QUALITY ASSESSMENT OF MULTIFOCUS IMAGES USING FUZZY LOGIC

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ABSTRACT

The information extraction process of image, for example image taken from precise camera, is full of complexities and noises. As a result, cost spends on such processing like time and assets is high, particularly for large and complex amount of information. The fusion of images is the process of merging two or more images into a single image preserving significant features from each. The result of fused image is a single image which is highly appropriate for person and machine observation or further image-processing missions. In this paper, we are going to extract image from two or more images. In this paper, we proposed a fuzzy logic method to fuse images from different sensors, in order to enhance the quality and compared proposed method with other method i.e. image fusion using wavelet transform along with quality evaluation parameters mean square error (MSE), peak signal to noise ratio (PSNR), and Normalized cross correlation(NCC). The results obtained from proposed fuzzy based image fusion approach improves quality of fused image as compared to earlier reported wavelet transform based image fusion methods

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Keyword : - *Image Fusion, pixel level, fuzzy logic, multi focus, wavelet transform.*

1. INTRODUCTION

In the application of digital cameras, when a lens focuses on a subject at a certain distance, all subjects at that distance are sharply focused. Subjects not at the same distance are out of focus and theoretically are not sharp. Multi-focus image fusion is a sub-field of image processing techniques in which the images of the same scene, taken by the same sensor, are combined to create a fully sharp and in-focus image. Image fusion has many important applications such as digital auto-focusing [3], microscopic imaging, remote sensing [4], and medical imaging . This paper concentrates on multifocus image fusion.

Image fusion is generally performed at three different levels of information representation, including pixel-level, feature-level and decision-level [4]. This paper aims to suggest some ways to improve the pixel-level image fusion methods. Image fusion combines registered image to make a high quality fused image with spatial and spectral information. Multi-focus image fusion is a sub-field of image processing techniques in which the images of the same scene, taken by the same sensor, are combined to create a fully sharp and in-focus image. Image fusion has many important applications such as digital auto-focusing, microscopic imaging, remote sensing, and medical imaging, Weather forecasting and biometric images.Image fusion methods are classified under two groups :
1.Spatial domain fusion method 2.Transform domain fusion.

Spatial domain straight-forward works with the pixel values. To get the approporiate result, pixel values are manipulated. It is modifying or changing an image representing an object in space to further improve the image for a given application. Pixel level algorithms that fall under Spatial domain are Simple maximum, Simple minimum, Averaging, Intensity-hue-saturation(IHS) transform,Principal component analysis (PCA).

In frequency domain methods, image is initially transferred into frequency domain in order to caclulate Fourier transform followed by applying inverse fourier transform to produce resultant image. For identifying salient features, the transformed coefficients, each matches to a transform basis of image that are recognized. As a result, as stated in the information specified by transformed coefficients, it can decide the appropriate data provided from the source images to develop the final fused image. Types of Transform domain methods include Wavelet tranform, ContourletTransform.

Fuzzy logic is widely applied techniques as it allows the problems to be solved in linguistic term. The fuzzy sets and fuzzy membership functions are required for system implementation was carried out considering that the input image and the output image obtained after defuzzification are both 8-bit quantized; this way, their gray levels are always between 0 and 255. The original image in the gray level plane is subjected to fuzzification and the modification of membership functions is carried out in the membership plane. The result is the output image obtained after the defuzzification process.

2. MULTI FOCUS IMAGE FUSION USING WAVELET TRANSFORM

Wavelet transform is a type signal representation that can give the frequency content of the signal at a particular instant of time. In [5] the wavelet based image fusion process proposed in which steps mainly involved are registering source images, performing wavelet transform on each input images, then generating a fusion decision map based on a defined fusion rule and constructing fused wavelet coefficient map from the wavelet coefficients of the input images according to the fusion decision map. Finally, transform back to the spatial domain. Image fusion based on wavelet transform is the most commonly used approach, which fuses the source images information in wavelet domain according to some fusion rules.The block diagram of a generic wavelet based image fusion approach is shown in the Fig1 [6].

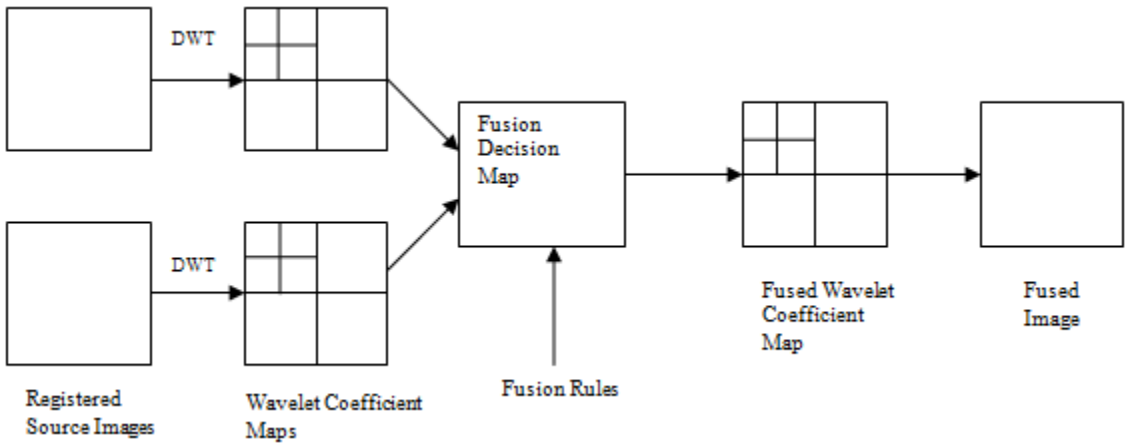

Figure 1: The generic structures of the image fusion using wavelet transform[6]

2.1 WAVELET BASED IMAGE FUSION ALGORITHM

Wavelets are localized waves .They have finite energy. They are suited for analyses of transient signal. They are finite duration oscillatory functions with zero average value. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities.

The steps involved in wavelet based image fusion algorithm are as following [7]

1. Read the set of images having same size (registered images).
2. Perform wavelet decomposition on both the images using filter.
3. Extracts horizontal, vertical, or diagonal detail from the wavelet decomposition structure.

4. Computes average of approximation coefficients of both decomposed images
5. Analyse horizontal, vertical and diagonal coefficient of both the images. Perform maximum selection scheme to select the highest coefficient value by differentiating the coefficient of the two images and implement this for all the pixel values of image i.e. m x n.
6. Apply wavelet decomposition on both the images with the help of different wavelet filters.
7. Apply inverse wavelet transform to reconstruct the resultant fused image and display the result

3. MULTI FOCUS IMAGE FUSION USING FUZZY LOGIC

Fuzzy image processing is not a unique theory. It is a collection different fuzzy approaches that understand, represent and process the images, their segments and features as fuzzy sets. Therepresentation and processing depend on the selected fuzzy technique and on the problem to be solved. Fuzzy logic derives from the fact that most modes of human reasoning and especially commonsense reasoning are approximate in nature. It allows computerized devices to reason more like humans. The fuzzy inference process can formulate the mapping from the inputs to the output using the membership functions, fuzzy logic operation and fuzzy control rules.[9]

Fuzzy set is a class of object grade of membership function. Fuzzy set represents spatial information in images along with its imprecision. Membership function that represents a graphical method. Participation of each input in the input space. Input space refer to universe discourse (or) set universal. MF's assign to each object a grade of membership ranging between [0,1]. Fuzzy logic operations are performed in Boolean operation (AND, OR, NOT). Fuzzy control rules are used to IF-then rules. Fuzzy inference process uses two main methods, which are Mamdani and Sugeno. Mamdani fuzzy inference systems require the output membership functions are fuzzy sets and this requires defuzzification. The Sugeno inference system uses the output Membership function's that is either constant or linear and this avoids the need for Defuzzification.[8]

3.1 FUZZY LOGIC IN IMAGE PROCESSING

Fuzzy process involves 3 main steps: Fuzzification, rules based on inference system and Defuzzification.

Fuzzification: The procedure that converts crisp numerical input values into linguistic variables.
Rules: if -then rules
Defuzzification: This process of producing a crisp output from the fuzzy response, the Defuzzifier is the aggregate output fuzzy set that covers a set of output values.

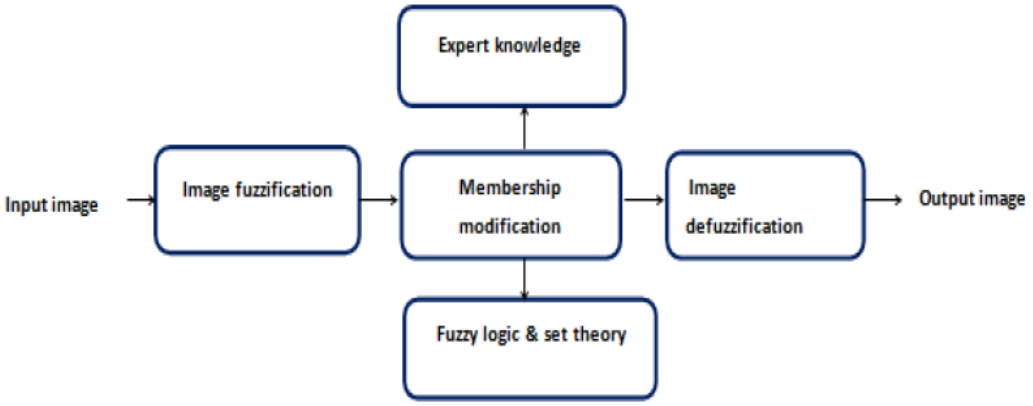

Figure 2: The generic structures of image fusion using Fuzzy Logic

3.2 PROPOSED IMAGE FUSION ALGORITHM

Algorithm steps for pixel level image fusion using Fuzzy Logic approach

1. Read the satellite blur images captured from two different cameras or sensors.

2. Resizing the images to keep both images of same size. (imresize function is used)

3. (Fuzzification) Decide number and type of membership functions for both the input images by tuning the membership functions. Input images in antecedent are resolved to a degree of membership ranging 0 to 255.

4. Create a fuzzy inference system using appropriate membership function and proper rules.

5. Fuse input images using the rules developed above on the corresponding pixel values of the input images which gives a fuzzy set represented by a membership function.

6. Apply DeFuzzification to obtain the final fused image.

3.3 STEPS INVOLVED IN IMPLEMENTATION

The fuzzy sets and fuzzy membership functions are required for system implementation. input image and the output image are both 8-bit quantized; this way, their gray levels are always between 0 and 255.

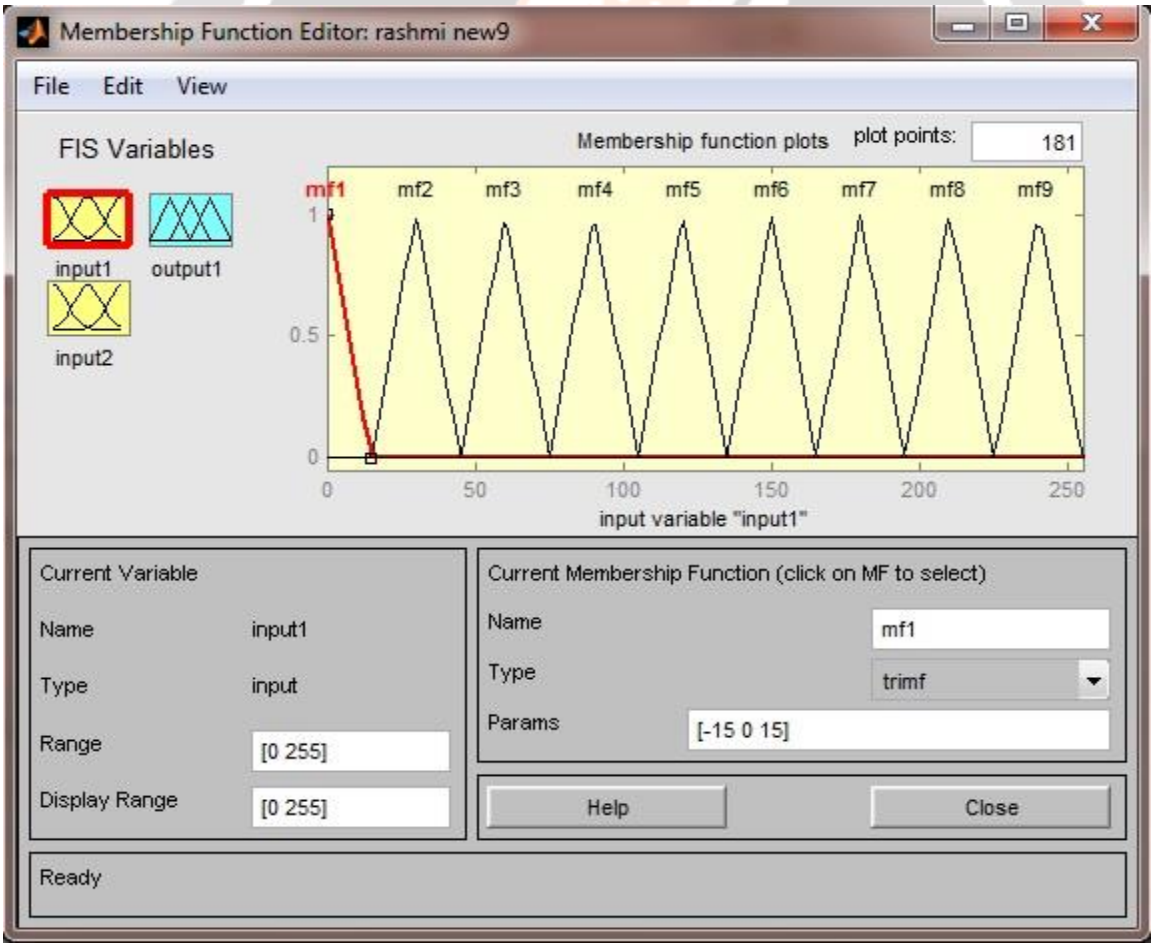

Figure 3: Membership Functions for Inputs

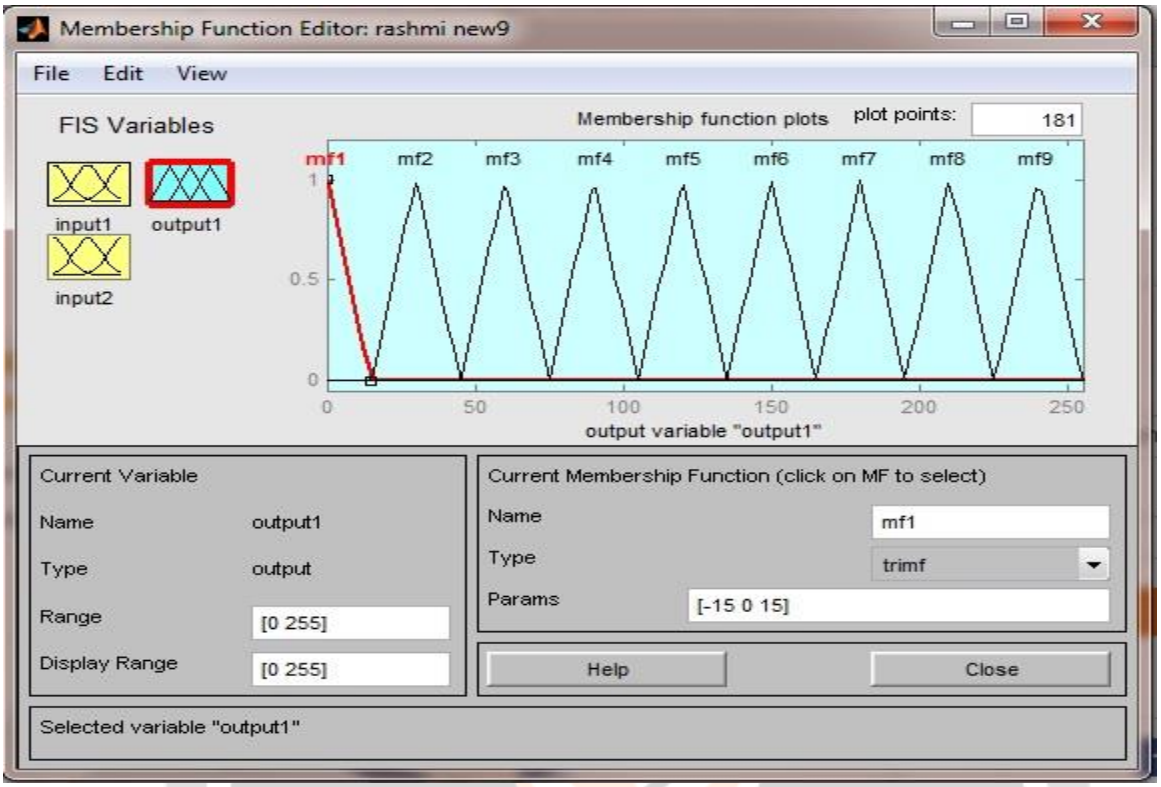

Figure 4 : Membership functions for Outputs

Rules considered in the fuzzy system are as follows:

Fuzzy Rules	**Mf1**	**Mf2**	**Mf3**	**Mf4**	**Mf5**	**Mf6**	**Mf7**	**Mf8**	**Mf9**
Mf1	Mf1	Mf1	Mf1	Mf1	Mf1	Mf1	Mf1	Mf1	Mf1
Mf2	Mf1	Mf2	Mf2	Mf2	Mf2	Mf2	Mf2	Mf2	Mf2
Mf3	Mf1	Mf2	Mf3	Mf3	Mf3	Mf3	Mf3	Mf3	Mf3
Mf4	Mf1	Mf2	Mf3	Mf4	Mf4	Mf4	Mf4	Mf4	Mf4
Mf5	Mf1	Mf2	Mf3	Mf4	Mf5	Mf5	Mf5	Mf5	Mf5
Mf6	Mf1	Mf2	Mf3	Mf4	Mf5	Mf6	Mf6	Mf6	Mf6
Mf7	Mf1	Mf2	Mf3	Mf4	Mf5	Mf6	Mf7	Mf7	Mf7
Mf8	Mf1	Mf2	Mf3	Mf4	Mf5	Mf6	Mf7	Mf8	Mf8
Mf9	Mf1	Mf2	Mf3	Mf4	Mf5	Mf6	Mf7	Mf8	Mf7

Table 1: Fuzzy Rules

4. Experimental Results

The experimental results of Wavelet transform and Proposed image fusion method (fuzzy Logic) for fusion of multifocus images are shown in figures.

Figure 5: Image from Sensor-1

Figure 6 : Image from Sensor-2

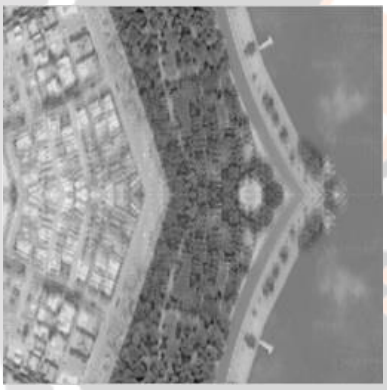

Figure 7: Fusion using DWT

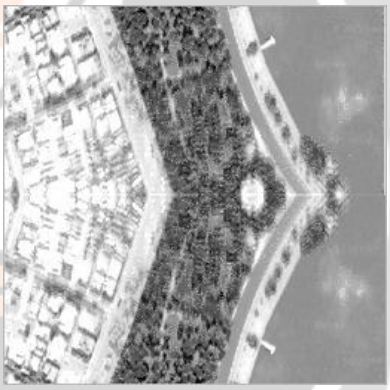

Figure 8 : Fusion using fuzzy Logic

To evaluate and compare the results of the algorithm designed in this paper with other algorithms, **PSNR (Peak signal to noise ratio) and NCC (Normalized cross correlation)** metrics are used. So, these two metrics are briefly explained.

PSNR (Peak signal to noise ratio)

PSNR computes the peak signal-to-noise ratio, in decibels, between two images. PSNR ratio is used as a quality measurement between the original and a newly constructed image. The higher the PSNR, the better is the quality of the reconstructed image. To compute the PSNR, first we have to compute the **Mean squared error (MSE)** using the following equation:

$$MSE = \Sigma M, N\ [If\ (m, n) - Ii\ (m, n)]^{2} / M * N \quad \text{..... (1)}$$

Here M and N are the number of rows and columns in the images to be compared. After the MSE calculation is over, the answer of the MSE is used to compute the PSNR using the following equation:

$$PSNR = 10\log10\ (R^{2} / MSE) \quad \text{..... (2)}$$

In this scenario R is the maximum fluctuation in the input image data type. For example, if the input image has a

double-precision floating-point data type, then *R* is 1. If it has an 8-bit unsigned integer data type, *R* is 255, etc .

NCC (Normalized Cross Correlation)

Normalized cross correlation are used to find out similarities between fused image and registered image is given by the following equation

$$NCC = \Sigma M, N [A_{ij} * B_{ij}] / \Sigma M, N [A_{ij}]^2 \quad \ldots\ldots\ldots \quad (3)$$

Where, A - the perfect image, B - the fused image to be assessed, i – pixel row index, j – pixel column index, M, N No. of row and column.

IMAGE FUSION TECHNIQUES	DWT		FUZZY LOGIC	
	PSNR	NCC	PSNR	NCC
Image-1 and IDEAL	38.1888	1.4154	38.1888	1.4154
Image-2 and IDEAL	36.3859	1.4162	36.3859	1.4162
FUSED IMAGE and IDEAL	45.7086	1.4156	50.7878	1.8808

Table 2 Quantitative analysis of fusion methods

4. CONCLUSIONS

Image fusion deals with integrating data obtained from different sources of information for intelligent systems. The discrete wavelet transform has become a very useful tool for fusion. The two images of the same object from different sources are fused using DWT algorithm and using fuzzy logic and then results are compared on the basis of performance parameters.With the help of experimental results on Multifocus images, we have proved that , The application of the fuzzy logic in image fusion would give an efficient and better fusion results than that obtained using Discrete wavelet transforms (DWT).

5. REFERENCES

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