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Theoretical Study of Image Fusion Techniques: A Review

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***Abstract*—the goal of image fusion is to combine relevant information from two or more images of the same view in to single image. The result of image fusion is a new fused image which is more suitable for human being and machine discernment for further image-processing tasks like segmentation, feature taking out and objects recognition. In this paper the image fusion techniques described using the PCA, and wavelet family. Principal component analysis (PCA) is a well-known scheme for feature extraction and dimension reduction. In DCT low frequency region of the image has large DCT co-efficient. So it has very good energy compactness properties. In DWT image are dividing in low sub bands and high sub bands are fused using various fusion methods. Finally, the output of the fused image is obtained by applying inverse wavelet transform on the fused coefficients of low sub bands and high sub bands. Where in curvelet it given smooth cured edge detection. Above technique mainly done in two domain: spatial domain and transform domain where it performed fusion at three different processing levels which are pixel level, feature level and decision level according to the stage at which the fusion takes place. This is depends on the required application.**

***Keywords*— Image Fusion, PCA, DCT, DWT, Curvelet Transform**

I. INTRODUCTION

The image fusion (IF) process is to integrate multisensory or multi-view or multi focus information into a new image that contains better quality features and is more informative of all the individual input information. The term quality, and its meaning and measurement depend on the particular application. Image fusion is the process of integrating two or more images of the same organ to obtain a single image which has as much more information as possible.
In today's era image fusion has many applications in the various fields. Most significant applications of the image fusion include medical image fusion, microscopic of imaging, remote sensing area, computer vision, and robotics etc. In all this application the output fused image is achieved by applying a sequence of operations on the input images that would make the good information in each of the image prominent. The output fused image is constructed by combining magnified information from the input images.

But the basic problem of image fusion is one of determining the best procedure for combining the multiple input images. So a lot of image fusion techniques have been developed for image fusion. Also it joins a panchromatic image and a Multispectral image into a multispectral image with high spatial and unearthly determination in the meantime.

An ideal image fusion technique should have three essential factors, i.e. high computational efficiency, preserving high spatial resolution and reducing color distortion. The main aim of the image fusion is Pan sharpening which used to integrate the geometric details of the high resolution (Panchromatic) images and color of the low resolution or multispectral (MS) images. The output image contains high resolution multispectral image.

Panchromatic image is broad visual wavelength range which is rendered in black and white. Multispectral image is that is obtained in different spectral band. Here on that bases list of the technique which is described in this paper is given below:

II. IMAGE FUSION TECHNIQUES

A. Principle Component Analysis:

Principal component analysis (PCA) is a statistical mathematical procedure. It was developed by Pearson in 1901 and hotelling in 1933. PCA is mathematical tool and used a mathematical variable. It uses an orthogonal transformation. This transforms a number of correlated variables into a several uncorrelated variables. PCA is widely used in image classification [1].

The number of principal components in output is less or equal to the number of original variables in the input image.The intend of the technique is to reduce the dimensionality of multivariate data whilst preserving as much of the relevant information as possible [2]. It is measure a basic two things which is variance and covariance from the correlation matrix.

The matrix basically contains the eigenvalue and corresponding Eigen vectors. This eigenvalue and Eigen vectors given principle component of the fused image which is given below:

- First principal component is taken to be beside the direction with the maximum variance. And it replaced with the panchromatic image because it contains the common information for all band.

- First principal component will have largest Eigen value with high contrast, it is best for gray scale images, for color images it require three principal components for Red, Green and Blue [3].

- The second principal component is constrained to lie in the subspace perpendicular of the first principle component [4]. Within this subspace, this component points the direction of maximum variance.
- The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on [5].

The conventional PCA fusion method may not be appropriate to fuse high-resolution images and lower solution multi-spectral images. PCA distort the spectral characteristics of the multispectral data and decreased quality of the image [3]. The adaptive PCA approach provides efficient spectral transformation between the two images by selecting the best principal component to be replaced by the panchromatic image with high spatial resolution [6].

The fundamental advantage of PCA is that you need to put various inputs and that the vast majority of the data inside all the inputs can be compacted into a much littler amount of yields without much loss of data [7].

B. Discrete Cosine Transform:

A DCT is used to express a sequence of finite data points in terms of a sum of cosine functions oscillating at different frequencies. This is widely used in image compression.

Discrete cosine transform (DCT) is an important transform extensively used in digital image processing. Large DCT coefficients are concentrated in the low frequency region; hence, it is known to have excellent energy compactness properties [8].

At first the image divided in to sub image blocks (8x8), and then DCT is applied on each block and get the coefficients. Each sub block containing 1 DC coefficient and 63 are other coefficients.

Basic equation of 2D-DCT is given below,

$$Z(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} \alpha(u)\alpha(v)Z(x,y)\cos\left(\frac{\pi(2x+1)u}{2M}\right)cos\left(\frac{\pi(2y+1)v}{2N}\right)$$

$$Where\ \ 0 \le u \le M-1$$
$$0 \le v \le N-1$$

.....(Eq. 1)

$$\text{Where, } \propto(u) = \begin{cases} \frac{1}{\sqrt{M}}\ ;\ u = 0 \\ \sqrt{\frac{2}{M}}\ ;\ 1 \le u \le M-1 \end{cases}$$

$$\alpha\ (v) = \begin{cases} \frac{1}{\sqrt{N}}\ ;\ v = 0 \\ \sqrt{\frac{2}{N}}\ ;\ 1 \le v \le N-1 \end{cases}$$

$$Z(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \alpha(u)\,\alpha(v)\,Z(u,v)\cos\left(\frac{\pi(2x+1)u}{2M}\right)cos\left(\frac{\pi(2y+1)v}{2N}\right);$$

$$Where\ \ 0 \le x \le M-1$$
$$0 \le y \le N-1$$

.....(Eq. 2)

Problem with this method is it can extract most of the global features and some of the local feature. So some of the local features are missed.

C. Discrete Wavelet Transform (DWT)

Discrete wavelet transform (DWT) is part of wavelet family transform for which the wavelets are discretely sampled the signals.DWT is the basic and simplest transform among the wavelet transform family and where numerous multiscale transform and other type of wavelet based fusion schemes are available.

The DWT is used to overcome the problem of the standard image fusion technique like PCA and IHS and recover the problem of spectral distortion.

Discrete wavelets transform (DWT) allows the image decomposition in different level of coefficient preserve the image information [10].

The signal can be represented in terms of these coefficients as

$$f(x) = \sum_{k} c_{jk}\, \Phi_{jk}(x) + \sum_{j=1}^{J} \sum_{k} d_{jk}\, \Psi_{jk}(x)$$

.....(Eq. 3)

Where C_{jk} are the scaling coefficients and d_{jk} are the wavelet coefficients. The first expression above equation(3) gives the Low-resolution approximation of the signal. The second expression of above equation(3) gives the complete information at resolutions from the original down to the present resolution J [11].

The process of apply in the DWT can be represented as a bank of filters, as in Fig.1. At each level of decomposition, the signal is divide into high frequency and low frequency components. The low frequency components can be further decomposed awaiting the desired resolution is reached. When numerous levels of decomposition are applied, the process is referred to as multi resolution decomposition. In general when wavelet decomposition is applied for image fusion, first level of decomposition can be sufficient, but this depends on the ratio of the spatial resolutions of the images being fused and as per application [12].

This kind of coefficient originated from different variety of images can be properly combined to gain new coefficient of the image, so that the information in the original images is gathered properly. This information used for the fused image. Once the coefficients are merged, the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficient is also preserved.

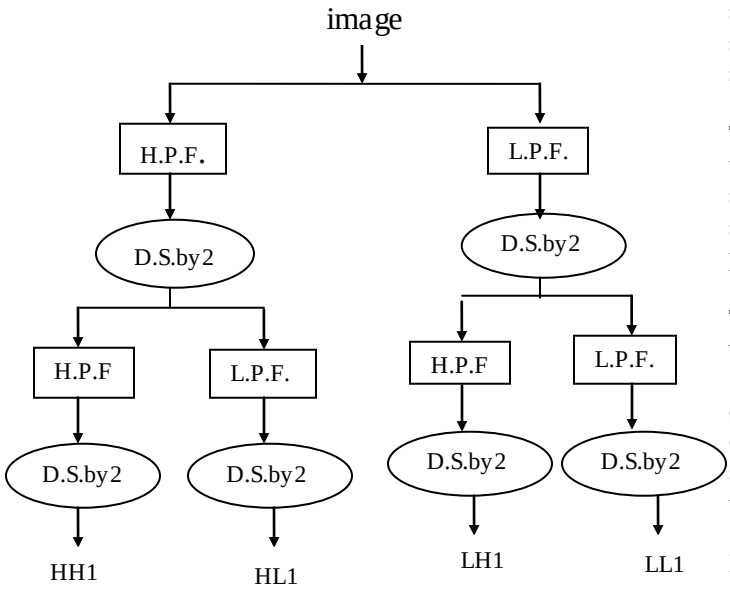

Fig.1 Bank Of Filters

Here is given the information about the output of the first level decomposition of the image in fig-2. When DWT is applied to the panchromatic image resulting in a four-component image: a low-resolution approximation component (LL) and three images of horizontal (HL), vertical (LH), and diagonal (HH) wavelet coefficients which contain information of local spatial detail. The low-resolution component is then replaced by a selected band of the multispectral image [13].

A (LL)	HD (LH)
VD (HL)	DD (HH)

Fig-2First Level Decomposition

This procedure is rehashed for each one different band until all groups are changed independently. A reverse wavelet transform is applied to the fused components to create the fused multispectral image [14].

D. Curvelet Transform:

Curvelet transform overcome the drawback of the wavelet transform. Wavelet transform not detect the edges of the image. And edge is the most important parameter for image enhancement. So curvelet transform have ability to detect the smooth curve, edge anisotropic structure and it have highly directional sensitivity.

The curvelet transform have two types: First generation and second generation. First generation have complex step while second have less complexity compared to first. So mostly second generation curvelet is used [15].

The first approach uses an un-uniformly spaced fast Fourier transform samples of images. The second approach selects special samples from images and wraps these samples at each scale and angle. The Curvelet wrapping leads to more edge preservation and spatial information off used image [16].

Therefore, the curvelet transform represents edges better than wavelets, and is well-suited for multiscale edge enhancement. So the main features curvelet transform is that it is sensitive to directional edges and capable of representing the high pass details of object contours at different scales through few sparse nonzero coefficients. The curvelet transform mainly used in the medical field with wavelet.

In curvelet transform procedure, the curvelet transform is obtained by applying the ridgelet transform to square blocks of detail frames of an undecimated wavelet decomposition. Since the ridgelet transform possesses basis functions matching directional straight lines, the curvelet transform is

capable of representing piecewise linear contours on multiple scales through few significant coefficients [17].

III. CONCLUSIONS

This paper is providing the four techniques as per its performance. The PCA & DCT are conventional fusion techniques with many drawbacks, whereas DWT based techniques are more favorable as they provides better results for image fusion. The DWT is very effective method compare to PCA and DCT. But DWT have problem for the edge detection which is overcome in the Curvelet Transform.

This study concludes saying that there are still more challenges to be met in image fusion by using hybridization of described techniques in this paper and these techniques could also be used to enhance image quality in several application of the images which gives further research perspective.

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