Image Edge Detection using Fuzzy C-means and Three Directions Image Shift Method

YongSang Ryu, YoungSoo Park, JinSoo Kim, and SangHun Lee

***Abstract*—Edge detection algorithm is wondering why both using a mask. So were analyzed the existing algorithms. As a result, object detection was studied edge detection method without using a mask. First, using clustering, the pre-treatment step was separated into a number of clusters in order to simplify the pixels of image prior to using the proposed method. Second, the simplified moving picture is separated to the left, down, and diagonal directions by measuring the changes from the original image to detect edges. Therefore, edge detection due to similar color is reduced to detect edge features of the object standing out. Edge detection algorithms detect the edge by using a majority mask. For improvement of the paper relating to the edge, and detects the improved results by modifying the weight of the mask. However, the method proposed in this paper is a method for detection without using an edge mask. When compared to 8-directions detected by merging all directions of the edge, it is possible to confirm that the extremely fast 3-directions to speed. And when compared the Mean squared error and Peak Signal-to-noise ratio, it is possible to determine that there is no difference between the two. The proposed method cannot detect texture similar to Contour detection to obtain a favorable edge map in object partition. So there is possibility that power generation in object detection field.**

***Index Terms*— Image Shift, Edge Detection, Sobel, Clustering, Fuzzy C-Means**

I. Introduction

Image processing is a discipline dealing with picture or video. It is a general term for a number of applications and technologies. Image processing is the process of compositing two or more images, repairing damaged image as a mosaic or noise, and converting to image more suitable for a particular application purpose. There are many techniques to zoom in, zoom out, and rotate, such as Euclidean geometric transformations, feature point1, and filtering extraction2. Of different image processing techniques, detecting the edges is a technique for detecting a particular portion of suddenly changed brightness.

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Application of edge detection is the detection of a particular person in CCTV3 and the tracking4 or a license plate recognized or Lasso tool in Photoshop. The edge detection is used for fingerprint identification5 with a particular filter6 in the camera of smartphone. As above, edge detection techniques are frequently used in daily life. Typical methods for edge detection are Sobel algorithm7,8 and Canny algorithm9,10. Sobel algorithm can detect edges in all directions with a strong noise at due to averaging pixel operation. Canny algorithm can detect edges in all directions and it to review the actual edge and It responds in one place. In the proposed algorithm, the entire image is moved and FCM algorithm11,12 is used to separate similar data into a single bundle rather than detecting all edges, whereas a conventional algorithm is an algorithm for edge detection to help object partition.

This paper is organized as follows. Chapter 2 is focused on Canny algorithm and Sobel algorithm as well as features and methods described in the FCM algorithm used in the preprocess step. The clustering algorithm introduces the use of clustering definitions and clustering algorithms. Chapter 3 describes the proposed method and the difference between the initial model and the proposed method. Chapter 4 shows the results from using the proposed method and existing methods at the same time to show the feasibility of this paper through objective evaluation. Finally, Chapter 5 describes the conclusions and future work.

II. Relate Research

A. Existing Edge Detection

Sobel and Canny algorithms are representative methods for detecting part of the edge that changes the brightness of an image sharply. Sobel algorithm uses the mask with the first derivative edge detection method to detect the edge. To use the mask, several rules must be satisfied. First, the size of the horizontal and vertical mask must be the same in two or more odd number. Second, the mask must be vertically and horizontally symmetrical relative to the center pixel. Third, the value of the center pixel is always a positive integer (including zero). Fourth, the sums of all mask pixels are zero. After satisfying the above four conditions, a 3× 3 vertical and horizontal mask and a 5× 5 horizontal and vertical mask were obtained as shown in Figure 1. Using the mask edge, detection is possible in any direction with a strong characteristic to

noise. In addition, compared to size of 5 × 5, 7 × 7 mask edge is thicker and clearer. Amount of calculation is larger according to the size of mask and size of image because the mask applied to each pixel.

1	2	1
0	0	0
-1	-2	-1

(a) **3 × 3** verticality Sobel Mask,

-1	0	1
-2	0	2
-1	0	1

(b) **3 × 3** horizontality Sobel Mask

1	4	6	4	1
2	8	12	8	2
0	0	0	0	0
-2	-8	-12	-8	-2
-1	-4	-6	-4	-1

(c) **5 × 5** verticality Sobel Mask

1	2	0	-2	-1
4	8	0	-8	-4
6	12	0	-12	-6
4	8	0	-8	-4
1	2	0	-2	-1

(d) **5 × 5** horizontality Sobel Mask

Fig. 1.Sobel Mask,
(a) **3 × 3** verticality Sobel Mask, (b) **3 × 3** horizontality Sobel Mask,
(c) **5 × 5** verticality Sobel Mask, (d) **5 × 5** horizontality Sobel Mask

Canny edge detection algorithm uses the second derivative because the first derivative reacts to a small fraction of change in pixel data for detecting relatively thick edge. The second order derivative is used to differentiate the result of the primary differential portion of the change in the pixel data. The order of the canny algorithm is as follows.

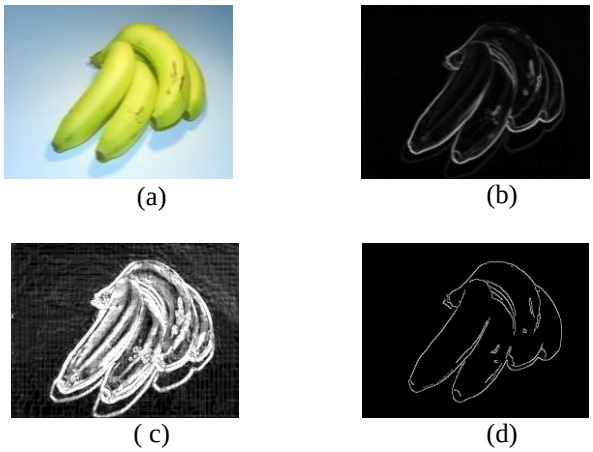
Step 1: Use filter because weaker noise can lower the probability of false detection.

Step 2: Use Sobel It to detect the edge with the first derivative Sobel algorithm.

Step 3: Use Non-Maximum Suppression to determine the edge by comparing the equation of gradient direction.

Step 4: It uses hysteresis using a high threshold and low threshold. If less than the low threshold is initialized to 0, greater than the high threshold 255 to initialize. While a value between low threshold values and high threshold values, if the neighboring edge pixels are present is determined as an edge pixel.

Figure 2b and 2c are Sobel images with mask size of 3 × 3 and 5 × 5, respectively, using the edge detection algorithm. Figure 2d shows the result after using algorithm Canny.



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

Fig. 2. (a) Original Image, (b) **3 × 3** Sobel filter, (c) **5 × 5 Sobel filter**, (d) Canny filter

$$G = \sqrt{G_x^2 + G_y^2}, \theta = atan\left(\frac{G_y}{G_x}\right) \quad (1)$$

Where G is slope, and Equation 1 is a variation of G_x and G_y. In Equation 1, G is the angle of inclination to change in the amount of G_x and G_y. The slope is equal to θ. Therefore, these methods could detect edge mask. By changing the size and weight of the mask, a variety of edge detection contexts have been studied.

B. Fuzzy C-Means (FCM)

Clustering may be used to determine the properties of all data belonging to the central point to decide the representative point in consideration of the characteristic data

and the classification[13] defined by similar data in a single bundle to find the center point of the bundle. FCM is a representative example of clustering. It is very similar to K-means[14]. This algorithm calculates the center point by assigning data by Euclid distance. FCM is used to obtain the center by using similarities and distance data. The algorithm of applying FCM to subsequent procedure is as follows.

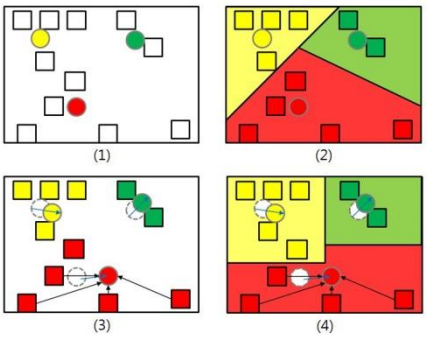


Fig. 3. Fuzzy C-Means (FCM) Algorithm

Step 1: It allocates the determined K clusters without a center point under no special conditions.

Step 2: Using the distance from the center point assigned to an object, it can optionally create a cluster by assigning data to the nearest central point.

Step 3: It sets the center point for the cluster again.

Step 4: It repeats the second step until the center point matches the set center point.

$$\underset{C}{argmin} \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \left\| x_i - C_j \right\|^2 (1 \le m < \infty) \quad (2)$$

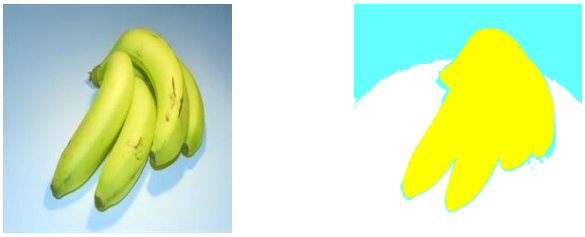
$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\left\| x_i - c_j \right\|}{\left\| x_i - c_k \right\|} \right)^{\frac{2}{m-1}}} \quad (3)$$

In equation 2 is terminated if there are same between the new objective function and updated existing objective function. It has a finite number of set of n vector x_i. Equation 3 is the equation for obtaining the degree of membership of the data belonging to the cluster, where u_{ij} of i represents the membership degree of the i-th cluster j-th data. The sum of membership functions of the data belonging to each cluster is

$$C_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}} \quad (4)$$

In equation 4 is an equation for obtaining the value of the center vector of the cluster.

It was similar to populating the data using clustering according to the equation. Pixel of similar color is from a single cluster.



(a) (b)

Fig. 4. Clustering Image (a) Original, (b) FCM

III. Proposed Work

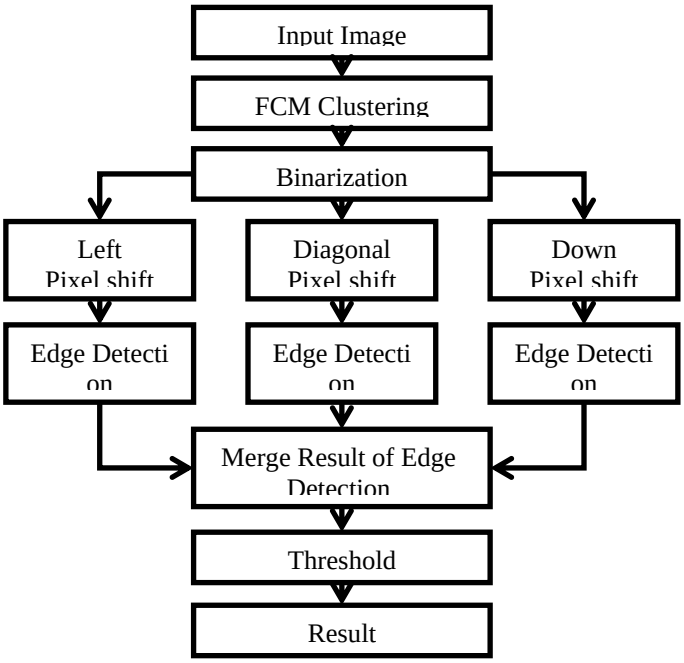


Fig. 5. A Flow Chart of the Proposed Method

A flow chart of the proposed method is shown in Figure 5. Using clustering, the pre-treatment step was separated into a number of clusters in order to simplify the pixels of the image prior to using the proposed method. After that, the simplified moving picture is separated to the left, down, and diagonal directions by measuring the changes from the original image to detect edges. Therefore, edge detection due to similar color is reduced to detect the edge features of the object standing out[15].

$$\Delta G_x = f(x-1, y) - f(x, y) \quad (5)$$

In equation 5, G_x is the amount of change in brightness, current pixels $f(x, y)$ is the difference between a value shifted by -1 in the x-axis. $If\ G_x \neq 0$, because changes in the value of the pixel is the x-axis Edge.

$$\Delta G_y = f(x, y-1) - f(x, y) \quad (6)$$

In equation 6, G_y is the amount of change in brightness, current pixels $f(x,y)$ is the difference between a value shifted by -1 in the y-axis. $If\ G_y \neq 0$, because changes in the value of the pixel is the y-axis Edge.

$$\Delta G_{xy} = f(x+1, y-1) - f(x,y) \quad (7)$$

In equation 7, G_{xy} compares the pixel value of the diagonal direction of the current pixel.

$$\text{Edge} = \Delta G_x + \Delta G_y + \Delta G_{xy} \quad (8)$$

In equation 8, G_x, G_y, G_{xy} are the amount of changes in edge summing G_x, G_y, G_{xy} . It generates a three directions Edge map.

$$\begin{aligned} \Delta L &= f(x-1,y) - f(x,y) \\ \Delta R &= f(x+1,y) - f(x,y) \\ \Delta U &= f(x,y+1) - f(x,y) \\ \Delta D &= f(x,y-1) - f(x,y) \\ \Delta LU &= f(x-1,y+1) - f(x,y) \\ \Delta RU &= f(x+1,y+1) - f(x,y) \\ \Delta LD &= f(x-1,y-1) - f(x,y) \\ \Delta RD &= f(x+1,y-1) - f(x,y) \end{aligned}$$

$$\text{EDGE} = \Delta L + \Delta R + \Delta U + \Delta D + \Delta LU + \Delta RU + \Delta LD + \Delta RD \quad (9)$$

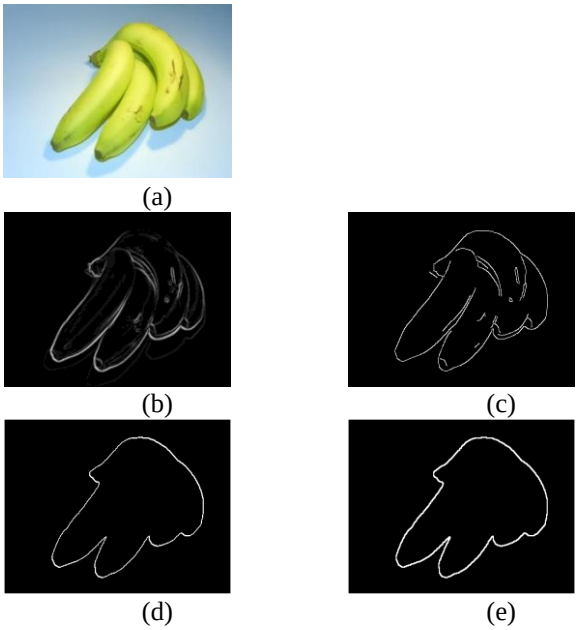
In equation 9, ΔL, ΔR, ΔU, ΔD, ΔLU, ΔRU, ΔLD and ΔRD are the amount of changes in edge summing of ΔL, ΔR, ΔU, ΔD, ΔLU, ΔRU, ΔLD and ΔRD. It generates an 8-directions Edge map.

a. 8-directions detection using image shift method

The detection of 8-directions can be performed by moving a total of eight horizontal bi-directional, vertical bi-directional, or diagonal bi-directional in order to detect all directions like a conventional Sobel edge detection algorithm to the edge. Results are merged. This method has disadvantage because it takes a long time to detect. Its advantage is that it can detect the edges in any direction.

b. 3-directions detection using image shift method

The 8 directions method takes a long time. Because of that, to reduce the time required, 3-directions (left, upper-right, down) detection can be performed to obtain an edge image with less time. Except for the horizontal and vertical directions, the directions can be classified into diagonal upper-left, lower left, upper right, and lower right. This only in one direction horizontal and vertical directions can be strengthened to detect the hard edges. Adding to the resulting direction, even small differences in the results can cause problem because the time needed will increase using the 3-directions detection method.



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

Fig. 6. Comparison of Existing edge maps and Proposed method (a) Original image, (b) Sobel, (c) Canny, (d) 3-direction pixel shift, (e) 8-direction pixel shift.

As seen in Table 1, the time required for the 3-directions detection for the edge was shorted than that for the 8-directions detection. However, the time differences between the two methods are a few seconds, which makes no difference in the detection of an image which takes a long time. Since the detection method was proposed in three directions, its impact on the complexity of the image is not huge because the task of moving image is small compared to the total task of detecting an image.

TABLE I
3-DIRECTIONS PIXEL SHIFT TIMES COMPARED TO 8-DIRECTIONS PIXEL SHIFT TIMES

Image Size	3-DIRECTIONS Time (s)	8-DIRECTIONS Time (s)
320×180	0.066	0.144
800×600	0.408	0.888
1024×768	0.672	1.559
1920×1080	2.162	5.013
2560×1440	3.818	8.861

Therefore, size and operation speed of a video image may have a proportional constant. The average time of applying the image 30, one for each size of the image did derive the results shown in TABLE1. If the image size is 1024×768 pixels, this operation took the longest time (0.68 seconds and 1.57 seconds). If the operation is fast 0.66 seconds and average 1.55 second, According to complexity of images, velocity

difference might be affected by the size of image.

TABLE II
COMPARE MSE AND PSNR BETWEEN THE 3-DIRECTIONS PIXEL SHIFT / 8-DIRECTIONS PIXEL SHIFT

	3-DIRECTIONS		8-DIRECTIONS	
	MSE	PSNR	MSE	PSNR
Banana	6714.759	22.708	6722.387	22.707
House	16693.380	13.598	16907.819	8.980
Sparrow	29696.474	7.837	29795.318	7.804
Human	12530.109	16.467	12995.905	16.101

In this process, the results of experiments with image used are shown in Section 4. When the processing time was compared, the time difference for detecting a large image was greater in proportion to the difference between the 3-directions pixel shift and the 8-direction pixel shift methods. However, we did observe difference between measurement using MSE and that using PSNR. A lot of time is needed for the detection in eight directions. The differences between the 3-directions and 8-directions makes detected more direction.

IV. EXPERIMENTAL RESULT

This study was developed using OpenCV with Visual Studio 2013 on Windows 7 environments. Figure 7 in (a) is an original image, (b) was applied as a pre-treatment method of the proposed algorithm this FCM. (c) is the result of applying the conventional Sobel algorithm, (d) was detecting the edge using the proposed method. Edge of similar color compared to Sobel algorithm was not detected. However, the Contour was detected.

The resulting image of Figure 7 is the result of an experiment with a simple image. By clustering similar pixels, same result of edge detection was obtained.

Figure 8 shows the results of a more complex image, unlike the previous figure. To detect such wires with grass and texture detection in Sobel algorithm, the proposed method was not suitable for edge detection for such object. Although Figure 8 (d) detected such object, its binary edge of a specific portion is thicker.

Results of experiments with the image of a Sparrow are shown in Figure 9. Using Sobel algorithm, the object was detected with a blurred background, with a lot of textures of the wings and the head of a sparrow. However, the proposed method revealed the background and the texture object was removed from the sparrow.

Figure 10 shows the result of experiment for a person in the image. Sobel algorithm showed the texture of the small building. It is hard to distinguish it from the windows and walls. The proposed method ensured that the girl was behind the windows of the building. The boundary is broken. There is no presence of the edge part. The texture was gone with other objects in the water.

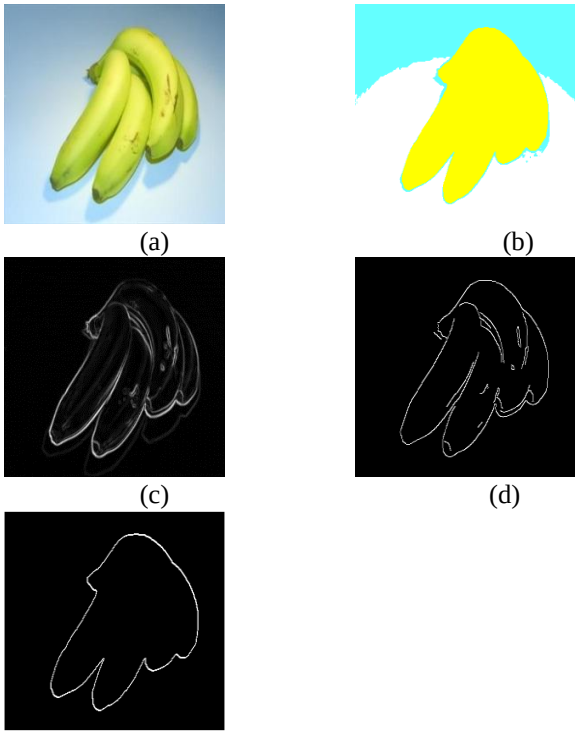


Fig. 7. Banana image edge detection (a) Original image, (b) FCM, (c) Sobel, (d) Canny, (e) Proposed Method.

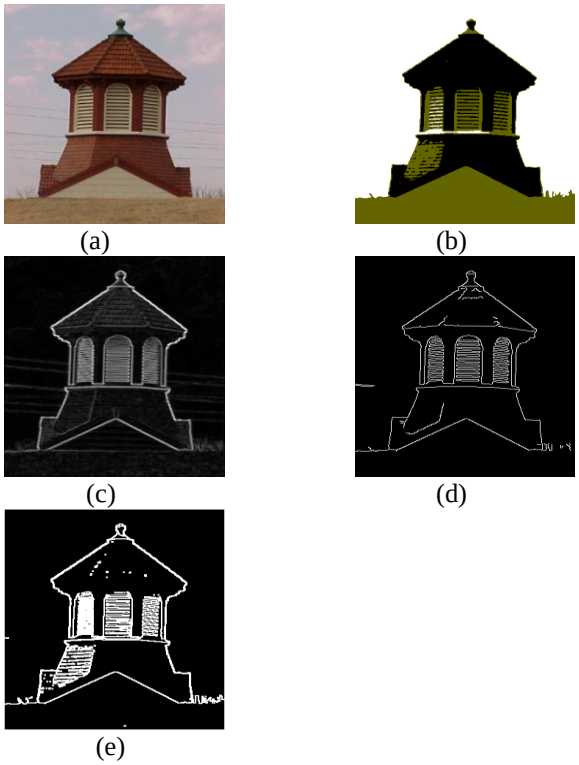


Fig. 8. House image edge detection (a) Original image, (b) FCM, (c) Sobel, (d) Canny, (e) Proposed Method.

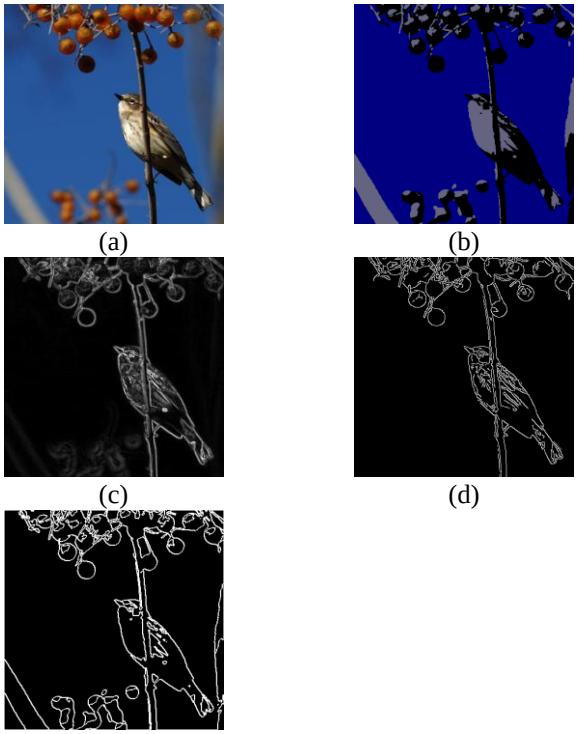


Fig. 9. Sparrow image edge detection (a) Original image, (b) FCM, (c) Sobel, (d) Canny, (e) Proposed Method

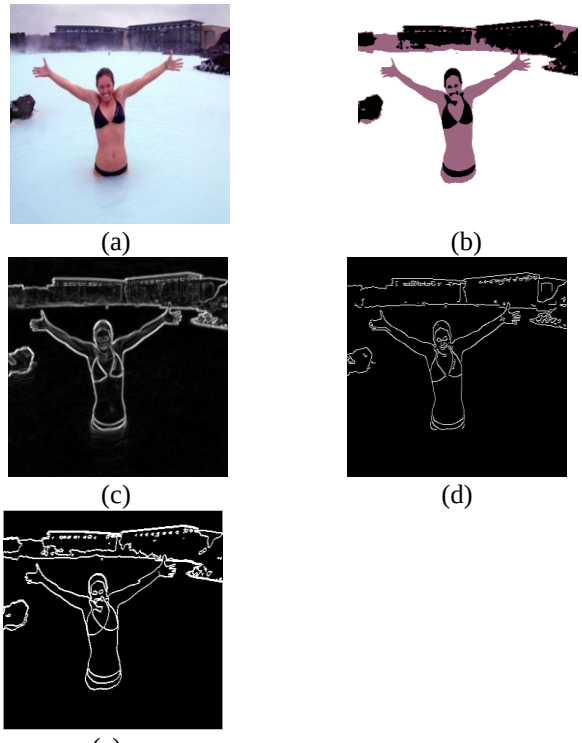


Fig. 10. Human image edge detection (a) Original image, (b) FCM, (c) Sobel, (d) Canny, (e) Proposed Method

V. Conclusion

In this paper, after a pre-treatment step before FCM clustering, the edges of three detections moving image could be detected using the proposed algorithm. Conventional algorithms can be used to detect all edges of the image. However, the proposed method could detect the appearance of an independent object with edge because its classification is similar to data clustering in pre-processing steps as a single bundle. In this experiment, we used several simple picture images, house, animals, and so on. However, the proposed method cannot detect a texture similar to Contour detection to obtain a favorable edge map in object partition.

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References

[1] David G. Lowe, “Distinctive Image Features from Scale-Invariant Keypoints”, International Journal of Computer Vision, vol. 60, no. 2, pp 91-110, 2004

[2] Aaron Wilbee, Ferat Sahin, Ugur Sahin. “A Framework for Intelligent Creation of Edge Detection Filters”, Systems, Man, and Cybernetics (SMC), 2015 IEEE International Conference on, China, pp 2702-2707, October 2015

[3] Fabio Baselice, Giampaolo Ferraioli, Diego Reale, “Edge Detection Using Real and Imaginary Decomposition of SAR Data”, IEEE Transactions on Geoscience and Remote Sensing, vol. 52, no. 7, pp 3833-3842, 2014

[4] Mohd Firdaus Zakaria, Shahrel A. Suandi, “Malaysian Car Number Plate Detection System Based on Template Matching and Colour Information”, (IJCSE) International Journal on Computer Science and Engineering, vol. 2, no. 4, pp 1159-1164, 2010

[5] Mohd Ali Mat Nong, Rosiah Osman, Juraina Md Yusof, Roslina Mohd Sidek. “Motorcycle image tracking and edge detections based on Simulink software”, Intelligent and Advanced Systems (ICIAS), 2016 6th International Conference on, Malaysia, pp 15-17, August 2016

[6] Ratiporn Chanklan, Kedkarn Chaiyakhan, Anusara Hirunyawanakul, Nittaya Kerdprasop, “Fingerprint Recognition with Edge Detection and Dimensionality Reduction Techniques”, 2015 Proceedings of the 3rd International Conference on Industrial Application Engineering 2015, Japan, pp 569-574, January 2015

[7] Jong-Hun Park, Gang-Seong Lee, Sang-Hun Lee, “A Study on the Convergence Technique enhanced GrabCut Algorithm Using Color Histogram and modified Sharpening filter”, Korea Convergence Society, vol. 6, no. 6, pp 1-8, 2015

[8] Wenshuo Gao, Xiaoguang Zhang, Lei Tang, Huizhong Liu. “An Improved Sobel Edge Detection”, Computer Science and Information Technology (ICCSIT) 2010 3rd IEEE International Conference on, China, pp 67-71, July 2010

[9] John Canny, “A Computational Approach to Edge Detection”, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. PAMI-8, no. 6, pp 679-698, 1986

[10] Weibin Rong, Zhanjing Li, Wei Zhang, “An Improved CANNY Edge Detection Algorithm”, Mechatronics and Automation (ICMA), 2014 IEEE International Conference on, China, pp 577-582, August 2014

[11] ChuanLong Li, Ying Li, XueRui Wu, “Novel fuzzy c-means segmentation algorithm for image with the spatial neighborhoods”, Remote Sensing, Environment and Transportation Engineering (RSETE), 2012 2nd International Conference on, China, pp 1-4, June 2012

[12] Perez-Aguila, Ricardo, “Enhancing Brain Tissue Segmentation and Image Classification via 1D Kohonen networks and Discrete Compactness: An Experimental Study”, International Association of Engineers. vol. 21, no. 4, pp 171-180, 2013

[13] Vikas Verma, Shaweta Bhardwaj, Harjit Singh, “A Hybrid K-Mean Clustering Algorithm for Prediction Analysis”, Indian Journal of Science and Technology, vol. 9, no. 28, pp 1-5, 2016

[14] Ga-On Kim, Gang-Seong Lee, Sang-Hun Lee, “An Edge Extraction Method Using K-means Clustering In Image”, The Society of Digital Policy and Management, vol. 12, no. 11, pp 281-288, 2014

[15] Fangyan Nie, Pingfeng Zhang, “Fuzzy Partition and Correlation for Image Segmentation with Differential Evolution”, IAENG International Journal of Computer Science, vol. 40, no. 19, pp 164-172, 2013