SPATIAL DOMAIN IMAGE FUSION TECHNIQUES

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Abstract

The target of Image fusion is to join the information from number of images of a similar scene from various sensors or the images with spotlight on various objects. The after effect of image fusion is a image which is progressively enlightening and of better quality. In this paper a definite overview of primitive and principal component analysis for spatial domain image fusion techniques is finished. . Based on the study an improved spatial domain fusion system is proposed. The proposed spatial domain strategy output performs as the state of the art spatial domain techniques.

Keywords: Spatial Domain, primitive, PCA

1. Introduction

Image fusion is the way toward combining information at least two images of a similar scene with the goal that the resultant image will be increasingly appropriate for human and machine perception or further image processing tasks such as segmentation, feature extraction, and target recognition [1]. Image fusion is pertinent to numerous fields including PC vision, medical imaging, and remote detecting. Image fusion is generally performed in spatial domain or transform domain. This paper presents a comprehensive survey of special domain techniques such as Select Maximum /Minimum and PCA [2], [3], [4].

This paper is sorted out as pursues: section 2 presents brief portrayal of spatial domain image fusion techniques, section 3 performance estimates parameter of fusion procedures, section 4 proposed approaches of fusion techniques, section 5 resultants are discussion and section 6 conclusions this paper.

2. Image Fusion Techniques

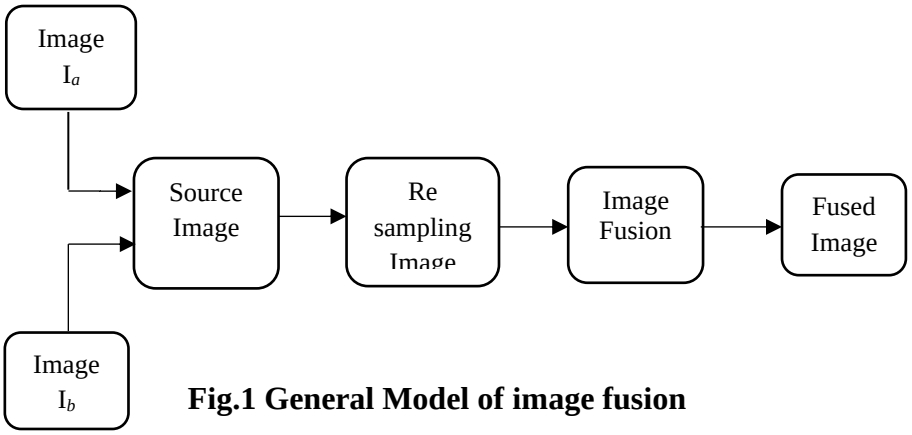

Fig.1 General Model of image fusion

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The objective of image fusion is to coordinate basic information from multimodality images with goal that the new images are more suitable for the purpose of human visual discernment and PC processing. All of the given images are fused to shape a resultant image, whose quality is better than any one of the information images. The process of image fusion is presented in Fig.1. Image fusion technique can be exhaustively requested into two strategies. They are spatial domain fusion technique and transform domain fusion strategy. The spatial domain method, directly manages with the pixels of the information image. The pixel values are manipulated to achieve desired outcome. In the transform domain methods the image is first transferred in to frequency domain i.e. the Fourier transform of the image is computed first. All the fusion activities are performed on the fourier transform of the image and then the inverse fourier transform is performed to get the resultant image.

Image Fusion applied in every field such as medical image analysis, microscopic imaging, analysis of images from satellite, remote detecting application, PC vision, robotics, and so on [5], [6]. Image fusion schemes methods of simple image fusion consists of averaging, Select max / min [2], and principal component analysis (PCA) [7], [8]. These strategies fall under spatial domain techniques. The detriment of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing such as classification problem [9].

2.1 Simple Primitive Fusion (SPF)

The image fusion method plays out a fundamental activity such as pixel selection, addition, subtraction and averaging. These procedures are not continually convincing yet are on occasion basic dependent on the sort of image under thought. A choice procedure is performed here wherein, for every comparing pixel in the information image, the pixel with Max/Min intensity is chosen, individually, and is placed in as the resultant pixel of the fused image [10].

***2.1.1 Simple Maximum Techniques (F_M)*:** In this strategy, the resultant fused image is acquired by choosing the maximum intensity of comparing pixels from both the information images [11].

$$F_M(i,j) = \sum_{i=1}^{M}\sum_{j=1}^{N} \max\{I_a(i,j), I_b(i,j)\} \qquad (1)$$

Where $I_a(i,j)$ and $I_b(i,j)$ are information images and $F_M(i,j)$ is fused image.

***2.2.2 Simple mid-Maximum Techniques (F_{mM})*:** In this technique, the resultant fused image is obtained by taking the mid- maximum intensity of comparing pixels from both the information images.

$$F_{mm} = \sum_{i=1}^{M}\sum_{j=1}^{N}\left[\frac{\max[I_a(i,j), I_b(i,j)] + av[I_a(i,j), I_b(i,j)]}{2}\right] \qquad (2)$$

Where $I_a(i,j)$ and $I_b(i,j)$ are information images and $F_{mM}(i,j)$ is fused image.

***2.2.3 Simple Average Techniques (F_a)*:** In this strategy, the resultant fused image is acquired by taking the average intensity of comparing pixels from both the information images.

$$F_a(i,j) = \sum_{i=1}^{M}\sum_{j=1}^{N}\left[\frac{I_a(i,j)+I_b(i,j)}{2}\right] \quad (3)$$

Where I_a(i,j) and I_b(i,j) are information images and F_a (i,j) is fused image.

2.2.4 Simple mid-minimum Techniques (F_{mm}): In this technique, the resultant fused image is obtained by taking the mid-minimum intensity of comparing pixels from both the information images.

$$F_{mm} = \sum_{i=1}^{M}\sum_{j=1}^{N}\left[\frac{av[I_a(i,j),I_b(i,j)]+\min[I_a(i,j),I_b(i,j)]}{2}\right] \quad (4)$$

Where I_a(i,j) and I_b(i,j) are information images and F_{mm}(i,j) is fused image.

2.2.5 Simple minimum Techniques (F_m): In this procedure, the resultant fused image is gotten by choosing the minimum intensity of comparing pixels from both the information images. [12].

$$F_m(i,j) = \sum_{i=1}^{M}\sum_{j=1}^{N}\min\{I_a(i,j),I_b(i,j)\} \quad (5)$$

Where I_a(i,j) and I_b(i,j) are information images and F_m(i,j) is fused image.

In primitive method all non-focused objective are acquired to be engaged in the single yield image. This strategy attempts to put prepared an incentive for pixels to make the fused image. In the wake of getting their aggregate we take its F_M, F_{mM}, F_a, F_{mm}, and F_m. The last yield image of the relating pixel F_M, F_{mM}, F_a, F_{mm}, and F_m worth are relegated. This procedure is proceeding for all the pixel values.

2.2 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a measurable procedure that utilizations symmetrical transformation to convert a set of perceptions of possibly correlated factors into a set of values of linearly uncorrelated factors called principal components analysis [13]. The PCA strategy is like the IHS technique [14]. Principal component analysis is a statistical or numerical technique. It is an amazing tool for break down information. The primary preferred positions of PCA are decreasing the quantity of dimensions without much loss of information. The following steps describe the use of PCA algorithm for image fusion [15]. 1. Create the column vectors of the information images. 2. Calculate the covariance matrix of the two column vectors formed in step1. 3. The corner to corner components of the 2x2 covariance vector would contain the variance of each column vector with itself, separately. 4. Compute the eigen vectors and the eigen values of the covariance matrix. 5. Standardize the column vector relating to the larger eigen value by dividing every element with the mean of the eigen vector. 6. The values of the Standardized eigen vector act as the weight values which are individually multiplied with each pixel of the information images. 7. Aggregate of the two scaled frameworks determined in step 6 will be the fused image matrix.

PCA produces the coefficients of ideal weighting regarding the information content and furthermore the evacuation of excess without loss of information. At that point the

performing of a PCA to the covariance matrix, the weightings for each information image are acquired from the eigenvector to the comparing of the largest eigen value.

Since primitive spatial techniques act at pixel level, they are influenced by blurring effect which directly effects on the contrast of the image but PCA strategy produces spectral degradation [16]. The trivial image fusion techniques strategies perform a exceptionally essential operation for example, pixel selection, addition, subtraction or averaging. These techniques are not always effective but are at times critical based on the kind of image under through. A selection process is performed here wherein, for each corresponding pixel in the information images, the pixel with max/min intensity is selected, individually, and is put in as the resultant pixel of the fused image [2]

3. Performance Measures

The general necessities of a fusing procedure are that it should protect all legitimate and useful pattern information of the source images; simultaneously it should not present artifacts that could meddle with subsequent analyses. The performance measures used in this paper give some quantitative comparison among various fusion schemes, mainly aiming at measuring the meaning of an image.

3.1 Peak Signal to Noise Ratio (PSNR): The PSNR block registers the peak signal-to-noise ratio, in decibels, between two images. This proportion is frequently utilized as quality estimation between the original and a fused image. The higher value of peak signal-to-noise Ratio the better is the fused outcome. The PSNR is characterized as:

$$\text{SNR} = 10 \log_{10}\left[\frac{MAX^2_I}{MSE}\right] \qquad (6)$$

Where MAXI is the maximum conceivable pixel value of the image and MSE is the Mean Square Error values. When the pixels are represented utilizing 8 bits for every sample, this is 255.

3.2 Signal-to-Noise Ratio (SNR): The fused image is fundamentally difference between the signal image and the fused image. The larger the signal-to-noise ratio value, better the fused result. The SNR is characterized as:

$$\text{SNR} = \left[\frac{I_n}{I_s}\right] \qquad (7)$$

Where I_n is noise image and I_s is signal image.

3.3 Root Mean Square Error (RMSE): The Root Mean Square Error (RMSE) is an outstanding parameter to assess fused image. It represents the amount of deviation present in fused image contrasted with reference image. The RMSE is determined between fused image and standard reference image. RMSE is characterized as:

$$\text{R MSE} = \sqrt{\frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}[A(i,j) - B(i,j)]^2} \qquad (8)$$

Where *A (i, j)* and *B (i, j)* are the reference and fused images, separately, i and j are image dimensions, and m*n is the size of the image.

3.4 Entropy (EN): Entropy is a proportion of information amount contained in an image. It reflects the measure of information in the fused image. The larger the EN is, the more information the image carries. If the value of entropy becomes higher after fusing, it demonstrates that the information increments and the fusion exhibitions are improved. Entropy is characterized as:

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i \quad (10)$$

Where L is the total of grey levels, $p = \{p0, p1, p2\ldots\ldots pl\text{-}1\}$ is the probability distribution of each level.

4. PROPOSED METHOD

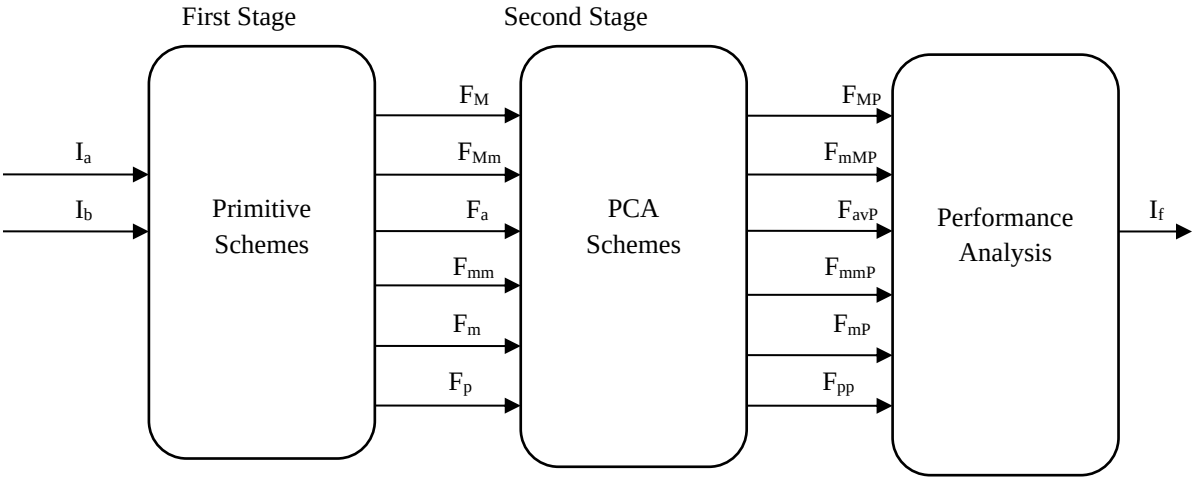
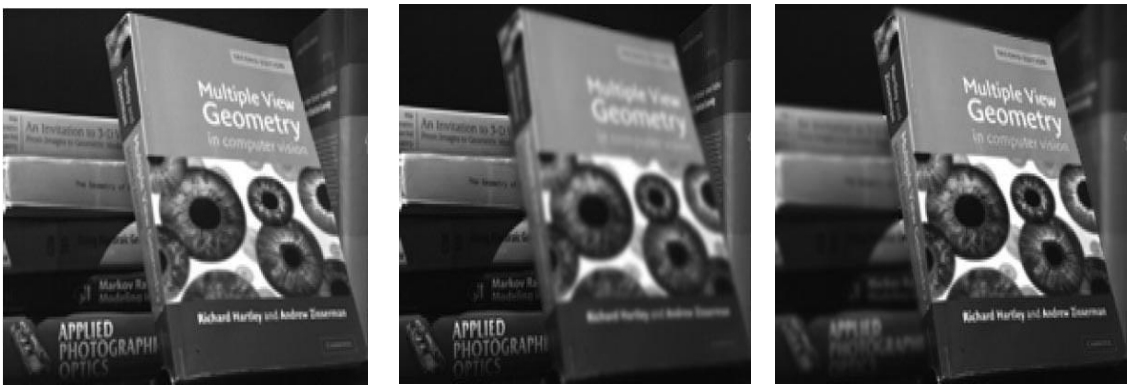


Fig.2 Proposed Two Stage Fusion

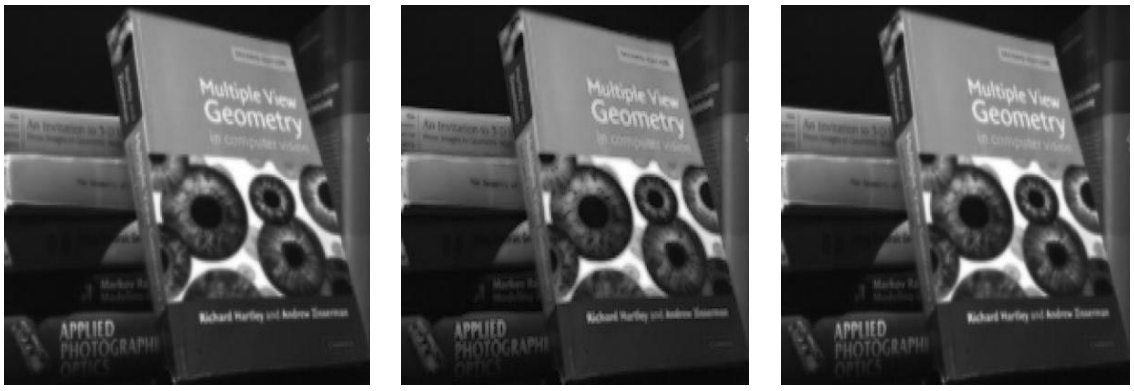
This proposed strategy considers just two information images (image $I_a(i,j)$ and image $I_b(i,j)$). The proposed spatial domain approach consists of two phases of fusions. Stage1 fusion utilises any one of the primitive methods and Stage 2 fusion uses PCA method. The process of Two Stage Fusion (TSF) approach is shown in fig 2. The proposed image fusion scheme uses gray scale images. Initially, the original source images I_a and I^b are applied to first stage fusion. The first stage fusion consists of primitive method. Primitive image fusion stage is fusing the five source images and selecting the F_M, F_{mM}, F_a, F_{mm}, and F_m intensity of fused image. These fused images are applied to the second stage fusion. The second stage fusions consist of Principle Component Analysis method. PCA image fusion stage is consolidated together to yield a better fuse average image. PCA image fusion stage is fusing the five source images and selecting the F_{MP}, F_{mMP}, F_{aP}, F_{mmP}, and F_{mP} intensity of fused image.

5. Experiential Result And Analysis

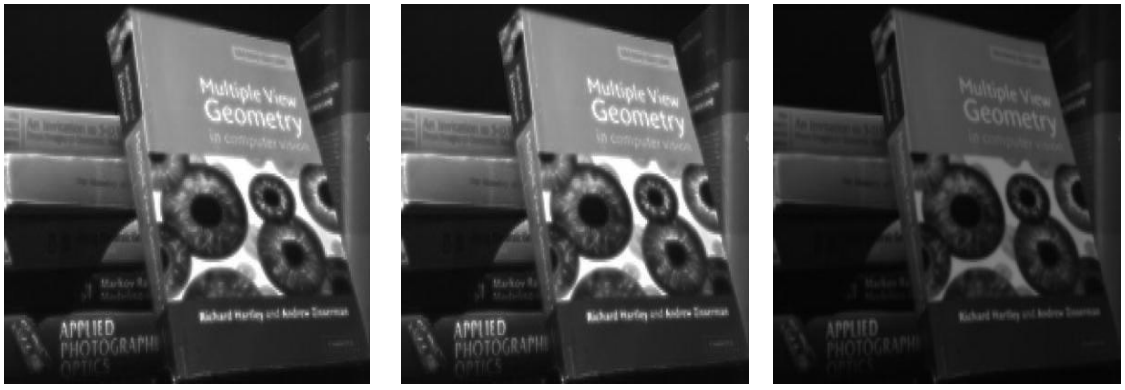


(a) (b) (c)

Fig. 3 image Book-(a) Original image (b) foreground (I_{fb}) image (c) background blur (I_{bb}) image



(a) (b) (c)



(d) (e) (f)

Fig.4 Proposed TSF Scheme- (a) F_{PP} (b) F_{MP} (c) F_{mMP} (d) F_{aP} (e) F_{mmP} (f) F_{mP}

Table -1 Comparison of Proposed TSF Scheme

Method	EN	RMSE	PSNR	SNR
F_{PP}	9.66	8.34	29.09	6.39
F_{MP}	7.44	9.30	23.10	5.13
F_{mMP}	7.14	9.22	20.59	5.11
F_{aP}	7.14	9.31	18.62	5.45
F_{mmP}	7.40	9.24	19.66	5.99
F_{mP}	6.14	10.43	19.98	3.79

In this section, the exhibition of the proposed Two Stage Fusion (TSF) is evaluated in term of Image Quality Metrics (IQM) presented in section 3. 50 examples information images are taken from ORL database for the investigation each information image and various characteristics. A sample Book image is illustrated in fig 3. For the experiment, grayscale image with standard dimension 256*256 pixels is used. In the experimental study, the first image shown in fig 3 (b) is manipulated with 30% blur on the foreground image (I_{fb}) and clear focus on the back-ground image. The second image shown in fig 3 (c) is manipulated with 30% blur on the back-ground image (I_{bb}) and clear focus on the foreground image. Absolutely 100 sets of poor quality images are made. For each pair of information images, the algorithm proposed in section 4 are run utilizing MATLAB10 and 100 fused images are created from proposed Two Stage Fusion (TSF) technique (F_{MP}, F_{mP}, F_{aP}, F_{mmP}, F_{mP}, and F_{PP}). Performance metrics are measured and the average performance metric values for 100 images are computed and are compared with the existing spatial domain primitive and PCA based schemes.

6. Conclusion

This paper plays out the review of Image fusion utilizing spatial domain techniques and usage of two phase spatial domain fusion methods. The spatial domain fusion methods such as Simple Max / Min, PCA and Two Stage Fusion are analyzed as far as various performance measures. This review presents that the proposed methodology is better among all the existing image fusion techniques.

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