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Research Paper

Image mosaicing by using random seeds generation based on fuzzy membership function

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Abstract

A mosaic is a combination of two or more images with various combining techniques. One of the computer graphics applications is the image mosaic used for various purposes such as texture maps and better image backgrounds. One of the important things in making image mosaic is how to create small pieces of the image in such a way that it produces a good image mosaic. A number of methods have been proposed to build an image mosaic system that produces good mosaic results, but it usually requires complicated calculations. Fuzzy image processing is a form of information processing that input and output both images. This is a collection of fuzzy approaches that understand, represent and process their images, segments, and features as a fuzzy set. In this study, fuzzy image processing concept is used to create image mosaic by random seed generation using Fuzzy Membership Function (MF).

Keywords: *Image Mosaic, Random Seed, Fuzzy MF.*

1. Introduction

An image mosaic is a synthetic composition of the image sequence and can be obtained through analysis of geometric relationships between images. The geometric relationship is the coordinate transformation between different image coordinate systems. By applying the proper transformation through the merging of overlapping image area operations, it is possible to create a single image called the image mosaic. The principle of image mosaic technique is how to create a mosaic that produces a visual difference of the image between the small pieces of the image with the overlapping parts of the image [1].
The technique of inserting some parts of the image into an image will produce mosaic panes, this is often referred to as photo mosaic that produces a more beautiful panorama. Techniques developed based on the ability to align the differences from a scene pieces (tiles) are varied against a whole picture. So as to produce a smooth mosaic gam-bar. Prior to the mosaic-making process, consideration should be given to geometric transformations which relate the relationship between the complete image and the part to be inserted [2], [3]. The simplest mosaic can be made from a set of images, in which the mutual displacements are pure image plan. If it is like art image, map image, and satellite image. If using a camera acquisition, a simple mosaic can be created by rotating the camera around its optical center using a special device and creating a panoramic image which repeats the projection of the scene onto a cylinder [4]. Mosaic images can occur well in the condition of release workload where the mosaic algorithm used is to combine the characteristics of the Regional Detection and Fourier – Mellin [5].
Computer graphics is a technique that appears and can be applied to various fields. Among these fields, the special effects industry is one of the important applications. Techniques such as image mosaics are one of the most widely used computer graphics to create better texture maps and background images. A number of methods have been proposed to construct an image mosaicking system such as the Levenburg-Marquardt nonlinear minimization algorithm and the manifold projection method. Both methods achieve good mosaic results, but the calculations are complex [1], [6], [7].
Improved image and noise removal aimed at removing noise while retaining as much as possible the features of mosaic image will be of great importance. How research has ever been conducted offers methods to remove noise with partial unsharp masking and conservative smoothing, comparing the performance of mean and median filtering[8], [9]. Then enhance color Image corrupted by Gaussian noise using fuzzy logic which describes the median filter and histogram methods based on automatic contrast enhancement combine with efficient fuzzy can be useful in a low color image. Similarly, fuzzy applied to the method of homomorphic filtering can be applied to the gray image contrast enhancement [10]–[12].
Fuzzy logic is a group of various fuzzy methods for various image processing purposes. Fuzzy image processing is a form of information processing that input and output both images. This is a collection of fuzzy approaches that understand, represent and process their images, segments, and features as a fuzzy set. The power of fuzzy image processing lies in how to modify membership values through various appropriate fuzzy approach techniques [13]–[16].
In this study, fuzzy image processing concept is used to create image mosaic by random seed generation using Fuzzy Membership Function (MF).

2. Experimental Details

In this study proposed a mosaic technique that generates random numbers by modifying the dynamic range of the grey level. In principle, the modification of a dynamic range of the grey level is to map the grey level of the input image to a certain grey level of the output image expressed by:

$$g(x,y) = f\left(I(x,y)\right) \tag{1}$$

The variable $f(\ )$ is the function that maps the gray level image $I(x,y)$ to $g(x,y)$. In general, the illustration of the mapping function is shown in Figure 1.

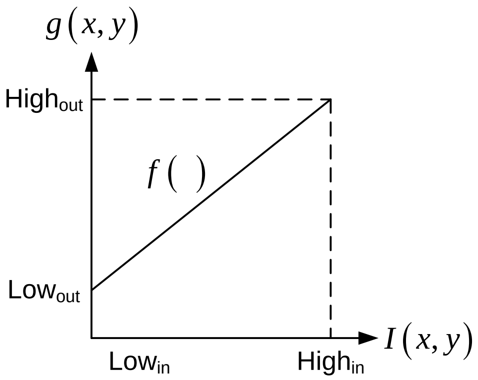


Fig. 1: Representation of Gray level mapping function

The linear function in Figure 1 maps $\left[Low_{in} \quad High_{in}\right]$ of the input image to $\left[Low_{out} \quad High_{out}\right]$ of output image. The map function is expressed by:

$$\begin{aligned} Low_{in} &= \min\left(I(x,y)\right) \\ High_{in} &= \max\left(I(x,y)\right) \\ g(x,y) &= f\left(I(x,y)\right) \\ &= Low_{out} + \left(High_{out} - Low_{out}\right).\left(\frac{I(x,y) - Low_{in}}{High_{in} - Low_{in}}\right) \end{aligned} \tag{2}$$

In this study, $f(\ )$ is a fuzzy membership function. There are four fuzzy membership functions used in this study, i.e. Triangular, Gaussian Curve, Trapezoidal, and Sigmoid MF as shown in Figure 2, which mathematically expressed by:

Triangular MF:

$$trimf\left(x,[a \quad b \quad c]\right) = \begin{bmatrix} 0 & x \le a \\ \dfrac{x-a}{b-a} & a \le x \le c \\ c & c \le x \end{bmatrix} \tag{3}$$

Gauss Curve MF:

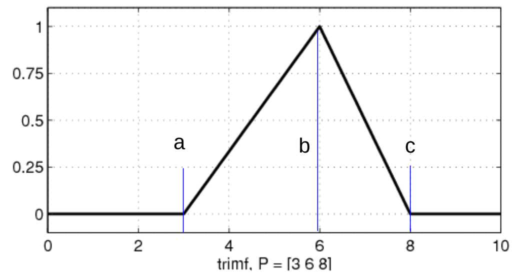
$$gaussmf\left(x,[sig \quad peak]\right) = \exp\left(-\frac{(x-peak)^2}{2sig^2}\right) \tag{4}$$

Trapezoidal MF:

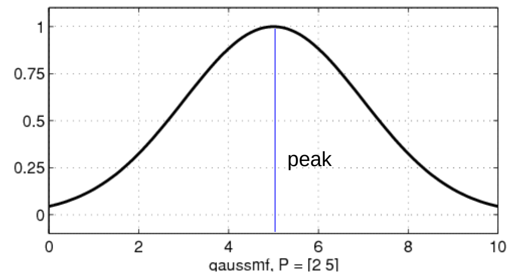
$$trapmf\left(x,[a \quad b \quad c \quad d]\right) = \begin{bmatrix} 0 & x \le a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ 1 & b \le x \le c \\ \dfrac{d-x}{d-c} & c \le x \le d \\ 0 & d \le x \end{bmatrix} \tag{5}$$

Sigmoid MF:

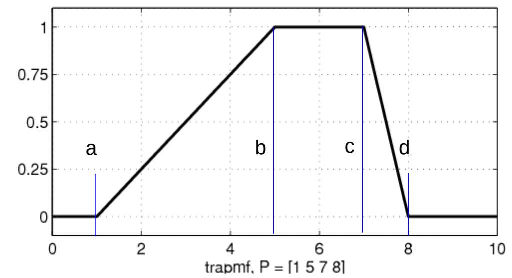
$$sigmf\left(x,[a \quad c]\right) = \frac{1}{1+\exp\left(-a(x-c)\right)} \tag{6}$$



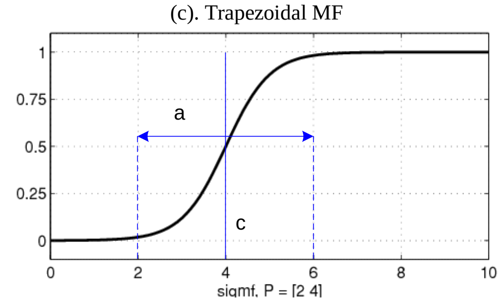
(a). Triangular MF



(b). Gauss Curve MF



(c). Trapezoidal MF



(d). Sigmoid MF

Fig. 2: Fuzzy membership function

Before applying the mosaic technique, each component of the RGB image needs to be segmented as well by using a fuzzy membership function expressed by:

$$I_{segmented} = I(x,y) + f\left(I(x,y) - f\left(I(x,y)\right)\right) \tag{7}$$

In Eq. (7), $f(\ )$ is a fuzzy MF. The segmented image is then used to build the mosaic image.

All parameters in the Triangular membership function (*a*, *b*, and *c*) are obtained from the minimum and maximum values of all pixel values in the mask, so also with *peak* parameter of the Gaussian curve membership function, whereas *sig* parameter is nonzero arbitrary.

The mask in this study used the 3x3 size required for operating the sliding neighborhood to collect the pixels required to determine all fuzzy membership function parameters. All pixels collected then convert into vector form. This process illustrated in Figure 3.

From Figure 3, I_{min} = 0.1 and I_{max} = 0.5. These constants are then used as the Triangular membership function parameters (for example) as follows: $a = I_{\min}$ $\quad c = I_{\max}$ $\quad b = a + (c - a)/2$

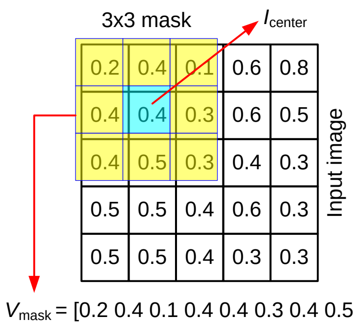


Fig. 3: Example of pixels collection operation in a mask

For Gauss curve membership function parameters, *peak* = *b*, while *sig* parameter set to nonzero number. By using the Gauss curve membership function, then the mosaic seed vector is obtained by using the formula:

$$V_{seed} = gaussmf\left(V_{mask}, sig, b\right) * rand \tag{8}$$

The center of the pixel is then replaced by the pixel value calculated by the formula:

$$I_{mosaic} = I_{center} - median\left(sort\left(V_{seed}\right)\right) * res \tag{9}$$

In Eq. (9), res is the density of the mosaic seed. The algorithms used as shown in Figure 4 & 5. Implementation of the proposed method is illustrated in Figure 6. All four types of fuzzy MF (triangular, gauss curve, trapezoidal, and sigmoid) will be used in the application of the proposed method on the test image to compare the resulting mosaic image.

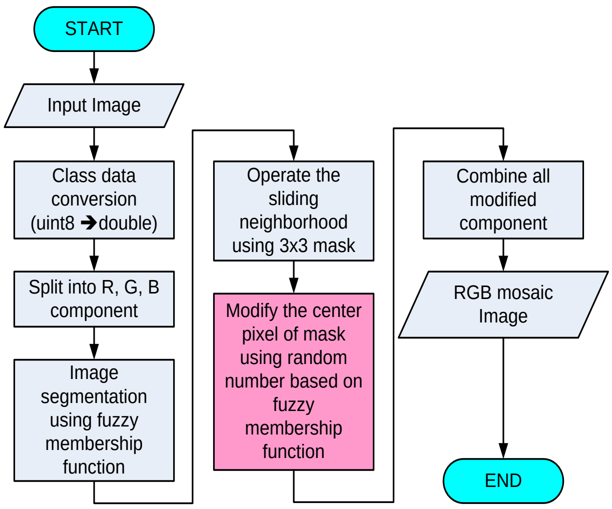


Fig. 4: Image mosaic algorithm

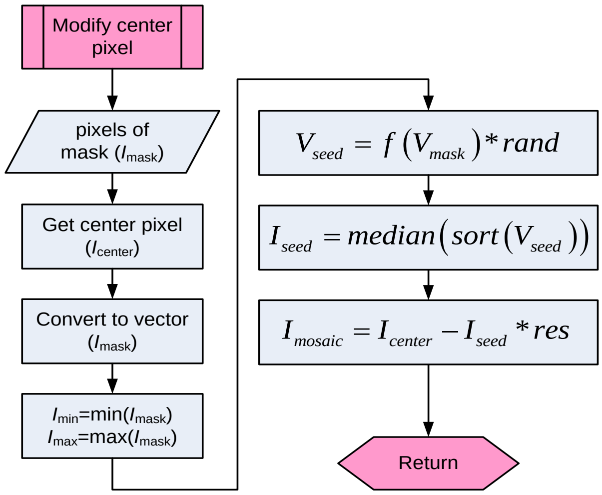


Fig. 5: Pixel center modification algorithm

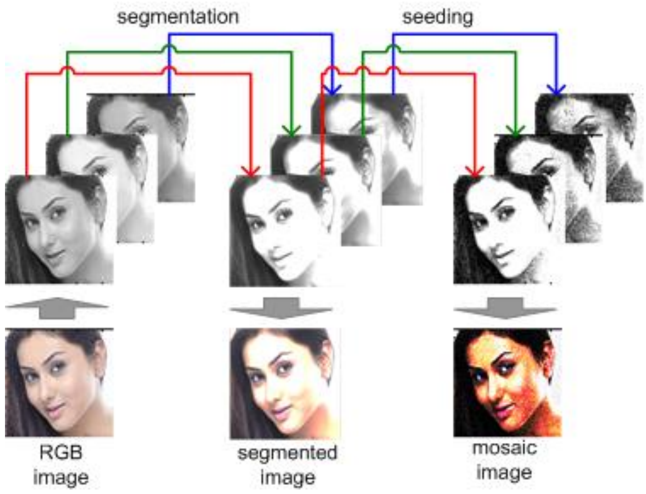


Fig. 6: Illustration of implementation of the proposed method

3. Result and Discussion

This study uses a jpg image of 253 x 199 pixels as an image sample to test the proposed method as shown in Figure 7. The results of image segmentation using various MF are shown in Figure 8 - 11. The results of the implementation of the mosaic technique using Gauss Curve MF are shown in Figure 12. These results are also used Gauss Curve MF for their segmentation. The mosaic results of the images with the various seed densities are shown in Fig. 13. The image mosaic results using the various fuzzy MFs are shown in Figure 14.

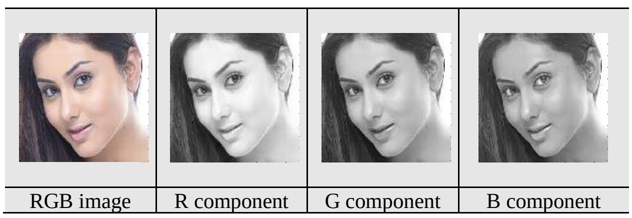


Fig. 7: Image sample and its components

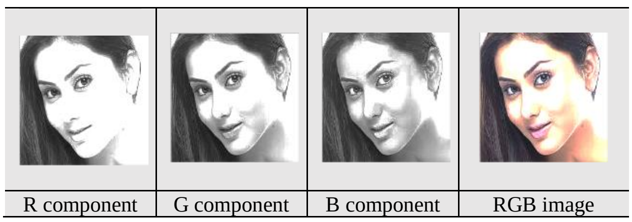
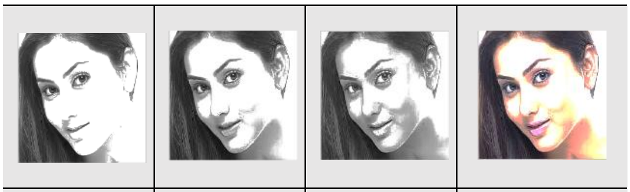
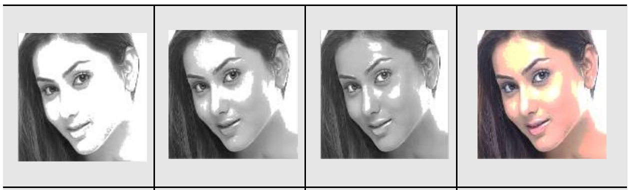


Fig. 8: Segmented image using Gauss Curve MF



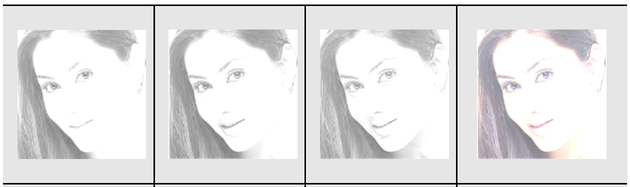
R component	G component	B component	RGB image

Fig. 9: Segmented image using Triangular MF



R component	G component	B component	RGB image

Fig. 10: Segmented image using Trapezoidal MF

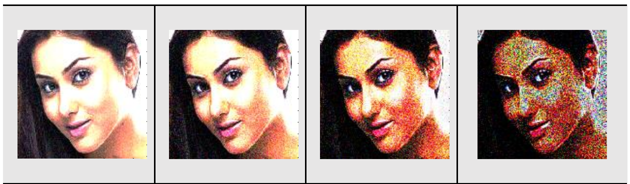


R component	G component	B component	RGB image

Fig. 11: Segmented image using Sigmoid MF

R component	G component	B component	RGB image

Fig. 12: Mosaic Image using Gauss Curve MF and its components



res = 0.25	res = 0.5	res = 1.0	res = 2

Fig. 13: Mosaic image using Gauss Curve MF and its components with various seed density

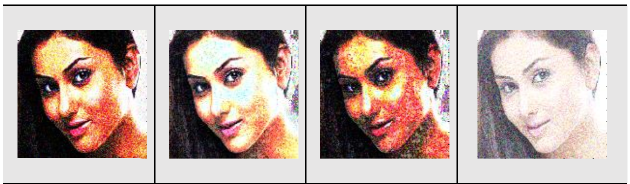
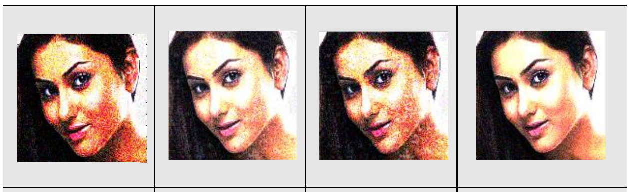


Image mosaic using Gauss Curve MF	Image mosaic using Trian-gular MF	Image mosaic using Trape-zoidal MF	Image mosaic using Sigmoid MF

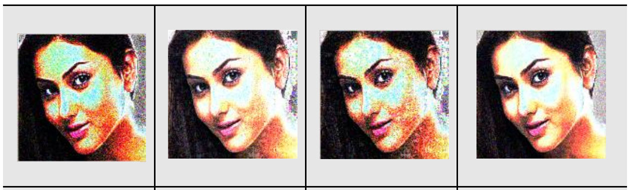
Fig. 14: Mosaic image using different Fuzzy MF with res = 1.0

Experiments were also performed using different segmentation functions on each variation of image mosaic function by using *res* = 1 as shown in Figure 15 – 18. These experimental results demonstrate the visual qualities of mosaic images based on various segmentation function. The good or bad quality of mosaic images visually is dependent on the purpose of the image mosaic.



Gauss Curve MF	Triangular MF	Trapezoidal MF	Sigmoid MF

Fig. 15: Various mosaic image using Gauss Curve MF segmentation

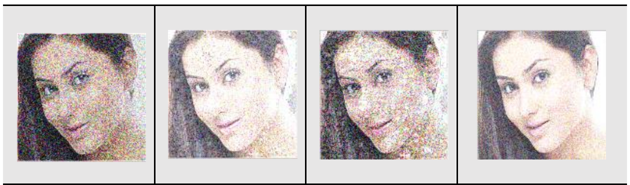


Gauss Curve MF	Triangular MF	Trapezoidal MF	Sigmoid MF

Fig. 16: Various mosaic image using Triangular MF segmentation

Gauss Curve MF	Triangular MF	Trapezoidal MF	Sigmoid MF

Fig. 17: Various mosaic image using Trapezoidal MF segmentation



Gauss Curve MF	Triangular MF	Trapezoidal MF	Sigmoid MF

Fig. 18: Various mosaic image using Sigmoid MF segmentation

4. Conclusion

From the research results can be concluded that the image mosaic built using Fuzzy MF produces a variety of mosaic images. The various mosaic images generated are obtained by selecting a specific Fuzzy MF and setting all its parameters. Assigning all fuzzy parameters of MF is primarily required to determine the density of random seeds, their contrast, and their brightness. While certain Fuzzy MF selections have an impact on the variation of the resulting mosaic pattern segment.
Future work is to test the proposed method using various fuzzy MFs in addition to those used in this study, as well as improving the results through possible innovations.

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