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Improvement of Fuzzy C-Mean using Local Laplacian Filter for Image Segmentation

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***Abstract*— the FCM (Fuzzy C-Mean) is on of algorithms used in the background image separation research. This study aims to improve the quality of image segmentation using FCM algorithm with Local Laplacian Filter. Thus, we applied the Local Laplacian Filter into the V (Value) and S (Saturation) component of the image. The result of Laplacian Filter then clustered using FCM method. The result of segmentation using FCM and Local Laplacian Filter will be compared with ground-truths images to reveal the value of the PSNR (Peak Signal to Noise Ratio) and the MSE (Mean Square Error). This study also compared the results of the MSE and PSNR with the FCM and K-Mean algorithms. The image is done preprocessing first by using Local Laplacian Filter which gives the color contrast to the image. So the image becomes sharper and when the image changed to the color space HSV already looks quite striking color differences between objects with the background. The results of this study indicate that segmentation using FCM and Local Laplacian Filter has the best MSE and PSNR results compared to the 2 tested algorithms.**

Keywords—FCM, HSV, Image Segmentation, Local Laplacian Filter

I. INTRODUCTION

Image segmentation is one of the methods in digital image processing used to classify an image. Image segmentation goal is to separate an image into many separated regions with every region corresponding to a visual essential object [1]. Image segmentation is used as a fundamental role in many computer vision applications [2].

Implementation of image segmentation can be utilized for various fields of science such as health, economics, medicine, etc. Image segmentation aims to cluster images in accordance with some similar features, i.e. texture, color, intensity, movement, etc. To implement the segmentation method on image, foreground color should be initialized first in RGB and converted the background color to 0 (zero) value for which the distance label is less than 128 [1]. Image segmentation can also applied in video proccessing by comparing each frames to get a movement object that captured [2]. In its development there are many methods used to implement image segmentation [3], one of them is using Fuzzy C-Mean algorithm [4].

The FCM (Fuzzy C-Mean) is one of methods implemented in the field of image classification and has some advantages, which is widely used in various research and goals. Based on the statement of H. Pei, et al [5], the FCM is an algorithm implemented in the soft clustering, which is based on fuzzy set theory. This algorithm can classify the image by changing the object of the image into the HSV color space [6]. HSV color space is better than the RBG to representing human view, because the HSV has a color range from 0 to 1 [7]. In this color space the FCM algorithm clusters the imagery based on the similarity of color and texture.

In this research the role of preprocessing the image becomes very important to get better image segmentation quality. Therefore the authors propose a method to improve the results of image segmentation using FCM so as to get maximum results. Local Laplacian Filter (LLF) is a method of color image correction that makes the color of the image becomes sharper [8]. The Laplacian of an image is a secondary method of enhancement [9].

Refer to Guangyu Zhang [8] using Local Laplacian Filter as an approach in which quickly make a high quality line drawings. In his research, he construct a local intensity remapping and then construct it into Laplacian Pyramid by computing a Laplacian pyramid of the transformed image.

Satish Bhairannawar [9], in his research, before implementing the Laplacian method he convert the color space from RGB to HSV. He applying the Laplacian filter to Value and Saturation component. To obtain the enhanced Value by stretching the contrast and appropriating the Saturation component, the output of luminance component is subjected to CLAHE (Contrast Limited Adaptive Histogram Equalization). And the last was reconverting from HSV back to RGB.

In this research, authors thought that LLF method is very suitable to be combined with FCM algorithm to get better image segmentation result. As mentioned above that FCM classify HSV component and LLF is stretching V and S component. To test the results of image segmentation using the authors' proposed model, the authors used sample dataset images obtained from Berkeley Segmentation

Dataset (BSD) [10].

Referring from the information above, research that using FCM combined with LLF as a filter is not yet investigated. Applying Laplacian filter to V and S component. Then cluster it using FCM using the image datasets to produce a better result of image segmentation obtained by using the results of the calculation of PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). Those are often implemented to evaluate the image segmentation results along with its ground truth. From their process, the value then calculated, the lower the value of MSE can be indicated that it is a better image segmentation. On the other hand, the higher the PSNR value, indicates a better image segmentation.

Hence, for the whole process, the MSE and PSNR results through the proposed model will be compared with the results of the FCM and K-Mean algorithms that are widely used in research to perform image segmentation.

II. FUNDAMENTALS

A. Image Segmentation

Image segmentation is widely applied in various researches that have many challenges in the field of computer vision [2]. Those researches most often implementing some fast and effective algorithms, which can easily be applied in the image segmentation field.

For several reasons, the main objective of the image segmentation research is to group some pieces of image into regions through its similar properties (i.e. intensity, color, spatial statistics) purposed to create the meaningful image and is easier for the analysis process [1]. The grouping of blocks that associated with similar image features can be called as the result of segmentation. Then, the most significance steps to achieve the successful segmentation is through grouping some schemes and choosing the image features.

B. Fuzzy C-Mean Clustering

It is said that the FCM is a well-recognized technique and categorized as a Hard K-Means [11]. The FCM is implementing some model of the fuzzy grouping to set up the level or degree of membership in a range at the interval of 0 (zero) to 1 (one) [4]. To count the membership level in a class or a cluster is determined by its membership degree. Here is the formula given (1):

$$Tfc = (max(xi\ (y{=}1) + min(xi\ (y{=}2))) / 2 \quad (1)$$

Determinating the center of the cluster become the basic concept of FCM method. Restoring repeatedly every membership values and the cluster center will show the center of the cluster precising its location [12]. The effectiveness and easy implementation is the reason for using the general algorithm of image segmentation using FCM. The function membership piece of fuzzy by the pixel of an image to the convinced amount of classes. To start the observed intensity collection in a pixel j, we used the equation (2):

$$yi = [yj1,yj2,....yjN]T \ , j = 1,.....,M \quad (2)$$

where yi, (i = 1,...., N) (in the *RMI*, N is the sum amount of *TR/TE*), and M is represent the pixel position sum number. The spectral canal amount can be the pixel intensity of the spectral canal inserted to the N. The minimum iteration between the membership function of fuzzy uj and the center of pixel vector in every single class vk is calculated in equation (3):

$$| \text{FCM} = \sum_{ij} \sum_{k=} u_k \ (i,j) - V_k \quad \| \quad (3)$$

where $Uk(I,j)$ is the membership amount in the pixel location (i,j) in the k class is. The q is the content exponent existed in every membership of single fuzzy determined as parameter and the fuzziness amount of the classification outcome. To reflecting the degree of similarity between the class center point and the pixel vector of the mentioned location, the value of 8 memberships is ranged from 0-1. Measuring how close the value function to 1 is providing the minimum FCM. The further the pixel intensity from the center is the smaller membership value it get [3].

C. Local Laplacian Filter

The LLF (Local Laplacian Filter) is one of techniques pf digital image processing, which is implemented often for color image enhancement. The LLF counts the result by calculating the LP (Laplacian Pyramid) independently each layer [9]. Once the Laplacian pyramid computed, the output image can easily be obtained by expanding the LP [9].

The LP is composed with spatially constant Gaussian kernels. It is said that the LP is widely recognized as the poor method to the edge-aware operations and some edges positioning [13].

Particularly, the Laplacian Filter is efficient to find the fine detail in an image. Some researchers conducted previously to train the Laplacian operator to find the enhancement of any feature along with the sharp discontinuity. In this study, to approximate the second derivative in the Laplacian operator, we used equation (4).

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \quad (4)$$

Before stepping to further processing, the Laplacian filter is implemented to count the S (Saturation) and V (Value) components, which is then used to sharpen the contents of the image. The CLAH (Contrast Limited Adaptive

Histogram) is implemented to process the enhanced luminance component. By applying the Laplacian filter to the V and S components will give the output, shown as V_α and S_α [9].

In this research, Local Laplacian filter used for increase the contrast from the dataset images [10]. The result of image segmentation processing was affected by quality of preprocessed images. After that, preprocessed images would be converted from RGB to HSV, then image will be clustering processed using Fuzzy C-Mean algorithm.

III. Research Experiment

This study aims to segment the image to distinguish the object image with background. The following sequence of research process conducted (1):

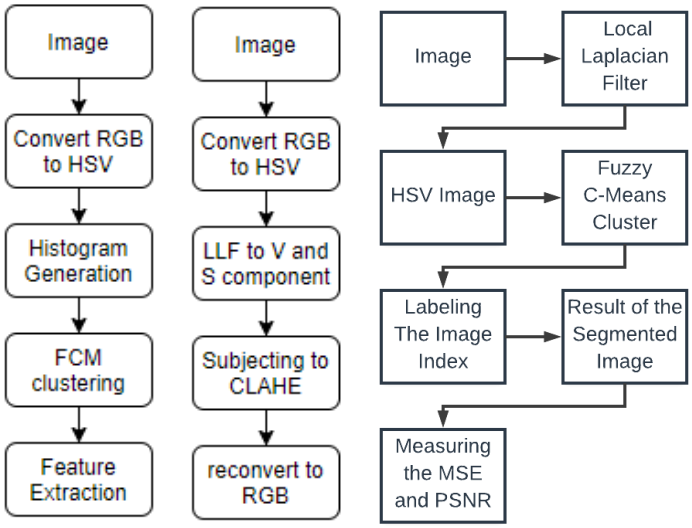

Fig. 1. (a) Research Flow Diagram of Implementing FCM on Image Segmentation by Jie Zhang, (b) Flow Diagram of Implementing Local Laplacian Filter by Satish Bhairannawar, (c) Flow Diagram of Proposed model by Adding LLF before clustering using FCM

Fig 1. (a) shows how the authors of that research implementing FCM on image segmentation, Fig 1. (b) shows hoe the authors of that research implementing Local Laplacian Filter to sharper value of V and S components. In this research, the authors implementing Local Laplacian Filter before FCM to get a better image segmentation result.

The original image to be processed will be enhanced by using Local Laplacian Filter, which aims to make image contrast better. For that implementation, the image will be changed firstly from RGB (Red, Green, Blue) into the HSV (Hue, Saturation, Value) color. That changing is clustered using the Fuzzy C-Mean technique by determining the center of the cluster and entering the Hue and Saturation values of the image. The Figure (2) shows the segmentation result.

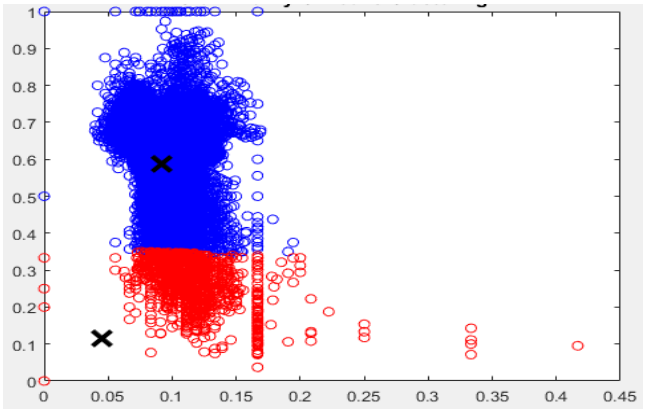

Fig. 2 Graph shown clustering using Fuzzy C-Mean

In the graph (2) it looks Fuzzy C-Mean algorithm successfully segmented to degrade object and background image. Image sequence result of image segmentation process can be seen in figure (3) following:

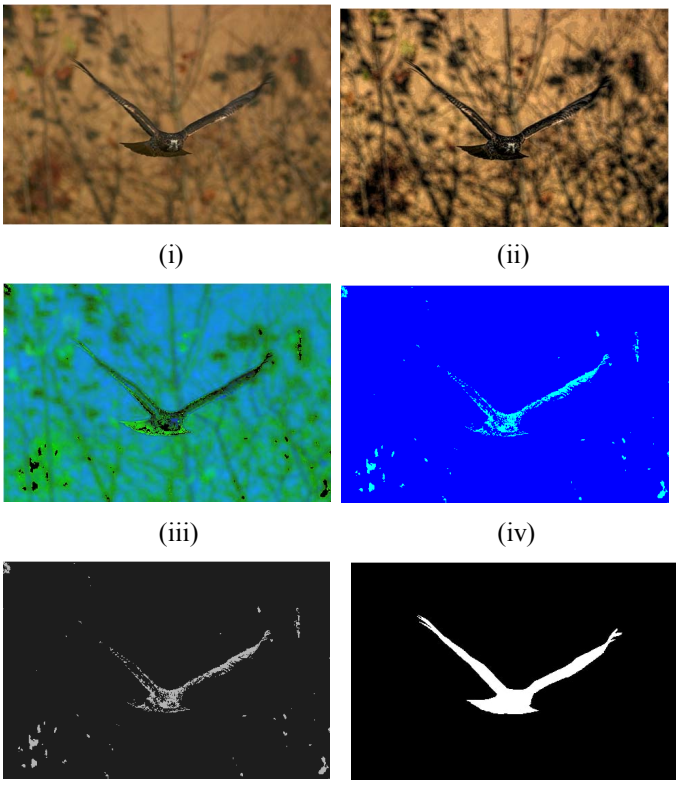

Fig 3. The (i) is the original image, (ii) is the image after processing the Local Laplacian Filter, (iii) is the image in HSV, (iv) is the result of segmented image, (v) is the segmented Image in grey, (vi) is the Ground-Truth Image

In figure (3) shows the process in this research from the selecting dataset images, preprocessing image using local laplacian filter, and then the result is image clustering using Fuzzy C-Mean.

After the image successfully segmented the next step is to compare the image quality of the results of segmentation with ground-truth image. In this study, we use the PSNR (Peak Signal to Noise Ratio) and the MSE (Mean Square Error) to measure the proposed model quality. The MSE

calculation formula can be seen at equation (5) as well as the PSNR calculation is at (6).

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}[f(i,j) - f_1(i,j)]^2 \quad (5)$$

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (6)$$

MSE and PSNR were selected for this research because previous studies [14] were used to monitor and evaluate the results of image segmentation. Furthermore, this research will compare the value of MSE and PSNR of two algorithms done in previous research with our proposed model. The author compares the results of MSE and PSNR from 10 Dataset Image with 2 other algorithms previously used, Fuzzy C-Mean and K-Mean. Here's the comparison:

TABLE I. COMPARISON OF MSE AND PSNR RESULT USING FCM, K-MEAN, AND PROPOSED MODEL

Image	Fuzzy C-Mean		K-Mean		Proposed Model	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
1	28116,7711	3,6411	36001,7632	2,5676	25344,2251	4,0920
2	41755,8675	1,9236	40581,1299	2,0476	41253,5554	1,9762
3	37545,8165	2,3852	39799,6490	2,1320	26310,4235	3,9295
4	36682,2648	2,4862	27126,4599	3,7969	28556,1138	3,5738
5	39740,7150	2,1384	33225,0531	2,9161	33298,1311	2,9066
6	32238,1705	3,0471	26461,7863	3,9046	22336,7905	4,6406
7	31466,1085	3,1524	32828,3458	2,9683	29976,4122	3,3630
8	38566,0196	2,2688	33521,2318	2,8776	25828,7365	4,0098
9	38202,6286	2,3099	28748,8528	3,5446	27483,8490	3,7400
10	39315,7581	2,1851	27916,6052	3,6722	37717,7195	2,3653
Average	**36363,0120**	**2,5538**	**32621,0877**	**3,0428**	**29810,5957**	**3,4597**

Based on the experimental result shown in table (1), the authors compare 10 (ten) sample images obtained from the public datasets [15] and compare the results of the segmentation using 3 (three) algorithms, i.e. Fuzzy C-Mean, K-Mean, and FCM + Local Laplacian. The MSE results can be seen in the following figure (5).

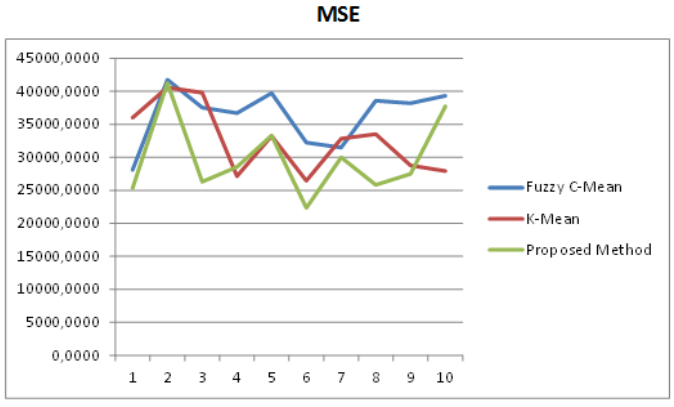

Fig 5. Graph of MSE Results from 3 Algorithms

From the result of MSE in figure (5) it is seen that the proposed model (Fuzzy C-Means + Local Laplacian Filter) has a lower error than the 2 algorithms tested with an average value of 29810.5957 compared with the average value of FCM and K-Mean that is equal to 36363,0120 and 32621,0877. The results show that the implementation of the fuzzy C-Means along with the incorporation with Local Laplacian Filter create the best MSE value compared to other 2 (two) algorithms. Furthermore, this study will make the graph of PSNR value comparison with 3 methods that were tested before. For graph of PSNR result can be seen in figure (6) :

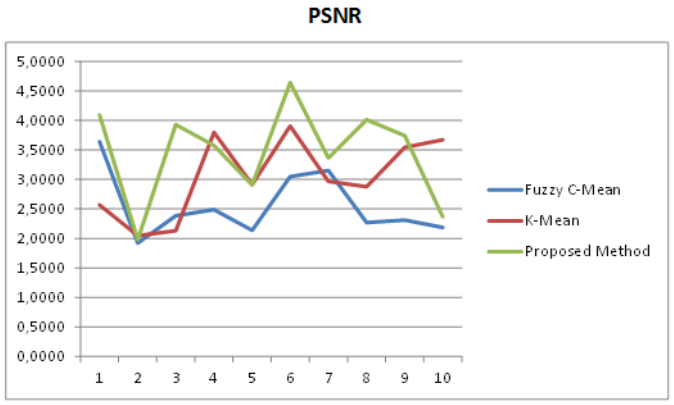

Fig 6. Graph of PSNR Results from 3 Algorithms

From the result of PSNR in figure (6) shows that the proposed model has the highest PSNR value with an average of 3.4597 compared with the mean value of FCM and Kmean that is 2,5538 and 3,0428. From these results it can be concluded that the image of the segmentation result using FCM and Local Lapaclian Filter has the best PSNR value compared to the 2 tested algorithms. Comparison of the segmented image between proposed model with FCM and K-Means can be seen in figure (7) below :

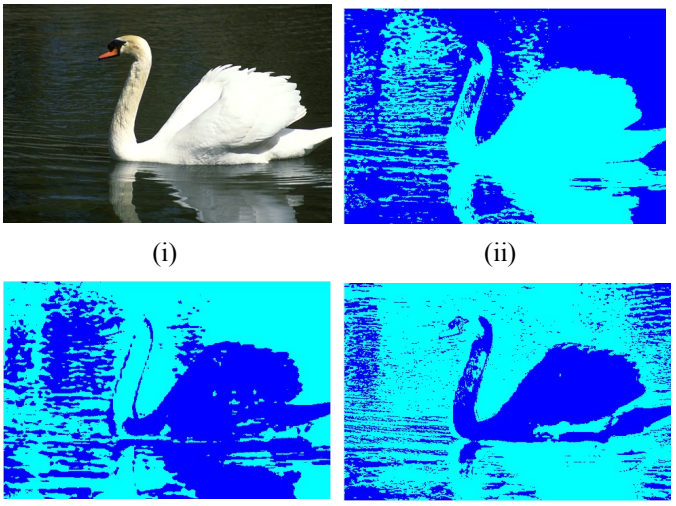

Fig 7. (i) is the original image, (ii) is the segmented image using FCM, (iii) is the segmented image using K-Means, (iv) is the segmented image using the proposed model.

IV. CONCLUTION

This research has been successful to show improvement of segmentation result using Fuzzy C-Mean and Local Laplacian Filter algorithm compared with 2 algorithms tested, that is using Fuzzy C-Mean and K-Mean. The results of this study provide the best value of MSE and PSNR compared to the 2 algorithms tested because before the image is clustered using Fuzzy C-Mean algorithm, the image is done preprocessing first by using Local Laplacian Filter which gives the color contrast to the image. So the image becomes sharper and when the image changed to the color space HSV already looks quite striking color differences between objects with the background. This results is shown the better method of image segmentation rather than the Fuzzy C-Mean and K-Mean algorithms. With this research the authors hope the future research can be developed into a method that can increase the quality of detection or classification of an object image and bring much benefits for various fields of science.

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DATASETS

To test the results of image segmentation using the authors' proposed model, the authors used sample dataset images obtained from Berkeley Segmentation Dataset (BSD) [15]. Below is the dataset used for this research and its result from proposed model.


Image Dataset 1

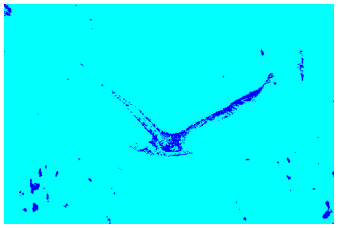

Segmentation Result 1


Image Dataset 2

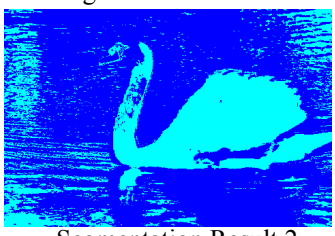

Segmentation Result 2


Image Dataset 3


Segmentation Result 3


Image Dataset 4

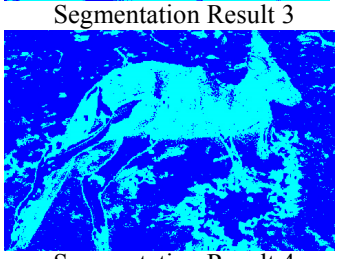

Segmentation Result 4


Image Dataset 5

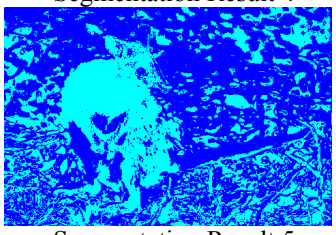

Segmentation Result 5


Image Dataset 6

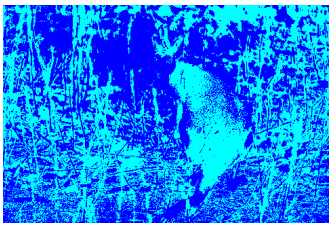

Segmentation Result 6


Image Dataset 7

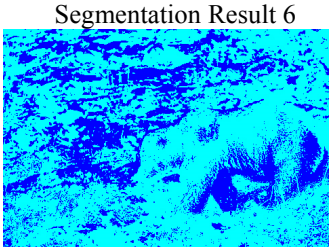

Segmentation Result 7


Image Dataset 8

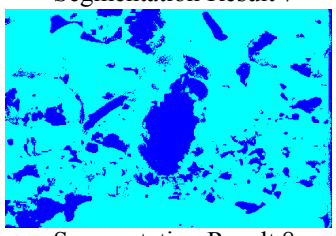

Segmentation Result 8


Image Dataset 9

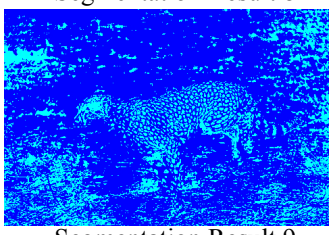
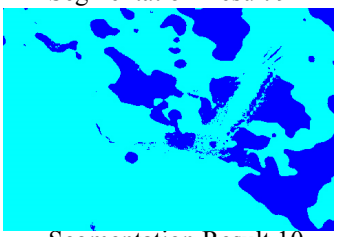

Segmentation Result 9


Image Dataset 10


Segmentation Result 10