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Comparative Analysis of Different Strategies of Image Fusion using Fuzzy logic

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Abstract

The term fusion means in general approach to extract information acquired in several domains. Image fusion is the process of integrating multiple images of same scene into a single fused image to reduce uncertainty, minimizing redundancy while extracting all the useful information from the source images. Fuzzy logic is very much useful in systems where there is no direct relation between input and output. In the process like image fusion there is no way of to find direct relation between intensity of every pixel of input image and output image. There has lot of uncertainty involved in the process. Fuzzy logic provides a way to create relation between intensity of every pixel of input and output image. This paper presents different strategies of image fusion using fuzzy logic. A comparative analysis of image fusion performance of different image fusion strategies using fuzzy logic applied on the images taken in different lighting condition gives the better approach to its future work.

Keywords: Fuzzy Logic, Image Fusion, Image Fusion Strategies, Image Fusion Performances

1. Introduction

Image fusion methods are divided into two types. First one is spatial domain image fusion and other one is transform domain image fusion. Spatial domain image fusion directly deals with the image pixels. Actually in spatial domain fusion process pixel values are manipulated to get desired results. Averaging, Principal Component Analysis[1], High Pass Filtering[2] are the example of spatial domain image fusion technique.

In transform domain image fusion, input images are firstly converted to frequency domain. In frequency domain all the fusion operations are done and then the result transferred back to spatial domain to get the resultant image. Example of Transform domain image fusion techniques are Discrete Wavelet Transform and Multi Wavelet Based image fusion[3], Contrast Pyramid based image fusion[4] etc. Main disadvantage of spatial domain image fusion approaches is that they generally produce lot of spatial distortion. Spatial distortion can be handled by transform

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domain approaches of image fusion. But the problem of using transform domain image fusion is that most of the time the resultant image have a less spatial resolution. Another important disadvantage of transform domain image fusion operation is complexity of the method. Most of the transform domain image fusion methods required very good fusion technique for better result. So, it is very important to develop a new and simple image fusion technique which is easy to implement and also meet the need of industry. Fuzzy logic[5] is very much useful in the cases where there no certain relation between inputs and outputs of the system. So, image fusion using fuzzy logic[6] will be a good way

Image fusion algorithm utilizing fuzzy rules to merge two images in terms of gray level values have been studied during last two decade. Surveillance systems of a restaurant, bar or disco have to deal with the images which are taken in extreme red, green or in any other lights. For this type of images, amount of information stored in red, green, blue domain differs a lot from the amount of information stored in gray scale version of that image. As an example, for an image taken in extreme red light, amount of information in red domain is much more than that of the grey scale domain. So, for this type of case, doing the fusion in grey scale domain is total waste of some vital information. Color Image fusion[7] where fusion done in red, green and blue domain separately can uses the information stored in input images more efficiently.

Doing the fusion in red, green and blue domain separately gives the flexibility of using different fuzzy inference system in different domain. For the fusion of images taken in very dark red light or green light different fuzzy inference system in red, green and blue domain is very much needed. For this types of images the amount of information in red, green, blue domain differs hugely from the information stored in gray scale domain. So using single fuzzy inference system, proper use of the information stored in different domain is not possible. To use the resources properly it is very much needed to create different fuzzy inference system in red, green and blue domain according to the input. This thing is very much true for all other cases.

Edge Preserving Image Fusion Technique[8] is very much necessary because edge strength of a pixel is high means that intensity of an image changes abruptly in this pixel. So, it is needed to give more priority on the intensity of pixel which has more edge strength because this pixel gives the viewer good visual perception. If edge strength of any pixel of one input image and edge strength of corresponding pixel of other image are same then no priority will be given to any input and a balanced fuzzy inference system has to be applied. If edge strength of any pixel of one input image is higher than that of edge strength of corresponding pixel of other image then more priority should be given on input which has better edge strength. In this way edge strength of the images can be used for better fusion.

2. Fuzzy Inference System

4 different strategies of image fusion using fuzzy logic has been used here. Firstly input images are fused in gray scale domain with an appropriate fuzzy inference system. Secondly these images are fused in red, green and blue domain separately with same fuzzy inference system. Thirdly these images are fused in red, green and blue domain separately with 3 different fuzzy inference system. Fourthly images are fused using a fuzzy logic where edge strength of every pixel along with intensity values are given to the system as input. All operation are done for the fusion of images which taken in very dark red or green lights also for the images taken in normal lighting condition.

2.1 FIS Used for First and Second Case

5 membership functions are used to represent intensity of two input images. 9 Constant membership functions are used to represent the inten-

Table 1. Rules for the system

Intensity of output image		Intensity of input image1				
		NB	NS	ZO	PS	PB
Intensity of input image2	NB	NB	NBM	NSM	NS	ZO
	NS	NBM	NSM	NS	ZO	PS
	ZO	NSM	NS	ZO	PS	PSM
	PS	NS	ZO	PS	PSM	PBM
	PB	ZO	PS	PSM	PBM	PB

sity of output image. In the membership function above, input and output variables are all as follow : { NB (negative big) ; NBM (negative big middle) ; NSM (negative small middle) ; NS (negative small) ; ZO (zero) ; PS (positive small) ; PSM (positive small middle) ; PBM (positive big middle) ; PB (positive big). Here every connection is 'or' and same weight is given to every rule. Table 1 represents the rules of this fuzzy inference system.

2.2 FIS for Third Case

Here different fuzzy logic is used in red, green and blue domain fusion giving more priority to one input. For the images taken in strong red or green or any other lights proposed fusion should be very useful because its gives more chance to use the information stored in the input images. For fusion of two images one taken in extreme red light and another one taken in extreme green light, in red domain fusion more importance is given to the image taken in red light. Similarly, in green domain fusion more importance is given to the images taken in green light.

Table 2. Rules for the system

Intensity of output image		Intensity on input image1 →						
		NB	NM	NS	ZO	PS	PM	PB
Intensity of input image 2 ↓	NB	NB	NBM	NSM	NS	ZO	PS	PSM
	ZO	NBM	NSM	NS	ZO	PS	PSM	PBM
	PB	NSM	NS	ZO	PS	PSM	PBM	PB

In this work triangular membership function are used for the representation of inputs. 7 membership functions are used to represent intensity of input image needed to give more priority. 3 membership functions is used to represent intensity of input image needed to give less priority. 9 Constant membership functions are used to represent intensity of output image. In the membership function above, input and output variables are all as follow : { NB (negative big) ; NSM (negative small middle); NM(negative middle) ; NBM (negative big middle) ; NS (negative small) ; ZO (zero) ; PS (positive small) ; PSM (positive small middle) ; PM (positive middle); PBM (positive big middle) ; PB (positive big) }. Here every connection is 'or' and same weight is given to every rule. Table 2 represents the rules of this fuzzy inference system.

2.3 FIS for Fourth Case

This is an edge based fuzzy inference system. Here edge strength of every pixel is also in consideration along with intensity of every pixel of

both images. Matrix which contains strength of the edge of every pixel is determined using sobel operator. These edge strength matrices of the two input images are fused to get a single matrix in a way such that this resultant matrix can carry edge information of both input images. Now question comes how to use this edge strength for fusion of these two input images. From the basic knowledge of image processing it is known thing that edge strength of a pixel is high means that intensity of an image changes abruptly in this pixel. So, it is needed to give more priority on the intensity of pixel which has more edge strength. If edge strength of any pixel of one input image and edge strength of corresponding pixel of other image are same then no priority will be given to any input and a balanced fuzzy inference system is applied. If edge strength of any pixel of one input image is higher than that of edge strength of corresponding pixel of other image then more priority should be given on input which has better edge strength. First step towards achieving goals of this section is edge fusion.

2.3.1 Edge Fusion

2 membership functions are used to represent edge of each input image. Edge strength of each input image is divided into two parts.

Table 3. Rules for the system

Edge srtrength of output matrix		Edge strength of input image1 →	
		NB	PB
Edge Strength of input image2 ↓	NB	ZO	PB
	PB	NB	ZO

Two parts are NB and PB. Output is divided into 3 parts. Two parts NB, ZO and PB. Here every connection is 'or' and same weight is given to every rule. Table 3 represents rule for the input output relationship of this system.

2.3.2 Edge Strength based Image Fusion

Result of edge fusion is actually used as one of three input to the edge based image fusion system. 5 membership functions are used to represent intensity of two input image. 2 membership functions are used to represent input 3 which is actually resultant edge matrix from edge fusion. 13 Constant membership function are used to represent intensity of output image. In the membership function above, input and output variables are all as follow : { NVB (negative very big); NB (negative big) ; NBM (negative big middle) ; NSM (negative small middle) ; NS (negative small) ; NVS(negative very small); ZO (zero) ; PVS(positive very small); PS (positive small) ; PSM (positive small middle) ; PBM (positive big middle) ; PB (positive big);PVB (positive very big) }

Table 4 describe the system's output intensity change with respect to both input images intensity change when third input to the system(resultant edge strength) belongs to first membership function (negative big) among of its two membership function (negative big, positive big). Table 5 describe the system's output intensity change with respect to both input images intensity change when third input to the system (resultant edge strength) belongs to second membership function (positive big).

3. Image Fusion Performance Measure

Experiment 1 done for the fusion of images which taken in very dark red or green lights. Experiment 2 done for fusion of images taken in

Table 4. Rules for the system

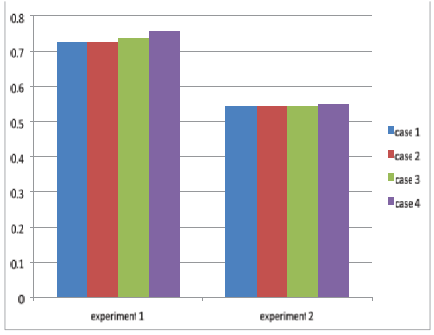
Intensity of output image		Intensity of input image1				
		NB	NS	ZO	PS	PB
Intensity of input image 2	NB	NVB	NB	NBM	NSM	NS
	NS	NBM	NSM	NS	NVS	ZO
	ZO	NS	NVS	ZO	PVS	PS
	PS	ZO	PVS	PS	PSM	PBM
	PB	PS	PSM	PBM	PB	PVB

normal lighting condition. In these two experiments, two different pairs of images are taken and fusion has done using different fusion strategies. Fusion performance, quality parameters of input and output images have measured. These results have analyzed from different point of view and different angle. Analyses of these data actually give a lot of idea about how fusion performance varied for fusion of two images using different fusion strategies. But it is important to compare this variation with the fusion of another two images. Because, it is very much necessary to know the impact of a fusion strategy for the fusion of different types of image. This analysis actually gives acceptability of one fusion strategy.

Primary requirement of any image fusion process is that it should preserve all the useful edge information from the source images. Objective image fusion performance measure proposed by Xydeas &

Table 5. Rules for the system

Intensity of output image		Intensity of input image1				
		NB	NS	ZO	PS	PB
Intensity of input image 2	NB	NVB	NBM	NS	ZO	PS
	NS	NB	NSM	NVS	PVS	PSM
	ZO	NBM	NS	ZO	PS	PBM
	PS	NSM	NVS	PVS	PSM	PB
	PB	NS	ZO	PS	PBM	PVB



Petrovic gives the measurement of how much edge information are returned to the fused image from the source images. Here among 4 different fusion strategies first and last, these two are gray scale fusion and in between these two are color fusion process. So, for comparative analysys of performance measure, QAB/F have been measured taking

gray scale version of both input and output images for both gray scale fusion and color fusion.

4. Conclusion

From fusion strategy-1 to fusion strategy-4, image fusion performance improved for the fusion of both types of images used here. For the fusion of images taken in very dark red, green light this improvement is very much significant. Here is clear indication of benefit of using different fuzzy logic red, green and blue domain when images taken in very dark red, green light. But the case is different where images are taken in normal lighting condition. Here the improvement is very less. So, for the images taken in normal lighting condition there is not much scope of benefit of using different fuzzy logic for the fusion in different domain. Experimental results reflect it. In the first experiment objective image fusion performance measure and quality of fused image improved significantly when different fuzzy logic are used for fusion in different domain. But same thing is not happened with second experiment. Here objective image fusion performance measure and quality of fused image not improved significantly. In edge strength based image fusion, fusion performance improved significantly from all other strategies for all type of images.

5. Scope for Future Work

Next step of this work will be use of edge strength of every pixel of input image for color fusion process. This edge based color fusion strategy will endorse to create more intense fuzzy inference system for fusion purpose. This fusion strategy will be more useful for the surveillance systems specially surveillance systems of restaurant, bar or disco where images are taken in very dark lighting condition.

6. References

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