ISSN: 0976-9102(ONLINE)
DOI: 10.21917/ijivp.2014.0131

TWO STAGE SPATIAL DOMAIN IMAGE FUSION TECHNIQUES

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Abstract

The objective of Image fusion is to combine the information from number of images of the same scene from different sensors or the images with focus on different objects. The result of image fusion is an image which is more informative and of better quality. In this paper a detailed survey of Select Maximum /Minimum and principal component analysis for spatial domain image fusion techniques is done. On the basis of the survey an improved spatial domain fusion technique is proposed. The proposed spatial domain technique output performs as the state of the art spatial domain techniques.

Keywords:

Spatial Domain, Simple Maximum/Minimum, PCA

1. INTRODUCTION

Image fusion is the process of combining information from two or more images of the same scene so that the resultant image will be more suitable for human and machine perception or further image processing tasks such as segmentation, feature extraction, and target recognition [7]. Image fusion is applicable to many fields including computer vision, medical imaging, and remote sensing. 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], [5], [10].

This paper is organized as follows: section 2 presents brief description of spatial domain image Fusion techniques, section 3 Performance measures parameter of fusion techniques, section 4 a new special domain comparative study of results, section 5 discusses the issues in this study and also presents a new special domain techniques and section 6 conclusion this paper.

2. IMAGE FUSION TECHNIQUES

The goal of image fusion is to integrate complementary information from multimodality images so that the new images are more suitable for the purpose of human visual perception and computer processing. Each of the given images are fused together to form a resultant image, whose quality is superior to any one of the input images. The process of image fusion is presented in Fig.1. Image Fusion method can be broadly classified into two methods. They are spatial domain fusion method and second method is Transform domain fusion method. The spatial domain method, directly deals with the pixels of the input image. The pixel values are manipulated to achieve desired result. In the transform domain methods the image is first transferred in to transform domain i.e. the Fourier transform of the image is computed first. 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 image. Image Fusion applied in every field where images are ought to be analyzed. For example medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing Application, computer vision, robotics, etc [9], [13].

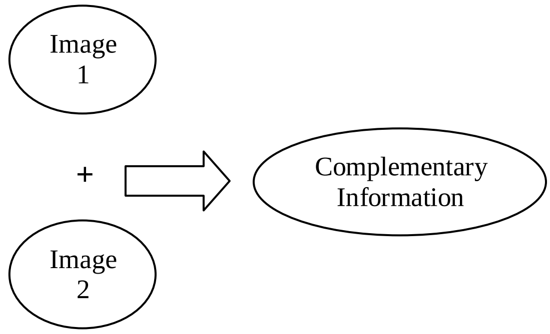

Fig.1. Image fusion schemes

Methods of simple image fusion consists of averaging, Select Maximum / Minimum [2], and principal component analysis (PCA) [8], [10].These methods fall under spatial domain techniques. The disadvantage 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 [11].

2.1 SIMPLE FUSION

The trivial image fusion techniques mainly perform a very basic operation such as pixel selection, addition, subtraction or averaging. These methods are not always effective but are at times critical based on the kind of image under consideration. A selection process is performed here wherein, for every corresponding pixel in the input images, the pixel with maximum/minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image [2].

2.1.1 Simple Maximum Method:

In this method, the resultant fused image is obtained by selecting the maximum intensity of corresponding pixels from both the input image.

$$F(i,j) = \sum_{i=1}^{M} \sum_{j=2}^{N} \max A(i,j) B(i,j) \quad (1)$$

where, A and B are input images and F is fused image.

2.1.2 Simple Minimum Method:

In this method, the resultant fused image is obtained by selecting the minimum intensity of corresponding pixels from both the input image [2].

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

where, A and B are input images and F is fused image.

2.2 PRINCIPAL COMPONENTS ANALYSIS (PCA)

Karl Pearson as an analogue of the principal axes theorem in mechanics was invented Principal component analysis in 1901. Later it was developed by Harold Hotelling in the year 1930. The method is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by Eigen value decomposition of a data covariance (or correlation) matrix or singular value decomposition of a data matrix, usually after mean centering (and normalizing or using Z-scores) the data matrix for each attribute. The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores (the transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardized original variable should be multiplied to get the component score). PCA helps to reduce redundant information and highlight the components with biggest influence so as to increase the signal-to-noise ratio. Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis PCA is widely used in data compression and pattern matching by expressing the data in a way to highlight the similarities and differences without much loss of information [9], [14], [15]. It is a useful statistical technique that has found application in fields such as face recognition and image compression. It is a common technique for finding patterns in data of high dimension [14].

Principal component analysis (PCA) is a statistical procedure that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components [11]. The PCA method is similar to the IHS method [10]. Principal component analysis is a statistical or numerical method. It is a powerful tool for analyzing data. The main advantage of PCA is reducing the number of dimensions, without much loss of information. The following steps describe the use of PCA algorithm for fusion [4].

1) Produce the column vectors, of the input 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.

3. PERFORMANCE MEASURES

The general requirements of a fusing process are that it should preserve all valid and useful pattern information of the source images, at the same time it should not introduce artifacts that could interfere with subsequent analyses. The performance measures used in this paper provide some quantitative comparison among different fusion schemes, mainly aiming at measuring the definition of an image.

Entropy (EN): Entropy is a measure of information quantity contained in an image. It reflects the amount 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 indicates that the information increases and the fusion performances are improved. Entropy is defined as,

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i \tag{3}$$

where, L is the total of grey levels, $p = \{P_0, P_1, P_2 \ldots\ldots P_{L-1}\}$ is the probability distribution of each level.

Peak Signal-to-Noise Ratio (PSNR): The fused image is looked upon an ideal image (signal) plus the noise image (difference between the ideal image and the fused image). The larger the PSNR value, the better the fused result. The PSNR is defined as,

$$PSNR = 10 \log 10 \left(\frac{MAX^2 I}{MSE} \right) \tag{4}$$

where, MAX_I is the maximum possible pixel value of the image.

Overall Cross Entropy (OCE): Overall cross entropy is reflect the difference between the two source images and the fused image. The smaller the Overall cross entropy is the better fusion result that is obtained [7].

Mean Square Error (MSE): The Mean Square Error (MSE) is a well known parameter to evaluate the quality of the fused image which is defined as,

$$MSE = \frac{1}{mn} \sum_{j=0}^{n-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)] \tag{5}$$

It represents amount of deviation present in fused image compared to reference image. Smaller value of Mean Square Error indicates better fusion results. The Mean Square Error is calculating between fused image and standard reference image.

Maximum Difference (MD): Maximum difference is defined as a difference between two pixels.

$$MD = Max|A_{ij} - B_{ij}| \; i = 1, 2, \ldots. m; \; j = 1, 2, \ldots. n \tag{6}$$

4. PROPOSED SYSTEM

A novel higher order singular value decomposition (HOSVD) - based image fusion algorithm proposed. The key points are given as follows: Since image fusion depends on local information of source images, the proposed algorithm,

i. Picks out informative image patches of source images to constitute the fused image by processing the divided sub Tensors rather than the whole tensor.
ii. The sum of absolute values of the coefficients (SAVC) from HOSVD of sub tensors is employed for activity-level Measurement to evaluate the quality of the related image Patch.

iii. A novel sigmoid-function-like coefficient-combining scheme is applied to construct the fused result. Experimental results show that the proposed algorithm is an alternative image fusion approach. This technique doesn't produce the blurring effects.

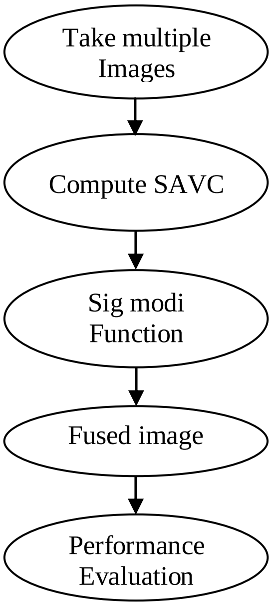

Fig.2. Proposed decomposition approach

Shown in Fig.3 two stage simple fusion method. Image A and image B are input images. Fusion I is a first fusion output. This fusion output is (image C) simple maximum and (image D) simple minimum. Fusion I images applied to the II stage of fusion for PCA image.

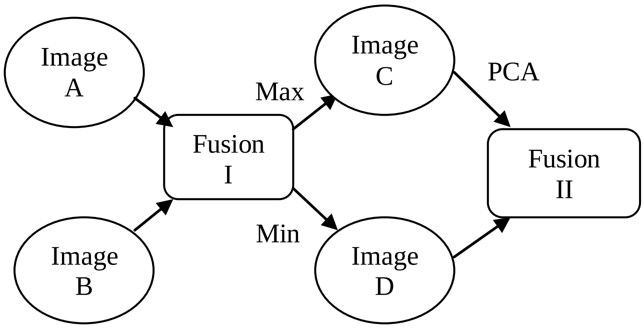

Fig.3. Two Stage fusion approach

5. IMPLEMENTATION

First is the simple Maximum and simple Minimum methods in which the all non-focused objects are obtained to be focused in the single output image. From each of the input images, the corresponding values of pixels are added. After obtaining their sum we then take its maximum and minimum. Now to the output image of the corresponding pixel, this Maximum and Minimum value is assigned. This process is repeated for all the pixel values.

PCA i.e. the principal component analysis of all input intensities can produce the coefficients of optimal weighting with respect to the information content and removal of redundancy without loss of information. After performing a PCA of the covariance matrix, the weightings for each input image are obtained from the eigenvector corresponding to the largest Eigen value.

6. RESULTS AND DISCUSSION

In this section, there are two images of bottle. First image contains the left bottle in focus, but the right bottle blurred, which means the right bottle is non-focused. Second image contains the left bottle non-focused and the right bottle is in focus. These images are not Pre registered but have been taken with a still camera, hence they can be considered as registered. Here we represent the results we have obtained, by implementing the algorithms. Once the sample set of input image pairs were fused, the quality of the same were assessed for all fusion algorithms, discussed in section 2 with the image quality metrics, discussed in section 3. On applying the Simple fusion maximum, simple fusion minimum, PCA and Two stage fusions, it is observed that two stage fusions gives the best result. This can be verified with the help of the metric table. If the entropy has higher value for fused image, it means the fused image by two stage fusion gives higher information than the fused image produced by simple maximum, simple minimum and principal component analysis scheme. Here we have made comparison of the spatial domain image fusion methods of simple maximum, simple minimum, PCA and two stage fusion discussed in section 2. The two stage fusion output has the highest peak signal to noise ratio (PSNR) and Entropy.

Table.1. Performance analysis of input

Methods	Entropy	OCE	PSNR	MSE	Maximum Difference
Proposed(Two stage fusion)	9.4495	0.0496	21.0060	567.2501	157
PCA	7.4012	0.6506	13.6614	397.9112	255
Simple Maximum	9.1431	0.0885	20.5931	567.2501	157
Simple Minimum	9.1443	0.1058	18.6241	892.6339	206

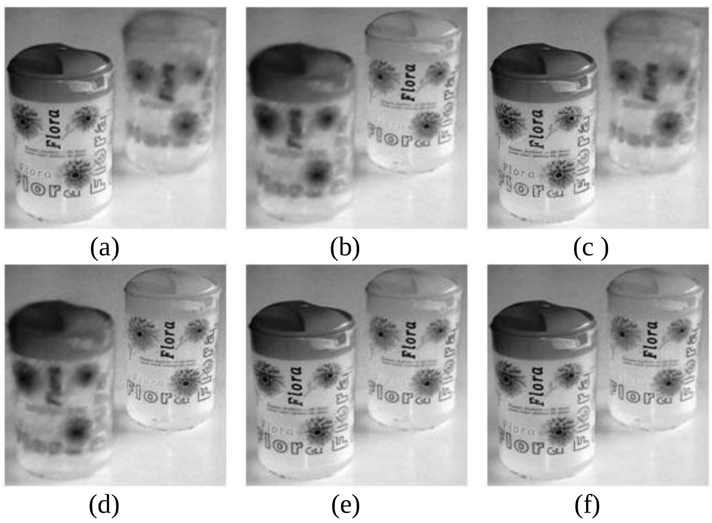

Fig.4.(a-b). Original images before fusion, (c). Fusion using Simple Minimum, (d). Fusion using Simple Maximum,(e). Fusion using PCA, (f). Fusion using Proposed (Two stage fusion)

7. CONCLUSION

This paper performs the survey of Image fusion using spatial domain techniques and implementation of two stage spatial domain fusion techniques. The spatial domain fusion techniques such as Simple Maximum / Minimum, PCA and Two stage fusions are compared in terms of various performance measures. This review presents that the proposed method is better among all the existing image fusion techniques.

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