Asian Journal of Applied Science and Technology (AJAST)
(Peer Reviewed Quarterly International Journal) Volume 2, Issue 4, Pages 194-205, Oct-Dec 2018

A Novel Optimized Mixed Spatial Domain Fusion Technique using Split Images

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Article Received: 30 May 2018 *Article Accepted: 29 September 2018* *Article Published: 17 November 2018*

ABSTRACT

The Objective of Image fusion is to combine the information content from two or more images of low entropy and to produce a high quality image for better visualization. Spatial domain fusion methods directly process input images at pixel level to produce a quality fused image. Many spatial domain techniques were proposed in the past. In this paper a novel optimized mixed spatial fusion approach is proposed by combining simple spatial and PCA based fusion technique to produce better fused image than single spatial technique. Here we apply the input images and corresponding fused image is obtained, with different RGB values for different techniques. The concept of PSO is a number of particles that constitute a swarm moving around in the search space and looking for the best solution. Each particle in the search space adjusts its "flying" according to its own flying experience as well as the flying experience of other particles. The experimental results show that optimized mixed spatial domain eliminates the draw backs of individual spatial domain approach.

Keywords: Image fusion, Maximum, Minimum, PCA, PSO.

1. INTRODUCTION

Image fusion is widely recognized as an important technique in pattern recognition and computer vision. Image fusion is the process of combining or mixing information content from two or more source images and transferred to one composite image. The composite image will be more informative than any of the input source images. General model of image fusion is shown in figure 1.

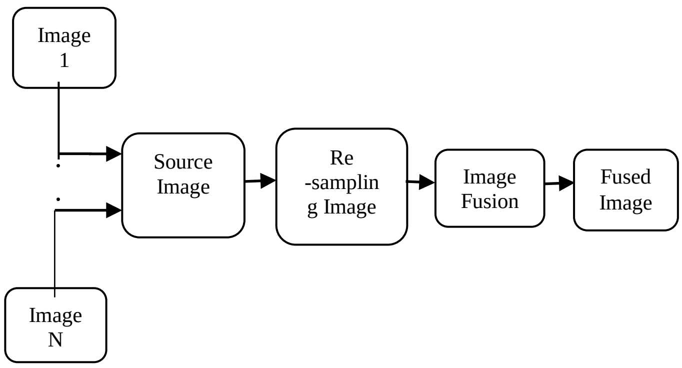

Figure 1. General Model for image fusion.

Image fusion techniques can be classified into two groups' i.e. spatial domain fusion and transform domain fusion [1]. Most popular spatial domain fusion techniques simple, Brovey, principal component analysis, Intensity hue saturation and high pass filtering. Image fusion operation can be performed into three levels, namely: low or pixel level middle or feature level and high or decision level [15], [16], [17], [18]. The Pixel level fusion works directly on the pixels obtained at imaging sensor outputs [13]. Feature-level fusion methods work on the features extracted from the source images and typically segment the image into contiguous regions and fuse the regions together using

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their properties. The decision-level fusion method uses the outputs of initial object detection and classification as inputs to the fusion algorithm to perform the data integration. Inaccurate and incomplete transfer of information from both feature level and decision level image fusion operations. Feature and decision level fusion techniques produce loss of information during the fusion process [19].

1.1 Image Fusion Techniques

Image Fusion can be broadly classified into two types namely spatial and transform domain fusion. Spatial domain image fusion is shown in figure 2. It directly deals with the position of pixels of the source image. In spatial domain fusion pixel values are directly manipulated to achieve desired result. The transform domain operates on fourier transform. Image is first transferred in to frequency domain all the fusion operations are performed on the fourier transform of the image and then the inverse fourier transform is performed to get the resultant fused image. The drawbacks of spatial domain approach are that it produces spectral distortion and spatial degradation in the fused image [2] and [20].

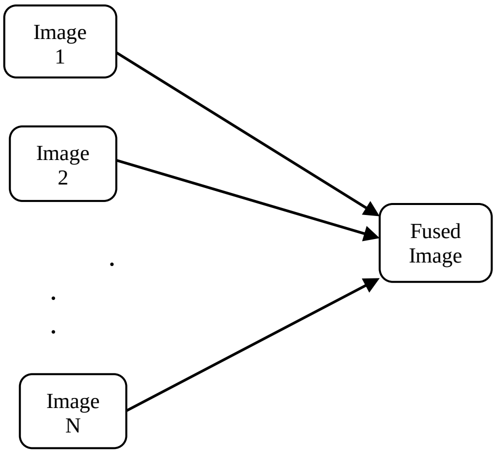


Figure 2. Spatial domain Image Fusion.

The PCA methods produce considerable spectral distortion [3]. Image fusion using pixel level methods are affected by blurring effect which directly affects the contrast of the image [4], [5] and [6]. In these techniques spatial fusion methods is effective only for a specific image fusion category. Combining the spatial domain methods shall yield better fusion results than single spatial domain method. With this idea we have developed an optimized mixed fusion method that combines the benefits of different spatial domain fusion methods to yield a better fusion strategy. Experimental analysis show that our technique is giving better fusion results both visually and quantitatively. The rest of the paper is discussed as follows Section 3 discusses the existing spatial domain fusion techniques, PCA, simple fusion techniques and PSO. Section 4 discusses the proposed mixed fusion techniques using split images and combination of spatial domain techniques and application of PSO. Section 5 presents the experiential and performance characteristics of the results obtained for the proposed method and Section 6 concludes the paper.

 Online ISSN: 2456-883X

2. EXISTING SPATIAL DOMAIN FUSION TECHNIQUES

2.1 Principal Components Analysis (PCA)

Principal component analysis was first invented in 1901 by Karl Pearson as an analogue of the principal axes theorem in mechanics [21], Later it was developed by Harold Hotelling in the 1933s [22]. The method is mostly used as a tool in exploratory data analysis and for making predictive models. Principal component analysis is a statistical. PCA can be done by Eigen value decomposition of a data covariance matrix usually after mean centering and normalizing the data matrix for each attribute. The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores and loadings [7]. Most of the image fusion techniques were based on principle component analysis [8]. The following steps involved the use of PCA algorithm for fusion [20].1) Create the column vectors, of the source images. 2) Calculate the covariance matrix of the two column vectors formed in step1. 3) The diagonal elements of the 2 × 2 covariance vector would contain the variance of each column vector with itself, respectively. 4) Calculate the Eigen vectors and the Eigen values of the covariance matrix. 5) Normalize the column vector corresponding to the larger Eigen value by dividing each element with mean of the Eigen vector. 6) The values of the normalized Eigen vector act as the weight values which are respectively multiplied with each pixel of the input images. 7) Sum of the two scaled matrices calculated in step 6 will be the fused image matrix.

2.2 Simple Fusion

Simple fusion method selection process is performed here for corresponding pixel in the source images; the pixel with maximum or minimum intensity is selected, respectively, and is put in as the final resultant pixel of the fused image [2], [20].

2.2.1 Simple Maximum Method: In this method, the final fused image is obtained by selecting the maximum intensity of corresponding pixels from both the input image [2], [20]. Maximum intensity of image is defined as

$$F(i,j)=\sum_{i=1}^{N}\sum_{j=1}^{N}\max A(i,j)B(i,j) \qquad (1)$$

Where A and B are source images and F is resultant fused image.

2.2.2 Simple Minimum Method: In this method, the final fused image is obtained by selecting the minimum intensity of corresponding pixels from both the input image [2]. Select minimum method pixel level is affected by blurring effect which directly affects the contrast of the image [4] and [20]. Minimum intensity of image is defined as

$$F(i,j)=\sum_{i=1}^{N}\sum_{j=1}^{N}\min A(i,j)B(i,j) \qquad (2)$$

Where A and B are source images and F is resultant fused image.

2.3 Optimization Using PSO

Elber hat and Kennedy in 1995 developed the Particle Swarm Optimization in revolutional computing techniques which is population-based optimization tool. Here N denotes the number of particles in a swarm. Altogether there are three attributes of a particles, the particles current position x_i, current velocity v_i and local best position p_i in the search space to present their features. In the search process, the particle successively adjusts its position towards the global optimum according to two factors. The first factor is the best position encountered by itself is each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best *pbest*. The second factor is encountered by whole swarm another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle. This value is called *gbest*.

3. PROPOSED OPTIMIZED MIXED FUSION TECHNIQUES

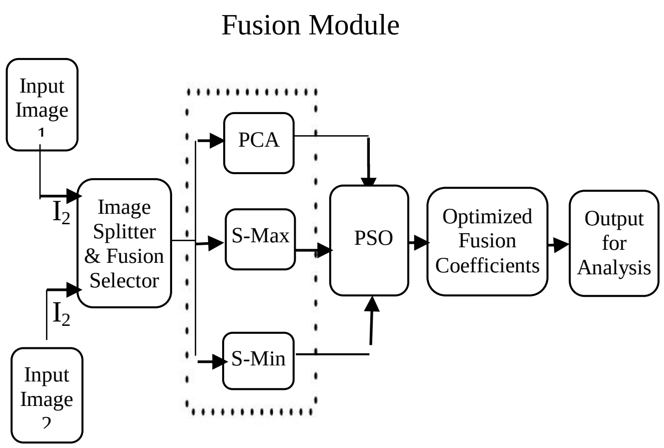


Figure 3. Proposed mixed split image approach

In this technique two input images are taken and fusion techniques are independently applied to the slices of input images instead of the whole image each input image is divided in to four sub images corresponding to each quarter.

First input image $I_1 = \{i_{11}, i_{12}, i_{13}, i_{14}\}$

Second input image $I_2 = \{i_{21}, i_{22}, i_{23}, i_{24}\}$

Where, I is input image and i_1, i_2, $i_3.i_4$ corresponding to each the four quarters of I respectively. Two input images are divided to four quarters. Instead of applying the fusion to the whole image pair, the proposed technique applies fusion to pair of sub images, i.e. i_{11} and i_{21} for the set of four pairs $\{i_{11}, i_{21}\}$, $\{i_{12}, i_{22}\}$, $\{i_{13}, i_{23}\}$, $\{i_{14}, i_{24}\}$. Three fusion methods are applied to the sub images. Finally simple max, simple min and PCA sub images are applied to the Particle Swarm Optimization. PSO optimize the maximum coefficient or maximum pixel from the output image in simple max, simple min and PCA.

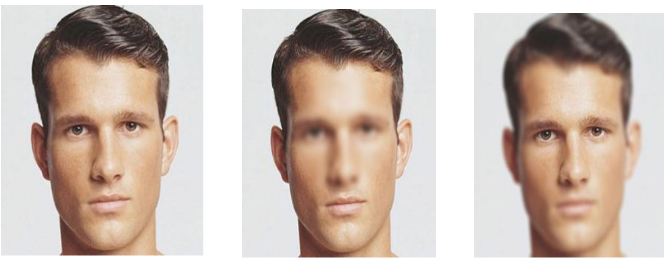
The algorithm corresponding to the above mixed fusion is given below

begin

1. *Get input images I_1, $I_{2;}$*
2. *Split I_1 and I_2 in to four sub images;*
3. ***for** i=1 to 4*
4. *get pair of slices of input images I_1,i, I_2,i*
5. *Apply PCA, simple maximum, simple minimum fusion on each pair;*
6. *Apply PSO for selecting optimization coefficient from PCA, simple maximum, simple minimum fusion on each pair;*
7. ***next i***
8. *Select the best fusion output for each pair;*
9. *Re construct resultant mixed fusion image I_{mf};*
10. ***End***

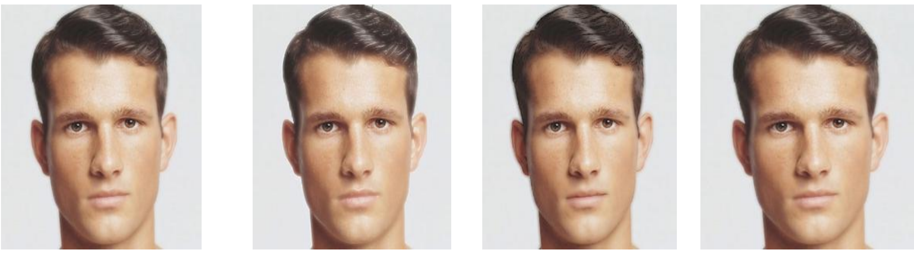
4. EXPERIENTIAL EVALUATION

50 samples input images are taken from ORL database for the study each input image represent clear, frontal face of a typical person. Then 20% noise (blur) is applied at the centre of the face, approximately 20% composite noise (blur) is applied to the outer edges of the face, they by two sets of poor quality images are created for each of the input face. Totally 100 pairs of poor quality images are created. For each pair of input images, the algorithm proposed in section 4 is run using MAT LAB 7.0, 150 fused images are created for implemented fusion techniques (PCA, simple maximum and simple minimum) and 50 fused images are obtained from mixed fusion techniques. The parameter SNR, PSNR, MSE and MD are evaluated. The measured value of average of these performance metrics are presented in table 1-6.



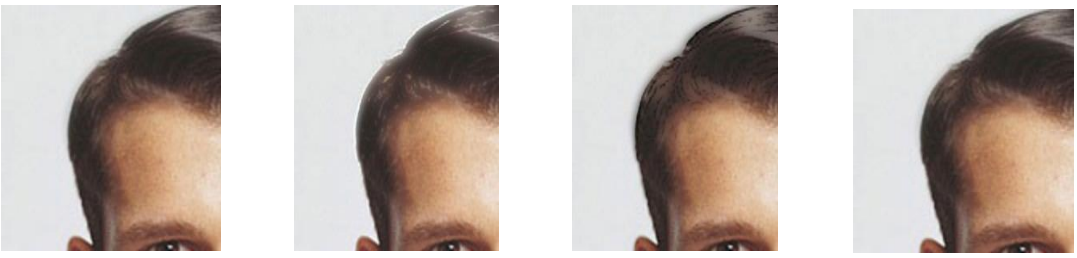
(a) (b) (c)

Figure 4. Input sample images. (a) Original (b) Centre blur image (c) Outer blur image.



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

Figure 5. Fused whole output images (a) PCA (b) Simple Maximum (c) Simple Minimum (d) Optimized Coefficient Image.

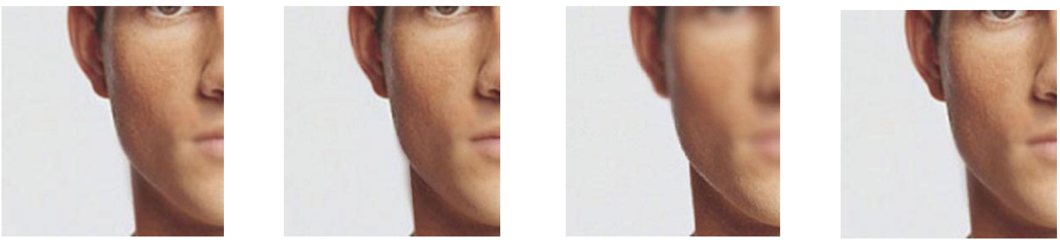


(a) (b) (c) (d)

Figure 6. Mixed fusion output for LST. (a) PCA (b) Simple Maximum (c) Simple Minimum (d) Optimized mixed fusion.

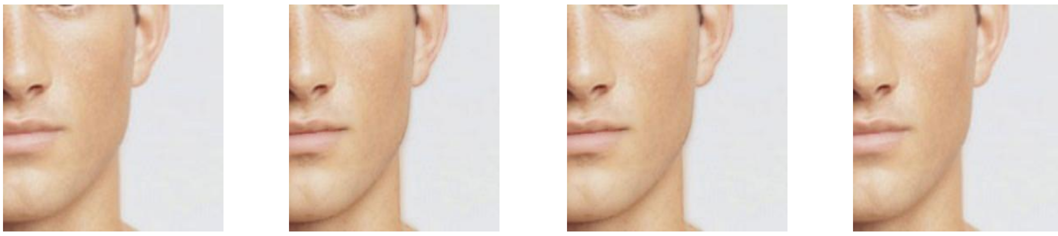
(a) (b) (c) (d)

Figure 7. Mixed fusion output for RST. (a) PCA (b) Simple Maximum (c) Simple Minimum (d) Optimized mixed fusion.



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

Figure 8. Mixed fusion output for LSB. (a) PCA (b) Simple Maximum (c) Simple Minimum (d) Optimized mixed fusion.



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

Figure 9. Mixed fusion output for RSB. (a) PCA (b) Simple Maximum (c) Simple Minimum (d) Optimized mixed fusion.

Table 1. Comparison Whole images fused result using face image.

	Para meter	PCA	Maximum	Minimum	Optimized Coefficient
Red	SNR	0.997	0.979	1.021	1.0105
	PSNR	36.71	34.60	34.45	38.9718
	MSE	13.84	22.50	23.29	8.2394
	MD	71	70	132	130
Green	SNR	0.997	0.979	1.021	1.0105
	PSNR	36.28	34.19	34.05	40.0709
	MSE	15.29	24.72	25.58	6.3972
	MD	72	61	141	90
Blue	SNR	0.997	0.979	1.021	1.0105
	PSNR	36.06	33.99	33.89	40.0665
	MSE	16.07	25.93	26.50	6.4037
	MD	68	62	129	123

Table 2. Comparison of Left Side Top (LST) fused result using face image.

	Para meter	PCA	Maximum	Minimum	Optimized Coefficient
Red	SNR	1.007	0.983	Inf	1.0286
	PSNR	35.56	33.32	33.51	36.3948
	MSE	18.06	30.27	28.94	14.9142
	MD	87	82	93	83

Green	SNR	1.007	0.983	0.781	1.0286
	PSNR	35.69	33.45	33.53	36.7889
	MSE	17.53	29.37	28.84	13.6203
	MD	69	60	95	86
Blue	SNR	1.007	0.983	0.761	1.0286
	PSNR	35.63	33.34	33.49	36.9426
	MSE	17.76	30.09	29.08	13.1469
	MD	64	59	100	89

Table 3. Comparison of Right Side Top (RST) fused result using face image.

	Para meter	**PCA**	**Maximum**	**Minimum**	**Optimized Coefficient**
Red	SNR	1.011	0.984	1.049	1.0369
	PSNR	33.85	32.24	32.21	35.2906
	MSE	26.78	38.75	39.04	19.2320
	MD	82	78	124	116
Green	SNR	1.011	0.984	1.049	1.0369
	PSNR	33.70	32.12	32.13	35.2839
	MSE	27.68	39.81	39.80	19.2613
	MD	68	66	131	107
Blue	SNR	1.011	0.984	1.049	1.0369
	PSNR	33.64	32.04	32.05	35.6209
	MSE	28.12	40.59	40.55	17.8232
	MD	69	63	129	106

Table 4. Comparison of Left Side Bottom (LSB) fused result using face image.

	Para meter	**PCA**	**Maximum**	**Minimum**	**Optimized Coefficient**
Red	SNR	1.008	0.996	1.021	1.0166
	PSNR	38.04	37.34	36.71	40.3004
	MSE	10.19	11.98	13.85	6.0679
	MD	58	57	60	57
Green	SNR	1.008	0.996	1.021	1.0166
	PSNR	37.22	36.58	35.92	39.4799
	MSE	12.32	14.26	16.60	7.3298

	MD	52	52	71	62
Blue	SNR	1.008	0.996	1.021	1.0166
	PSNR	37.17	36.35	35.80	39.8324
	MSE	12.45	15.06	17.09	6.7584
	MD	51	50	71	65

Table 5 Comparison of Left Side Top (RSB) fused result using face image.

	Para meter	**PCA**	**Maximum**	**Minimum**	**Optimized Coefficient**
Red	SNR	1.002	0.993	1.013	1.0097
	PSNR	40.45	39.65	38.77	43.0844
	MSE	5.856	7.036	8.615	3.1962
	MD	74	70	80	70
Green	SNR	1.002	0.993	1.013	1.0097
	PSNR	38.65	37.90	37.02	41.2557
	MSE	8.869	10.52	12.88	4.8698
	MD	83.53	82	85	82
Blue	SNR	1.002	0.993	1.013	1.0097
	PSNR	37.57	36.42	35.99	40.0815
	MSE	11.36	14.82	16.33	6.3817
	MD	79	75	83	75

Table-6. Comparison of PSNR.

PSNR				
	Whole image	**Whole images- Optimized mixed fusion**	**Split Images**	**Split Images- Optimized mixed fusion**
Maximum	34.26	39.7030	35.054	38.363
Minimum	34.13		34.350	
PCA	36.35		36.430	

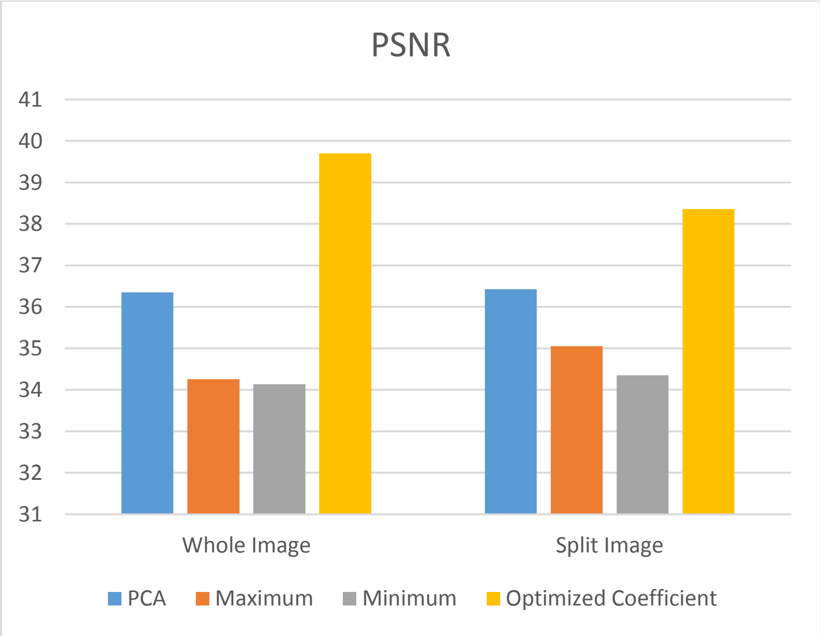


Fig.10. Comparison of Whole image and mixed fusion image on PSNR.

On applying the simple max, simple min, PCA and optimized mixed fusion, it is observed that the proposed optimized mixed fusion method gives the best result. PSNR for optimized mixed image I_{mf} is taken as the average of PSNR of four quarter of the optimized mixed fused image. It is observed that the peak signal-to-noise ratio has higher value for optimized mixed fused image; it means the fused image by optimized mixed fusion gives higher information than the fused image produced by max, min and Principal Component Analysis scheme. This can be verified with the help of the metric table 6.

5. CONCLUSION

This paper performs the image fusion using optimized mixed spatial domain fusion technique. The input images are partitioned in to four slices. Spatial domain fusion technique is applied to each pair of input images the best fusion of for each slice is derived. PSO is applied to retrieve the optimized fusion coefficient. The result is then combined to produce the original image. This fusion approach produces best result compare individual spatial domain. The optimized mixed fusion method is producing the best results than individual spatial domain techniques. Experimental results show that optimized mixed spatial domain techniques provide high spatial resolution and the proposed approach performs better in both visually and quantitatively.

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