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HISTOGRAM AND FUZZY C-MEANS BASED AUTOMATIC THRESHOLD SELECTION FOR EDGE DETECTION PROCESS BASED ON RELATION MATRIX IN COLOR IMAGES

Ferzan Katircioglu[1]
[1]Duzce University, Duzce, Turkey

Borders of objects and shadows in the image, reflections and lighting changes within objects are named as edge. The image features of the pixel with itself and its neighbors, play a significant role in detection of the edges. Automatic threshold edge detection algorithms on the similarity image obtained from color images have been proposed in this study. Firstly, the relation matrix based on the similarity feature between neighbor pixels is utilized and the color image is converted into two-dimensional similarity image. In the second stage, histogram curve and fuzzy c-means method have been employed to obtain the automatic threshold value. Threshold values obtained by virtue of these two methods have been applied to similarity images obtained separately by Linear, Exponential and Gaussian functions. Visual results have been utilized for the performance evaluations of the two algorithms. Thin edges have been created in the histogram-based edge detection algorithm while distinct and thick edges have been created in the fuzzy c-means algorithm. Clear and distinct edges have been created in linear and exponential functions. The results of the other two methods have been achieved in the Gaussian function, through utilization of the low *D* coefficient. The edge detection results are within acceptable measures and have responded to high performance and have the feature of to be applicable to large image types.

Index Terms —Histogram, similarity image, relation matrix, edge detection, fuzzy C-means

I. INTRODUCTION

SHADOW boundaries, reflection and illumination changes in the image are named as edge. The oldest color edge detection applications generally consist of applications parallel to monochrome edge detectors. Robinson has studied on derivative edge detection for color images [1]. The edge operators suggested for the gray level images in the processes subsequent to this study are obtained for color images by the vectorial sums of the individual components' derivatives [2-4]. Machuca [5] and Cumani [6] have employed vector slopes and second derivative operators.

A different application in solution of the edge detection problem of color images is basing on the ordered statistics of the vectors [7]. Morphological edge detector has been inspired in this application. Applications which work in the way of integrating them is followed for determining the maximum and minimum places of the display function and for an edge pixel[8- 9].

An effective edge detector structure which is both correct, computable and learnable has been presented in image paths in fast edge detection structure which is one of the edge detection works carried out recently. A learning framed structure applied to random decision forests has been utilized within the local border mask. Fast real-time performance results are considered as the most important advantage [10]. In another study, Sobel and Interval Type-2 Fuzzy System based edge detection method has been proposed for color images. Color images are applied to this database in as much as foregoing provide more edge information compared to gray level images [11]. The edge detection operator named ACO has realized the fusion of the Hue and PCA components. Comparison with existent techniques has been made through utilization of Pratt's value parameter [12].

Similarity Image based on proposed Relation Matrix, Histogram Based and Fuzzy C-Means Based Edge Detection processes are presented in the second part of this study. In the third part, the algorithms have been applied to the image of the peppers which is commonly used in image processing applications. In the last part, evaluations are made as to the cited method and the applicable features of the edge detection operator are stated.

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Corresponding author: Ferzan Katircioglu (E-mail: ferzankatircioglu@duzce.edu.tr; ORCID® ISNI: 0000-0001-5463-3792).
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II. HISTOGRAM AND FUZZY C-MEANS BASED AUTOMATIC THRESHOLD SELECTIONFOR EDGE DETECTION IN COLOR IMAGES

To realize the edge detection process in the image within the framework of the proposed method has been divided into two parts.

+ To obtain a similarity image based on the relation matrix,
+ To make the Edge Detection process based on Histogram and Fuzzy c-means on the obtained similarity image.

A. Obtaining the Similarity Image based on the Relation Matrix

The similarity image denotes the gray level image obtained by using the color properties of the pixels. First process to be performed is to applying a *3x3* mask on the image. As seen in figure 1 the pixel indicated by P_9 constitutes the center pixel of the mask [13]. By taking the center pixel as basis, the color distances with neighbors is found utilizing "Minkowski metric" in the R_n Euclidean space [14]. In (1) degree of is specified with a conventional approach while $p=1$ is named as function city blocks and $p=2$ is named as the Euclidean distance.

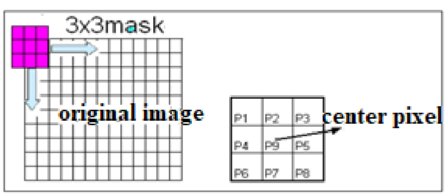


Fig. 1. Place of the mask on the image and location of the center pixel [15]

$$d = \left(\sum_{i=1}^{n} \left| x_i - y_i \right|^{p} \right)^{1/p} \tag{1}$$

Equation (2) is obtained if the distance between two pixels as $P_i(R_i,D_i,B_i)$ and $P_j(R_j,D_j,B_j)$ is applied to the Euclidean distance which is one of the distance methods provided here in above.

$$d_{ij} = \frac{1}{\sqrt{3}} \sqrt{(R_i - R_j)^2 + (G_i - G_j)^2 + (B_i - B_j)^2} \tag{2}$$

The distance approach provided in (2) is applied to the general functions given below and the similarity measurement between all the pixels in the mask are found [15].

$$S(i, j) = 1 - \frac{d_{ij}}{D} \tag{3}$$

$$S(i, j) = \exp\left(\frac{-d_{ij}^{\ 2}}{D^2}\right) \tag{4}$$

$$S(i, j) = \exp\left(\frac{-d_{ij}^{\ 2}}{D^2}\right) \tag{5}$$

The D coefficient in (3), (4) and (5) has been named as the normalization coefficient, and ensures the realization of the similarity value in the range of [0 and 1].

$$\begin{bmatrix} S(1,1) & S(1,2) & . & . & . & S(1,9) \\ S(2,1) & S(2,2) & . & . & . & S(2,9) \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ S(9,1) & S(9,2) & . & . & . & S(9,9) \end{bmatrix} \tag{6}$$

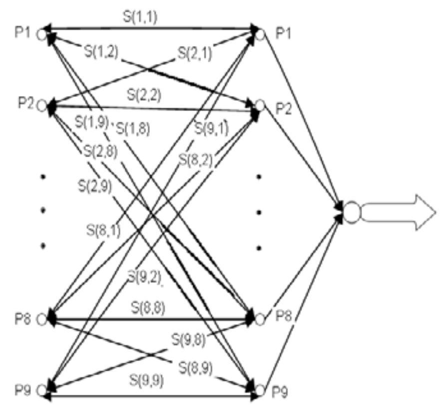


Fig. 2. The similarity network of the pixels in the mask

A mask under the relation matrix is shown in figure 2 while in (6) the similarity value which will be in the similarity image is calculated [15].

$$S_{merkez} = \frac{1}{81} * \sum_{i=1}^{9} \sum_{j=1}^{9} S_{ij} \tag{7}$$

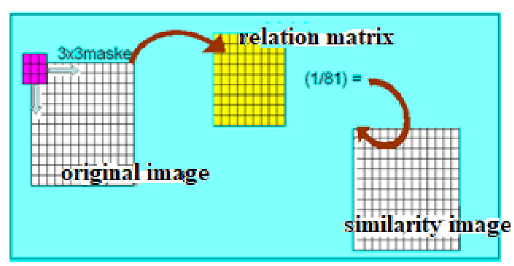


Fig. 3. Obtaining the similarity image [15]

As shown in figure 3, *3x3* mask has been applied on the real image and similarity values have been found by using distance finding between pixel method for the center pixel. *9x9* similarity relation matrix is created for the center pixel, the average value is found and recorded to the relevant pixel value [17].

B. Edge Detection of Automatic Threshold by Histogram Curve

Histogram of an image with [0, L-1] gray level interval is a discrete function and image statistic method gives the pixel number gray level values [18]. The histogram of the similarity image is first obtained in the flow pseudo code of which is provided in algorithm 1. Two peak points are searched in the histogram curve as the third step. One of the most important points here is to pay attention to the degree of proximity between the cited peak points. The threshold value is obtained by taking the average of the gray level values of the two obtained peak points.

$$S_{T,k} = \frac{L(Pik1) + L(Pik2)}{2} \quad (8)$$

Alg. 1. Pseudocode for automatic threshold edge detection by using histogram

Step 1. *Obtain similarity image*
Step 2. *Obtain the histogram of the similarity image*
Step 3. *Find two large peak values on the histogram*

$$\mathbf{S_{T,k}} = \frac{\mathbf{L(Pik1)+L(Pik2)}}{\mathbf{2}}$$

Step 4. *Do Edge Dedection*
if $S_{ij} > S_{T,k}$ **then** ***isnt edge.***
if $S_{ij} \le S_{T,k}$ **then** ***is edge.***

Finally, each pixel of the similarity image has been passed through the $S_{T,k}$ threshold by using the criterion in (9).

If $S_{ij} > S_{T,k}$ *than the pixel isn't edge* (9)
If $S_{ij} \le S_{T,k}$ *than the pixel is edge*

If S_{ij} is smaller than $S_{T,k}$ value it means that it is not similar with its environment. Not being similar, or in other words the existence of sharp changes reveals the edge property.

C. EDGE DETECTION OF AUTOMATIC THRESHOLD BY FUZZY C-MEANS

FCM(Fuzzy c-means algorithm) found by Bezdek and after improved by many different approaches is one of the most popular fuzzy clustering algorithms [19]. The fuzzy c-means algorithm works to minimize the objective function, which is the generalization of the method of least squares.

$$Jm = \sum_{i=1}^{N}\sum_{j=1}^{C} u_{ij}^{m}\|X_i - C_j\|^2 \qquad 1 \le m < \infty \quad (10)$$

In u_{ij}^{m} in (10) *"i"* represents the object while *"j"* represents its membership value of the cluster. $1 \le m < \infty$ value is expressed as fuzziness degree or fuzziness agent in fuzzy clustering algorithm.

In $\|X_i - C_j\|^2$ *"i"* represents the object and *"j"* represents the distance between it and the cluster center, and the Euclidean distance is used. Clustering centers are calculated after the membership values are randomly assigned. Cluster centers are detected according to the (11) below.

$$C_j = \sum_{i=1}^{N} u_{ij}^{m} X_i \Big/ \sum_{i=1}^{N} u_{ij}^{m} \quad (11)$$

The membership value in (12) is compared with the old value from the previous cycle. The process continues until comparison is less than the minimum value ε [20].

$$u_{ij} = \frac{1}{\sum_{k=1}^{C}\left(\frac{\|X_i - C_i\|}{\|X_i - C_k\|}\right)^{2/(m-1)}} \quad (12)$$

Alg. 2. Pseudocode for automatic detection of automatic threshold edge by using FCM

Step 1. *Obtain similarity image*
Step 2. *Run Fuzzy C- Means (FCM)*
Number of clusters = 2; m = 2;
ε = 0.001; iteration = 20;
Find C1 ve C2
Step 3. *Calculate threshold value*

$$\boldsymbol{S_{T,k}} = \frac{\boldsymbol{C1+C2}}{\mathbf{2}}$$

Step 4. *Do Edge Dedection*
if $S_{ij} > S_{T,k}$ **then** ***isnt edge.***
if $S_{ij} \le S_{T,k}$ **then** ***is edge.***

The fuzzy c-means clustering method specified briefly hereinabove has been utilized to separate the similarity image into two separate clusters in the presented study. The average of the centers of two clusters gives the threshold value for edge detection according to the flow provided in algorithm 2.

III. DISCUSSION

Fig. 4. Pepper image which is widely used in literature

The very well-known pepper picture seen in figure 4 has been utilized for image processing for the method used. It is a color image with the size of 256x256. The presented work has been applied in Matlab R 2012b version of the computer with features of Intel (R) Core (TM) i5-4200U CPU 1.60 GHz 2.30 GHz processor, 6 GB RAM and 64 bit Operating System. An interface has been designed in Matlab Gui for Edge Detection process. Firstly *D* value and the function it will work with it is determined in the interface design seen in figure 5 named Edge Detection. Histogram or fuzzy c-means based automatic edge detection process is made on the obtained similarity image depending on the user's wish.

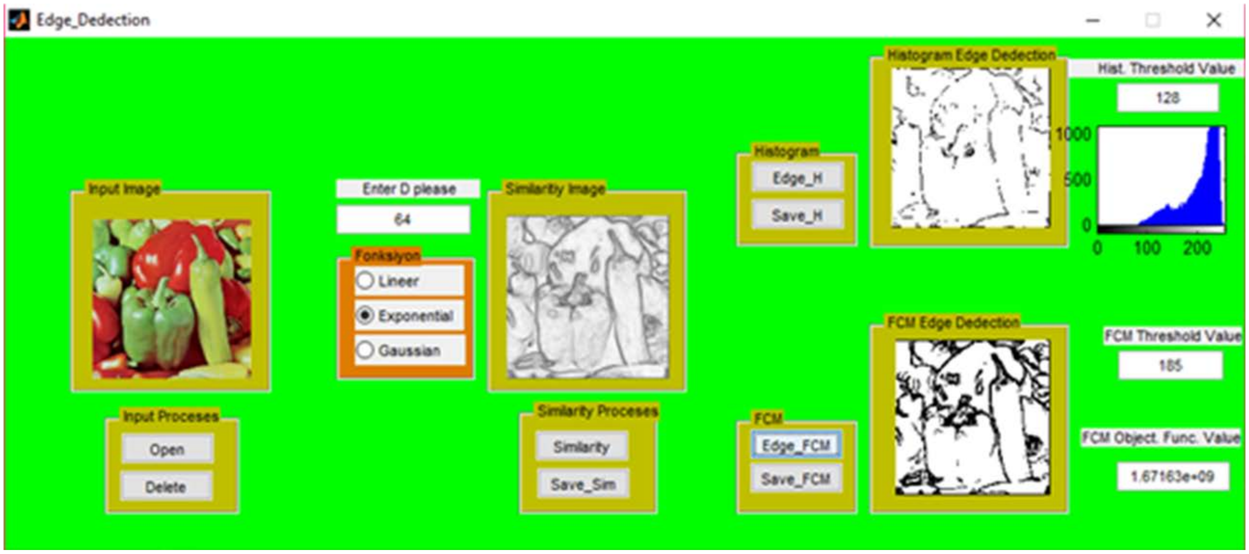


Fig. 5. Edge_Detection interface design

D normalization coefficient value, used to obtain the similarity image, has been selected as 64 for all applications. The thin edges have been created in the histogram-based edge detection algorithm in figure 6. (a), (b) and (c), while distinct and thick edges have been created in the fuzzy c-means algorithm in figure 6 (d), (e) and (f). Fuzzy C-means method is remarkable in achieving the edges, formation of different threshold values, and distinctness of the edges.

Contamination of the similarity image in figure 6 (a) and (d) linear function has been removed in both methods. The most important feature of the exponential function in figure 6 (b) and (e) is that as the distance between pixels becomes larger, the percentage of reduction rate of the similarity takes place with bigger changes. As such, contamination has been reduced and more flattened image has been obtained. The similarity output characteristic of equality in (5) is similar to exponential function. Glossy and clear images were obtained when figure 6 (c) and (f) has been analyzed. However, the disappearance of the image edges, even to a small extent, has occurred.

IV. CONCLUSIONS

The most important feature of the method used is that the color information in the color image is reduced by a one-dimensional smoothing process. Clean and well-defined edges have been formed in the linear and exponential function. If the

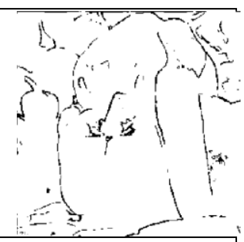
EDGE DETECTION OF AUTOMATIC THRESHOLD BY HISTOGRAM CURVE			
	(a) $S_{T,k}$ =128 Eq. (3)	(b) $S_{T,k}$ =128 Eq. (4)	(c) $S_{T,k}$ =128 Eq. (5)
EDGE DETECTION OF AUTOMATIC THRESHOLD BY FUZZY C-MEANS			
	(d) $S_{T,k}$ =129 Eq. (3)	(e) $S_{T,k}$ =185 Eq. (4)	(f) $S_{T,k}$ =194 Eq. (5)

Figure 6. Automatic edge detection threshold images with histogram curve and fuzzy c-means

edges are thick and there is a contaminated environment, *D* value is increased and finer images can be achieved and if the edges are obscure, *D* value is increased and the correction operation can be done. Selection of high threshold value can be achieved by the use of low *D* coefficient in the Gaussian function. The thin edges have been created in the histogram-based edge detection algorithm while distinct and thick edges have been created in the fuzzy c-means algorithm. The results of edge detection are within acceptable measures and have responded at high performance. They can be applied to wide image types. Furthermore, it is aimed to use the edge detection process via similarity image also in works for image correction and compression by evaluating the feature information again in the original image.

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BIOGRAPHIES

Ferzan Katircioglu was born in Turkey. He received B.Sc. in 1996 at Marmara University, Faculty for Technical Education, M.Sc. in 2007 at A.I.B.U., Institute for Natural Sciences, Department of Electricity Education and Ph.D. at Düzce University, Faculty for Natural Sciences, Department of Electricity-Electronis and Computer Engineering in 2016. He has worked as academic staff in the Control and Automation Technolpogy program at Düzce University, Düzce Vocational High School since 2000. His current research interests are Imagel Processing and Heuristic Optimization.