

# A Review : Image Fusion Techniques and Applications

Mamta Sharma  
*Pursuing M.tech (C.S.)*  
*Geetanjali institute of technical studies*  
*Udaipur, India*

**Abstract**—Image fusion is process of combining multiple input images into a single output image which contain better description of the scene than the one provided by any of the individual input images. 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. It also intends to review quality assessment metrics for image fusion algorithms. The gray-scale image fusion techniques are explored at pixel level, feature-level and review the concept, principals, limitations and advantages for each technique.

**Keywords**—Image fusion; fused image; PC; DWT; HIS; Discrete Wavelet Transform

## I. INTRODUCTION

Image fusion is the process of combining relevant information from two or more images into a single image. Image fusion techniques are widely used in various applications such as remote sensing, medical imaging, military and astronomy. Image fusion is a process of combining two or more images to enhance the information content. Image fusion techniques are important as it improves the performance of object recognition systems by integrating many sources of satellite, airborne and ground based imaging systems with other related data sets. Further, it also helps in sharpening the images, improve geometric corrections, enhance certain features that are not visible in either of the images, replace the defective data, complement the data sets for better decision making. It combines the significant information from two or more source images into a single resultant image that describes the scene better and retains useful information from the input images. A high resolution panchromatic image gives geometric details of an image because of the presence of natural as well as man-made objects in the scene and a low resolution multispectral image gives the color information of the source image. The aim of multisensor image fusion is to represent the visual information from multiple images having different geometric representations into a single resultant image without any information loss. The advantages of image fusion include

image sharpening, feature enhancement, improved classification, and creation of stereo data sets. Multisensor image fusion provides the benefits in terms of range of operation, spatial and temporal characteristics, system performance, reduced ambiguity and improved reliability.

Based on the processing levels, image fusion techniques can be divided into different categories. These are pixel level, feature level and symbol level/decision level. Pixel level method is the simplest and widely used method. This method processes pixels in the source image and retains most of the original image information. Compared to other two methods pixel level image fusion gives more accurate results. Feature level method processes the characteristics of the source image. This method can be used with the decision level method to fuse images effectively. Because of the reduced data size, it is easier to compress and transmit the data. The top level of image fusion is decision making level. It uses the data information extracted from the pixel level fusion or the feature level fusion to make optimal decision to achieve a specific objective. Moreover, it reduces the redundancy and uncertain information.

## II. LEVELS OF IMAGE FUSION

### 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

It justifies with the features of image like if one image has its distorted eye other have distorted any feature like head, nose. In this level of technique easily extract the features of both similar images individually, then fusion algorithm gives the enhanced image after feature extraction.

### 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.

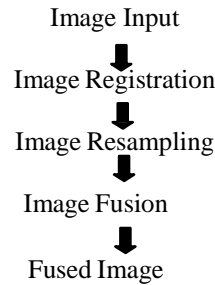


Fig.1. Preprocessing steps for image fusion

### III. LITERATURE SURVEY

A lot of research and work has been done on image fusion techniques since mid-nineteen eighties. The simplest way of fusing images is by taking the gray scale average of the pixels of source images. This simple method gives good results at the cost of reduced contrast level. These techniques of fusing images can be applied to different data sets depending upon their spatial and temporal characteristics. Spatial domain techniques and Frequency domain techniques are used for combining the images. Spatial domain techniques process image pixels to achieve the desired result while frequency domain techniques first transfer the image into frequency domain by applying Fourier transform and then obtain the resultant image by performing inverse Fourier transform. These methods are compared using performance measurement characteristics such as entropy, Peak signal to noise ratio (PSNR), Mean square error.

### IV. EXISTING IMAGE FUSION TECHNIQUES

Different image fusion techniques that have been studied and developed so far are as follows.

1. IHS (Intensity-Hue-Saturation) Transform
2. Principal Component Analysis (PCA)
3. Pyramid techniques
4. High pass filtering
5. Wavelet Transform
6. Artificial Neural Networks
7. Discrete Cosine Transform

#### 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].

#### 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.

#### 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) 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.

#### 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.

#### 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.

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

Artificial Neural networks (ANN) have found their importance in pattern recognition. In this a nonlinear response function is used. It uses Pulse Coupled Neural Network (PCNN) which consists of a feedback network. This network is divided into three parts namely the receptive field, the modulation field and the pulse generator. Each neuron corresponds to the pixel of the input image. The matching pixel's intensity is used as an external input to the PCNN. This method is advantageous in terms of hardness against noise, independence of geometric variations and capability of bridging minor intensity variations in input patterns. PCNN has biological importance and used in medical imaging as this method is feasible and gives real time system performance.

### V. TYPES OF IMAGE FUSION

**Single Sensor:** Single sensor captures the real world as a sequence of images. The set of images are fused together to generate a new image with optimum information content. For example in illumination variant and noise full environment, a human operators like detector operator may not be able to detect objects of his interest which can be highlighted in the resultant fused image.

The shortcoming of this type of systems lies behind the limitations of the imaging sensor that are being used in other sensing area. Under the conditions in which the system can operate, its dynamic range, resolution, etc. are all restricted by the competency of the sensor. For example, a visible-band sensor such as the digital camera is appropriate for a brightly illuminated environment such as daylight scenes but is not suitable for poorly illuminated situations found during night time, or under not good conditions such as in fog or rain.

**Multi Sensor :** A multi-sensor image fusion scheme overcomes the limitations of a single sensor image fusion by merging the images from several sensors to form a composite image an infrared camera is accompanying the digital camera and their individual images are merged to obtain a fused image. This approach overcomes the issues referred to before. The digital camera is suitable for daylight scenes; the infrared camera is appropriate in poorly illuminated environments. It is used in military area, machine vision like in object detection, robotics, medical imaging. It is used to solve the merge information of the several images.

**Multiview Fusion:** In this images have multiple or different views at the same time. Multimodal Fusion: Images from different models like panchromatic, multispectral, visible, infrared, remote sensing. Common methods of image fusion

- Weighted averaging pixel wise
- Fusion in transform domain
- Object level fusion

**Multifocus Fusion:** images from 3d views with its focal length. The original image can be divided into regions such that every region is in focus in at least one channel of the image.

### VI. APPLICATIONS AND USES OF IMAGE FUSION

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

### VII. ADVANTAGES AND DISADVANTAGES OF IMAGE FUSION

Advantages:

1. It is easiest to interpret.
2. Fused image is true in color.
3. It is best for identification and recognition
4. It is low in cost
5. It has a high resolution used at multiscale images.
6. Through image fusion there is improved fused images in fog
7. Image fusion maintains ability to read out signs in all fields.
8. Image fusion has so many contrast advantages basically it should enhance the image with all the perspectives of image.
9. It increases the situational or conditional awareness.
10. Image fusion reduced the data storage and data transmission.

Disadvantages:

1. Images have less capability in adverse weather conditions it is commonly occurred when image fusion is done by single sensor fusion technique.
2. Not easily visible at night it is mainly due to camera aspects whether it is in day or night.
3. More source energy is necessary for the good

visualization of mages based on spatial frequency.

4. Due to rain or fog visualization is not cleared if one click the two source images in this type of weather conditions it will give the worst output.
5. In this process there is huge chances of data loss
6. It needs the proper maintenance.
7. Processing of data is very slow when images are fused.

### VIII. RESULT AND DISCUSSION

The table given below shows the comparison of various methods of impulse noise removal by using parameters such as Peak signal to noise ratio (PSNR) and Root Mean Square Error (RMSE). RMSE is calculated as root mean square error of the corresponding pixels in the input images and the fused image. It measures the change in pixels because of processing. Peak signal to noise ratio is high when the fused and the reference image are similar.

TABLE 1: COMPARISON OF PARAMETERS OF VARIOUS TECHNIQUES

| Method   | RMSE   | PSNR (dB)  |
|----------|--------|------------|
| Fuzzylet | 0.05   | 71.062 [1] |
| Average  | 9.91   | 76.42 [10] |
| PCA      | 9.86   | 76.44 [7]  |
| DCT      | 0.0791 | 59.14 [9]  |
| Wavelet  | 9.18   | 77.08 [10] |

When the difference between the original and reconstructed image is smaller, the PSNR value is larger. There are some other performance measurement characteristics such as Entropy, Standard deviation, Execution time and Error Image.

### IX. CONCLUSION

The process of image fusion combines the input images and extracts useful information giving the resultant image. The Fuzzy let Fusion Algorithm uses the Fuzzy Interference system to perform image fusion. This system gives good results combining the advantages of both SWT and fuzzy logic. It also gives a high PSNR value and low RMSE value. These values are better than those obtained when SWT and Fuzzy logic are used independently. Thus it can be used in many applications of image processing domain.

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