hybrid Spatial Fuzzy C-Means Clustering and Intensity in Homogeneity Correction. EJNMMI Physics, 2014; DOI: 10.1186/2197-7364-1-S1-A49.

[15] Quan Wen, M Emre Celebi. Hard Versus Fuzzy C-means clustering for Color Quantization. *EURASIP Journal on Advances in Signal Processing*, 2011: 1-12.DOI: 10.1186/1687-6180-2011-118
[16] Yu J, Yang MS. Optimality Test for Generalized FCM and its Application to Parameter Selection. *IEEE Transactions Fuzzy Systems*. 2005; 13:164–176.
[17] Wu KL, Yang MS. Alternative c-means clustering algorithms. *Pattern Recognition*, 2002; 35: 2267–2278.