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# Survey of Spatial Domain Image fusion Techniques

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***ABSTRACT—*** *The objective of Image fusion is to combine the information of the 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. This Image fusion is finding its application in all spheres of life. In this paper a detailed survey of spatial domain image fusion techniques is done. On the basis of the survey a new special domain fusion techniques is also proposed.*

**Key Words: Image fusion, spatial domain, Simple methods.**

## 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 [6]. Image fusion is applicable to many fields includes computer vision, medical imaging, and remote sensing. Image fusion is performed in spatial domain and transform domain. This paper presents a comprehensive survey of special domain techniques such as averaging, Select Maximum /minimum, Bovey Transform, IHS, HPF and PCA are served [7] [1] [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 **c**onclusion 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. The good Information from each of the given are images is fused together to form a resultant image whose quality is superior to any one of the input images. Image fusion method can be broadly classified into two methods. First method is spatial domain fusion method and second method is Transform domain fusion method. The spatial domain method, directly deals with the pixels of the input images. 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 [4][2]. Methods of simple image fusion consists of Brovey method [11], principal component analysis (PCA) [11],intensity -hue-saturation(IHS) and high pass filtering(HPF) [11].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 [2].

### 2.1. Simple Fusion

The trivial image fusion techniques mainly perform a very basic operation like 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. The trivial image fusion techniques studied and developed as part of

**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 images.

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

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.

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

Where A and B are input images and F is fused image.

### 2.2. Brovey Transform (BT)

Brovey Transform is devolved by Gillespie et al., 1987. Brovey, is also called the color normalization transform because it involves a red-green-blue (RGB) color transform method. It is statistical/numerical methods. Brovey Transform uses addition, division and multiplication for the fusion of three multispectral bands. The Brovey Transform was developed to visually increase contrast in the low and high ends of an images histogram (i.e., to provide contrast in shadows, water, and high reflectance areas such as urban features). The Brovey transformation was developed to avoid the disadvantages of the multiplicative method. The following equation shows the mathematical algorithm for the Brovey method [9].

$$Fi = \frac{Mi}{\sum_{i=1}^{N} Mj + P} \qquad \text{--------------- (3)}$$

Where Fi is the fused Band, Mi is the multispectral Band, P is the Panchromatic Band.

### 2.3. Intensity Hue Saturation (IHS)

IHS is a color fusion technique. It effectively separates spatial (intensity) and spectral (hue and saturation) information from an image (Chavez et al.,1991; Carper et al., 1990). The fusion method first converts a RGB image into intensity (I) hue (H) and saturation (S) components. In the next step, intensity is substituted with the high spatial resolution panchromatic image. The last step performs the bands. In this method three multispectral bands R, G and B of low resolution. Finally, an inverse transformation from IHS space back to the original RGB space yields the fused RGB image, with spatial details of the high resolution image incorporated into it .The intensity I defines the total color brightness and exhibits as the dominant component . After resolution using the high resolution data, the merge result is converted back into the RGB After applying IHS [7].

### 2.4. High Pass Filter (HPF)

The High-Pass Filter model was first introduced by Schowengerdt (1980) as a method to reduce data quantity and increase spatial resolution potential for Landsat MSS data. Chavez et al. (1991) extended this idea to more diverse multi spatial data sets when they are merged Thematic Mapper (TM) data with a digitized National High Altitude Program (NHAP) aerial photograph. High Pass Filter is a statistical/numerical method. The HPF method submits the high spatial resolution imagery to a small convolution mask (3 x 3) which acts upon the high-frequency spatial information (Pohl, 1998), effectively reducing the lower frequency spectral information of the high spatial resolution image. The filtered result is then added to the Multispectral data and the result divided by two to offset the increase in brightness values:

$$HPF_{i,j,k}=(MS_{i,j,k}+FP_{i,j})/2 \qquad \text{----------------} \ (4)$$

Where HPF is the output image and i and j are pixels of band k. FP is the filtered result of High-Pass Filter, This technique preserves the multispectral data while incorporating the spatial resolution of the PN data [5].

### 2.5. Principal Components Analysis (PCA)

PCA was invented in 1901 by Karl Pearson as an analogue of the principal axes theorem in mechanics; it was later independently developed (and named) by Harold Hotelling in the 1930s. 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).

## 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, while 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.

**3.1. Entropy (EN):** Entropy is a measure of information quantity contained in an image. 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:

$$E = \Sigma \ pi * \log 1/2 \qquad \text{----------------- (5)}$$

Where = {$P_0$, $P_1$, $P_2$……P $_{l-1}$, Pl} is the probability distribution of each level.

**3.2. Signal-to-noise Ratio (SNR):** The fused image is looked upon as the ideal image (signal) plus the noise image (difference between the ideal image and the fused image). The larger the SNR value, the better the fused result.

**3.3. Overall cross entropy (OCE):** It can reflect the difference between the two source images and the fused image. The smaller the OCE is, the better fusion result that is obtained.

**3.4. Root Mean Square Error (RMSE) -** The Root mean square error (RMSE) is a well known parameter to evaluate the quality of the fused image. It represents amount of deviation present in fused image compared to reference image. The RMSE is calculating between fused image and standard reference image which is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}} \qquad \text{----------------- (6)}$$

## 4, COMPARATIVE STUDY OF RESULTS

Here we have made comparison of the spatial domain image fusion methods discussed in Section II.

| Methods | Simplicity | Advantage | Disadvantage | Application |
|---|---|---|---|---|
| Average Method | Simple and easy to implement | This is simple method | Pixel level method is that this method does not give guarantee to have a clear objects from set of images. | Average Method Used in Practical application. |
| Maxima /Minima method | Simple method | Highly focused image. | Pixel level methods are affected by blurring effects which directly affect on the contrast of the image | The greater the pixel values the more in focus the image. |
| Brovey Method | Simple and fast method | Very useful for visual Interpretation | Produce the Spectral degradation and BT should not be used if preserving the original scene radiometry is important. | BT uses addition, division and multiplication for the fusion of three multispectral bands |
| HIS | Simple method | It provides a better visual effect | Produce the Color distortion and It suffers from artifacts and noise. | IHS Used in Practical application. |
| HPF | Simple method | Low spatial quality | Produce the Spectral degradation | Reduce data quantity and increase spatial resolution potential for landsat MSS data. |
| PCA | Simple method | PCA is reducing the number of dimensions, without much loss of information. | Produce the Spectral degradation | This technique used in image compression |

For the above mentioned method, image fusion is performed using the spatial domain methods such as averaging, Select Maximum/minimum, Bovey Transform, IHS,HPF and PCA their performance is measured in terms of Entropy, Signal-To-Noise Ratio, Image Quality Metric, Root Mean Squared Error, and Spatial frequency. Above study are maintained for entropy and spatial frequency parameter are better performance for PCA method. The spatial domain methods have few serious issues Image blurring, spatial distortion, Spectral degradation and Artifacts.

## 5, ISSUES IN THE STUDY

The spatial domain approaches produce spatial and spectral distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing such as classification problem. Although selection of fusion algorithm is problem dependent but this review results that spatial domain provide high spatial resolution but have image blurring problem is existing in it. To rectify all such above mentioned problem. It is decided to propose a new spatial domain fusion technique. It is named higher order singular value decomposition.

## 6, PROPOSED SYSTEM

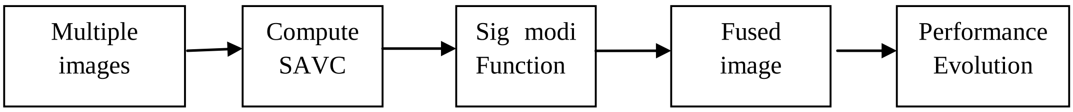


Fig.2 Proposed decomposition approach

A novel higher order singular value decomposition (HOSVD) - based image fusion algorithm is proposed. The key points are given as follows:

- Since image fusion depends on local information of source images, the proposed algorithm picks out informative image patches of source images to constitute the fused image by processing the divided sub tensors rather than the whole tensor.
- 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.
- 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. Shown in fig 2 stage simple fusion method.

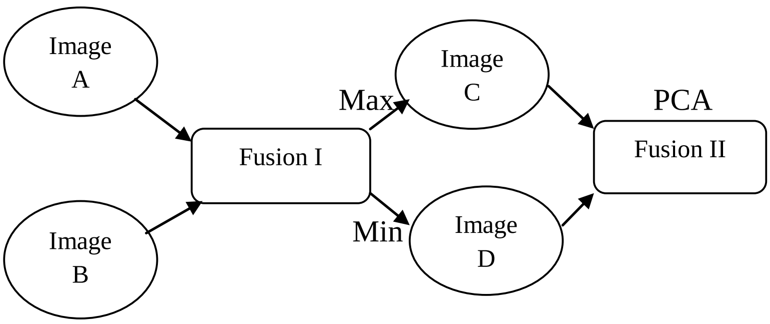


Fig. 3 Two Stage fusion approach

Image A and image B are input images. Fusion I is a first fusion output. This fusion output is divided in to (image c) simple maximum/simple minimum (image D). Fusion I output applied to the II stage of fusion for PCA image.

## VII. CONCLUSION

This paper performs the survey of Image fusion using spatial domain techniques. A comparison of all spatial domain fusion techniques multi focused images using averaging, Select Maximum / minimum, Bovey Transform, IHS, HPF and PCA in terms of various performance measures. This review presents that which approach is better among all the existing Image Fusion techniques. Although selection of fusion algorithm is problem dependent but this review results that spatial domain provide high spatial resolution but spatial domain have image blurring problem.

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