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# A Significant Assessment of Image Fusion Techniques and its Performance Matrices

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***Abstract-*** The main aim of image fusion (IF) is to integrate complementary multisensor, multitemporal and/or multiview information into one new image containing information the quality of which cannot be achieved otherwise. The need of image fusion for high resolution on panchromatic and multispectral images or real world images for better vision. There are various methods of image fusion and some techniques of image fusion such as IHS, PCA, DWT, Laplacian pyramids, Gradient Pyramids, DCT, SF. Several digital image fusion algorithms have been developed in a number of applications. Image fusion extracts the information from several images of a given scene to obtain a final image which has more information for human visual perception and become more useful for additional vision processing. Various performance matrices that used for the evolution of image fusion are Entropy, Standard Deviation, Peak Signal to Noise Ratio (PSNR), and etc.

***Keywords-*** Image fusion, Fused image, Discrete Wavelet Transform, Entropy, PSNR.

## I. INTRODUCTION

Image fusion [1] has been used in many application areas. In remote sensing and in astronomy, multisensory fusion is used to achieve high spatial and spectral resolutions by combining images from two sensors, one of which has high spatial resolution and the other one high spectral resolution. Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI, and/or PET images. Plenty of applications which use multisensor fusion of visible and infrared images have appeared in military, security, and surveillance areas.

In the case of multiview fusion, a set of images of the same scene taken by the same sensor but from different viewpoints is fused to obtain an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene. The multitemporal approach recognizes two different aims. Images of the same scene are acquired at different times either to find and evaluate changes in the scene or to obtain a less degraded image of the scene.

The former aim is common in medical imaging, especially in change detection of organs and tumors, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim requires the different measurements to be much closer to each other, typically in the scale of seconds, and possibly under different conditions.

## II. IMAGE FUSION LEVELS

*A. Pixel Level*

This is most his simple technique in image fusion done at lowest level. In this combine the values and intensities of two input images based on its average, gives the single resultant image.

*B. Feature Level*

This is most his simple technique in image fusion done at lowest level. In this combine the values and intensities of two input images based on its average, gives the single resultant image.

*C. Block or Region Based*

In region based fusion occurs according to the pixel blocks of the image. Blocks level technique is highest level technique. It is multistage representation and measurements are calculated according to the regions [2].

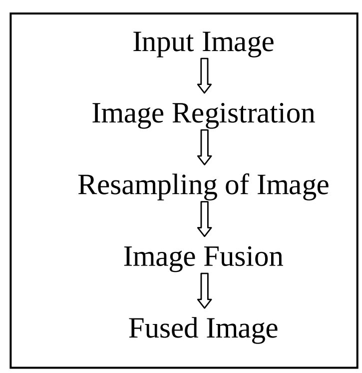


**Fig 1.** Preprocessing Steps for Image Fusion

## III. APPLICATIONS AND BENEFITS OFIMAGE FUSION [4]

- Fusion is basically used remote or satellite area for the proper view of satellite vision

 

- It must use in medical imaging where disease should analyses through imaging vision through spatial resolution and frequency perspectives.
- Image fusion used in military areas where all the perspectives used to detect the threats and other resolution work based performance.
- For machine vision it is effectively used to visualize the two states after the image conclude its perfect for the human vision.
- In robotics field fused images mostly used to analyse the frequency variations in the view of images.
- Image fusion is used in artificial neural networks in 3d where focal length varies according to wavelength transformation.

## IV. IMAGE FUSION TECHNIQUES

### *4.1 IHS (INTENSITY-HUE-SATURATION) TRANSFORM*

Intensity, Hue and Saturation are the three properties of a color that give controlled visual representation of an image. IHS transform method is the oldest method of image fusion. In the IHS space, hue and saturation need to be carefully controlled because it contains most of the spectral information. For the fusion of high resolution PAN image and multispectral images, the detail information of high spatial resolution is added to the spectral information. This paper presents many IHS transformation techniques based on different color models. These techniques include HSV, IHS1, IHS2, HIS3, IHS4, IHS5, IHS6, YIQ. Based on these different formula, IHS transformation gives different results [3].

### *4.2 PYRAMID TECHNIQUE*

Image pyramids can be described as a model for the binocular fusion for human visual system. By forming the pyramid structure an original image is represented in different levels. A composite image is formed by applying a pattern selective approach of image fusion. Firstly, the pyramid decomposition is performed on each source image. All these images are integrated to form a composite image and then inverse pyramid transform is applied to get the resultant image. The MATLAB implementation of the pyramid technique is shown in this paper. Image fusion is carried out at each level of decomposition to form a fused pyramid and the fused image is obtained from it.

### *4.3 HIGH PASS FILTERING (HPF)*

The high resolution multispectral images are obtained from high pass filtering. The high frequency information from the high resolution panchromatic image is added to the low resolution multispectral image to obtain the resultant image. It is performed either by filtering the High Resolution Panchromatic Image with a high pass filter or by taking the original HRPI and subtracting LRPI from it. The spectral information contained in the low frequency information of the HRMI is preserved by this method.

### *4.4 PRINCIPAL COMPONENT ANALYSIS (PCA)*

Despite of being similar to IHS transform, the advantage of PCA method over IHS method is that an arbitrary number of bands can be used. This is one of the most popular methods for image fusion. Uncorrelated Principal components are formed from the low resolution multispectral images. The first principal component (PC1) has the information that is common to all bands used. It contains high variance such that it gives more information about panchromatic image.

A high resolution PAN component is stretched to have the same variance as PC1 and replaces PC1. Then an inverse PCA transform is employed to get the high resolution multispectral image.

### 4.5 *WAVELET TRANSFORM*

Wavelet transform is considered as an alternative to the short time Fourier transforms. It is advantageous over Fourier transform in that it provides desired resolution in time domain as well as in frequency domain whereas Fourier transform gives a good resolution in only frequency domain. In Fourier transform, the signal is decomposed into sine waves of different frequencies whereas the wavelet transform decomposes the signal into scaled and shifted forms of the mother wavelet or function. In the image fusion using wavelet transform, the input images are decomposed into approximate and informative coefficients using DWT at some specific level. A fusion rule is applied to combine these two coefficients and the resultant image is obtained by taking the inverse wavelet transform.

### 4.6 DISCRETE *COSINE TRANSFORM (DCT)*

Discrete cosine Transform has found importance for the compressed images in the form of MPEG, JVT etc. By taking discrete cosine transform, the spatial domain image is converted into the frequency domain image. Chu-Hui Lee and Zheng-Wei Zhou have divided the images into three parts as low frequency, medium frequency and high frequency. Average illumination is represented by the DC value and the AC values are the coefficients of high frequency. The RGB image is divided into the blocks of with the size of 8*8 pixels. The image is then grouped by the matrices of red, green and blue and transformed to the grey scale image.

### 4.7 *ARTIFICIAL NEURAL NETWORKS (ANN)*

Discrete cosine Transform has found importance for the compressed images in the form of MPEG, JVT etc. By taking discrete cosine transform, the spatial domain image is converted into the frequency domain image. Chu-Hui Lee and Zheng-Wei Zhou have divided the images into three parts as low frequency, medium frequency and high frequency. Average illumination is represented by the DC value and the AC values are the coefficients of high frequency. The RGB image is divided into the blocks of with the size of 8*8 pixels. The image is then grouped by the matrices of red, green and blue and transformed to the grey scale image.

## V. IMAGE FUSION PERFORMANCE MEASURES

Several computational image fusion quality assessment metrics are proposed in recent years [5,6]. Although subjective visual evaluation can be used to give instinctive comparisons, it cannot be ignored as so many factors such as level of eye sight, mental state, even the mood may influence the subjective results18. Hence it is necessary to evaluate the fusion performance from both subjective visual evaluation and objective image quality assessment. There are different performance measures like Cross Entropy (CE), Average gradient, Standard Deviation (SD), Root Mean Square Error (RMSE), Peak Signal to Noise Ratio (PSNR), Correlation Coefficient (CC), Structural Similarity index (SSIM index), Mutual Information (MI) etc., used to measure the quality of an image. In main parameters such as Root mean square error, Peak signal to noise ratio, Correlation coefficient and Entropy are used in the most of the analysis process.

*5.1 Root Mean Square Error*

Root mean square error is one of the objective quality metric that is widely used and despite their well-known limitations if used carefully, they can be helpful19. It is given by,

$$\mathrm{RMSE} = \frac{1}{MN}\sum_{n=1}^{N}\sum_{m=1}^{M}(x_R(n,m) = x_F(n,m)^2)^{1/2}$$

*5.2 Peak Signal to Noise Ratio*

To determine the quality of an image, human eyes perception is the fastest approach but the results may differ from person to person. To find an objective criterion for digital image quality, a parameter named PSNR (Peak Signal to Noise Ratio) is defined as follows,

$$\mathrm{PSNR} = 10\log_{10}(255*255/\mathrm{MSE})$$

where MSE stands for the Mean-Square Error. When the PSNR is larger, the image quality is higher. On the other hand, a smaller value of PSNR means there is great distortion between the input and the fused image.

*5.3 Entropy*

Information Entropy (IE) reflects the amount of information in fused output image20,21. It is useful to determine the significant information of the image based on the probability of pixel values and is given by the equation,

$$\mathrm{IE} = \sum_{i=0}^{L-1} P(i)\log_2 P(i)$$

where P(i) is the probability of pixel. If the entropy value is becoming higher after fusion, the information quality will increase.

*5.4 Correlation Coefficient*

It gives similarity in the small structures between the original and reconstructed images where higher value of correlation means more information is preserved and lies between (0,1) and is given by,

$$\rho = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[F_{idea} i, j) - F_{fused}(i,j)0]^2}{MN}}$$

## VI. CONCLUSION

In this paper, different levels of image fusion and image fusion evaluation parameters were discussed. Concluding remarks are:

- Image fusion methods obtain more accurate and reliable Image information by eliminating redundancy.
- Analysis of some researchers shows that different image. Fusion methods suits different applications.
- The pixel level fusion has been extensively researched. For different approaches, since it gives comparatively better quality of fused results; but at the expense of more time consumption.
- For evaluation of image fusion algorithms, there is no Standardized reference hence common practice followed is to test the algorithms on more number of datasets and to use optimum fusion strategy depending on application.
- Along with the objective evaluation, many times it is reported that the fused result should be subjectively evaluated based on visual characteristics.

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