A Review on Image Fusion Techniques

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Abstract-Image fusion is a technique that integrate complimentary details from multiple input images such that the new image give more information and more suitable for the purpose of human visual perception. This paper presents a review on some of the image fusion techniques for pansharpning (simple average, multiplicative, PCA, DWT). Comparison of all the techniques concludes the better approach for its future research.

Keywords- Image Fusion, Discrete Wavelet Transform (DWT), Principal Component Analysis (PCA)

I. INTRODUCTION

Image Fusion is a process of combining the relevant information from a set of images of the same scene, into a single image, wherein the resultant fused image will be more informative and more suitable for the purpose of human visual perception. There are several stages that we can perform in the process of image fusion, which are Image Registration and Image Resampling. One of the important pre-processing steps for the fusion process is image registration. Image registration is the process of transforming different sets of data into one coordinate system. Image fusion find application in the area of navigation guidance, object detection and recognition, medical diagnosis, satellite imaging for remote sensing, robot vision, military and civilian surveillance, etc. We can classify image Fusion based on which type of level it is used for fusion process.

1) Pixel Level Image Fusion
2) Feature Level Image Fusion
3) Decision levels Image Fusion

Pixel level fusion works directly on the pixels of source images while feature level fusion algorithms operate on features extracted from the source images.

II. IMAGE FUSION TECHNIQUES FOR PANSHARPNING

Image fusion method can be divided into two groups

1.Spatial domain fusion method 2.Transform domain Fusion method

Spatial domain fusion method directly deal with pixels of input images.

The fusion methods such as simple maximum, simple minimum, averaging, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches. In frequency domain methods, the image is first transferred in to frequency domain. It means that, the Fourier Transform of the image is computed first. All the enhancement operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image.

We can also categorized image fusion in following parts:

1) Arithmetic Combination Methods

1. Simple Average Method
2. Multiplicative Method
3. Brovey Method

2) Component Substitution Methods

1. PCA Method
2. IHS Method
3. Wavelet Method

Some of these pixel-level algorithms are described below:

2.1 ARITHMETIC COMBINATION METHODS

2.1.1 Simple Average Method

In this method the pixel value of both images are taken and find the average value of that particular pixel. So the resultant image contain average of pixel from both the images. The equation for this is given below:

$$\boldsymbol{F(i,j) = \sum_{i=0}^{m}\sum_{j=0}^{n} (A(i,j) + B(i,j))/2}$$

Where A(i,j) and B(i,j) are the input images and F(i,j) is Fused image

2.1.2 Multiplicative Method

In this method the pixel values of both the images are multiply with each other and take the square root of it. The equation for this is given below:

$$\boldsymbol{F_k(i,j) = \sqrt{M_k(i,j) \times P(i,j)}}$$

Where M (i,j) and P (i,j) are input images which are multispectral and panchromatic respectively and k=number of band. F (i,j) is Fused image

2.1.3 Brovey Method

In this method each band of multispectral image is multiply with panchromatic image and then normalize with multi spectral image. So process is do for each band individually.The equation for brovey method is given below:

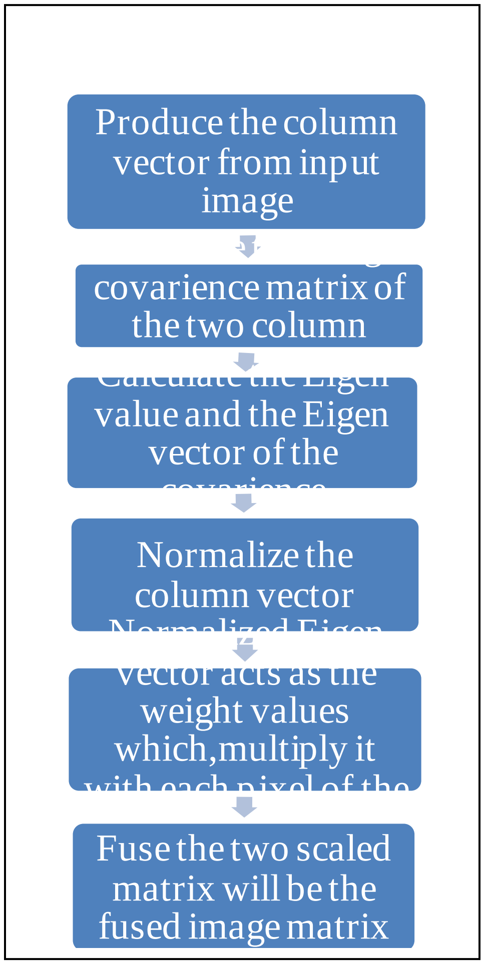
$$\boldsymbol{F_k(i,j) = \frac{M_k(i,j) \times P(i,j)}{\sum_k M_k(i,j)}}$$

Where M(i,j)and P(i,j) are input images which are multispectral and panchromatic respectively and k=number of band. F(i,j) is fused image

2.2 COMPONENT SUBSTITUTION METHODS

2.2.1 PCA Method

The process for PCA method is given below:



2.2.2 IHS Method

IHS (Intensity-Hue-Saturation) is the most common image fusion technique for remote sensing applications and is used in commercial pan-sharpening software. This technique converts a color image from RGB space to the IHS color space. Here the I (intensity) band is replaced by the panchromatic image. Before fusing the images, the multispectral and the panchromatic image are histogram matched. The image is converted to IHS color space using the following linear transformation:

$$\begin{bmatrix} I \\ V1 \\ V2 \end{bmatrix} = \begin{bmatrix} 1/3 & 1/3 & 1/3 \\ -\sqrt{2}/6 & -\sqrt{2}/6 & 2\sqrt{2}/6 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

2.2.3 Wavelet Method

Wavelet is a mathematical tool used in signal processing.

The general process is as follows [1]:

Step 1. Implement Discrete Wavelet Transform on both the input image to create wavelet lower decomposition.

Step 2. Fuse each decomposition level by using different fusion rule .

Step 3. Carry Inverse Discrete Wavelet Transform on fused decomposed level, which means to reconstruct the image, while the image reconstructed is the fused image F.

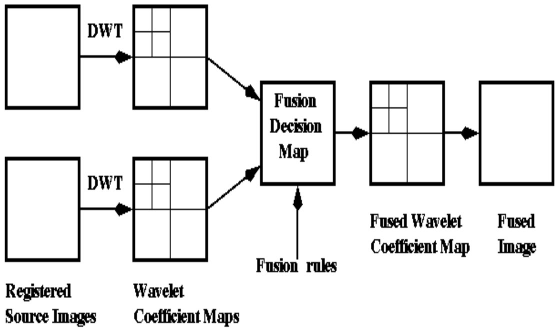


Fig 2. Wavelet Based image fusion

III.IMAGE QUALITY METRICS

The requirements of image fusion process is to preserve all valid and useful information from the source images, while at the same time it should not introduce any distortion in resultant fused image. Performance measures are used essential to measure the possible benefits of fusion and also used to compare results obtained using different algorithms.

a) Peak Signal to Noise Ratio(PSNR):

The phrase peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation [2]. One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content [3].

$$PSNR = 10 \times log_{10}\left(\frac{255}{RMSE}\right)$$

For better fused image PSNR value should high.

b) Root Mean Square Error (RMSE)

The root mean square error is a frequently-used measure of the differences between values predicted by a model or an estimator and the values actually observed from the thing being modeled or estimated.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[F(i,j) - R(i,j)]^2}{M \times N}}$$

Where, M, N indicate the size of the image is M×N, F (i, j), R (i, j) indicate the gray value of the pixel which is in the row i and in the column j of the image. The smaller RMSE is, the better the fusion effect is.

c) Standard deviation (σ):

Standard deviation reflects discrete case of the image grey intensity relative to the average. The standard deviation represents the contrast of an image. If the standard deviation is large, then the image grey scale distribution is scattered and the image's contrast is large that more information can be seen. It can be defined as

$$\sigma = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left[F(i,j)-\bar{f}\right]^{2}}{M \times N}}$$

F (i, j) is the grey value of fused image at point (i, j). $\bar{f}$ is the mean value of grey-scale image fusion. M×N is the size of image.

c) Entropy (EN):

Entropy is used to calculate the amount of information. Higher value of entropy indicates that the information

increases and the fusion performances are improved.

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

Where, L is the gray level, Pi is the relative value of the pixel Di, whose gray value is i, and the total pixels D of the image. In other words it means pi=Di/D, p= {p0, p1,...,p L-1 }, which shows the probability distribution of pixels with the distinct gray values.

CONCLUSION

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.To overcome this we use wavelet method and morphological processing with it.

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