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Image Fusion using PCA Based Fusion Rule in Wavelet Domain

Deepak Gambhir

Associate Professor, GCET Greater Noida, Uttar Pradesh, India

ABSTRACT

Image fusion deals with combination of two or more images at input to produce new fused output image. Image fusion is a branch of image processing which is developing rapidly. The main aim of image fusion is to provide maximum information in the resulting image produced from the fusion of two or more images of the same scene or different taken at different instant of time. The result of image fusion is an image with more information and better quality. PCA provides dimensionality reduction and feature extraction. DWT decomposes the image by a factor of two. LWT is a second generation wavelet.

KEYWORDS: *Image fusion, PCA, DWT, LWT*

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I. INTRODUCTION

Image fusion produces a single image by taking information from set of source images together, using pixel or feature level techniques. The fused image contains greater information content than individual image source alone. Image fusion combine redundant and complementary information obtained from source images. Redundant information improves the reliability and complementary information improves the capability of image. It provides efficient representation of data. Image fusion is used in variety of applications like security, remote sensing, medical imaging, military. This paper focuses on Lifting Wavelet Transform method and PCA fusion rule for image fusion. It is called second generation wavelet. It is the fastest image fusion scheme. The advantage of lifting wavelet transform [3] is that it clearly identifies the detail information in the image. It transforms the coarser signal into detailed signal. It is an efficient method for calculating the filtering operations. One of the purposes of the LWT is to decompose the original images into a series of frequency channels and combine the different features and details at multiple decomposition levels. It is proven that the lifting scheme cuts computation complexity in half than the conventional WT-based algorithm. LWT contains more details than the conventional WT-based one and the fusion algorithm based on LWT has the advantage of perfect reconstruction property. PCA is a pan sharpening method. It is implemented in spatial domain. It provides good quality images and avoids color distortion. This algorithm amplified the spectral and spatial information contents. Principal component analysis is a vector space transform used to reduce multidimensional data sets into lower dimensions for analysis. LWT-PCA provides computationally efficient and better qualitative and quantitative results among DWT, LWT, DWT-PCA and LWT-PCA. It clearly identifies the detail information in the image.

PCA

It is weighted superposition of all input images. It converts correlated variables into uncorrelated variables called principal components. PCA maintains most of the information found in original image data. It preserves both spectral and spatial characteristics. The PCA algorithm builds a fused image of several input images as a weighted superposition of all input images. The resulting images contain enhanced information as compared to individual images. The basis of PCA lies in multivariate data analysis.

DWT

It decomposes the signal into multiple scales. It is a multi resolution transform. It subsamples the image by a factor of two. Single level decomposition gives four different frequency bands namely LL, LH, HL and HH sub bands.

LWT

It is called second generation wavelet. The advantage of lifting wavelet transform is that it clearly identifies the detail information in the image. It transforms the coarser signal into detailed signal. It is an efficient method for calculating the filtering operations.

II. METHODOLOGY

A. PCA based fusion rule

In standard PCA fusion technique, the PAN image replaces the PC1 image and the whole spatial information of the

image is present in the resulting fused image. All spatial information of PAN image does not belong to MS bands. Standard PCA leads to spectral distortion. It provides linear transformation of multispectral space into Eigen vector space. In this PCA transform is applied to the spectral bands of multispectral images. It eliminates those components that contribute least to the variation in the data test. It orthogonalizes the components of input vector. So that they are uncorrelated with each other. The first principal component image contains the information that is highly correlated to all the MS bands used as input to PCA while spectral information unique to any of the bands is mapped into other components. PCA is performed using covariance and SVD. Principal components of dataset are found by calculating eigenvectors of the data covariance matrix. These eigenvectors give direction in which data distribution is extended most. The projections of data on the eigen vectors are the principal components. The eigen values give an clue of amount of information that principal components represent. Principal components analogous to large eigen values signify large amount of information in the dataset and thus inform about relation among data points.

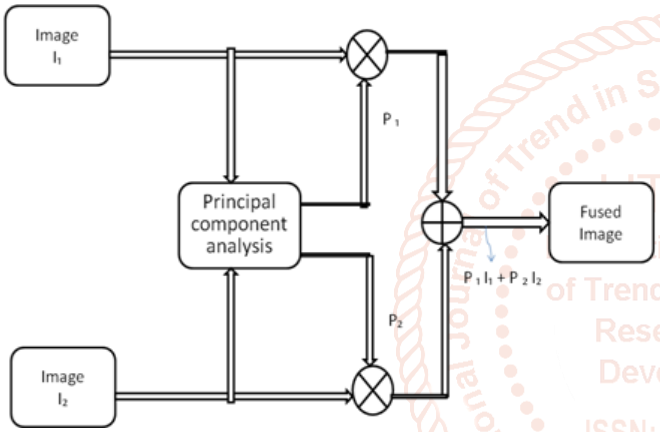


Fig.1

This figure provides fusion mechanism using PCA. The input images I1 and I2 are arranged in two column vectors and their empirical means are subtracted. The resulting vector has a dimension of n x 2, where n is length of the each image vector. Compute the eigenvector and eigen values for this resulting vector are computed and the eigenvectors corresponding to the larger eigenvalue obtained. The normalized components PI and P2 are computed from the obtained eigenvector.

The fused image is given by equation, If =P 1 I 1 +P 2 I 2 The resultant fused image is more informative and complete than any of the input images. It provides superior quality of information from set of images. It gives a better view for human or machine perception.

B. DWT based Image fusion

It analyzes the signal and decomposes the signal into multiple scales / sizes and features. Each scale / size has a bunch of features that describe something about the signal that was not seen in the other scales. DWT [7] is known as a **multi resolution** transform. DWT naturally subsamples your image by a factor of 2 (i.e. halves each dimension) after the analysis is done. Hence, called the multi-resolution bit. Dwt outputs four different variables, and these correspond to the variable names of the output of dwt.

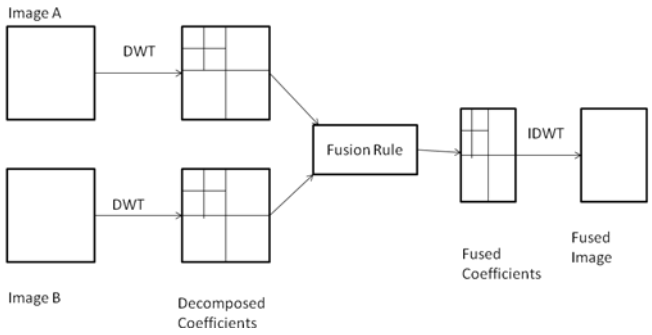


Fig.2 Discrete Wavelet transform

C. LWT based Image fusion

It is a type of decomposition process. After one level of decomposition, it will split into four frequency bands. Lifting wavelet transform is a three stage filtering process: split, prediction and update. The original input signal is f. It is transformed into a signal of high pass and low pass signal. In the split step, original signal is split into two non-overlap subsets, namely even sequence and odd sequence. In the prediction step, even sequences are used to predict odd sequences. The prediction error forms the high pass sub band. In the update step, an approximation sub band is obtained by updating even sequence with scaled high sub band samples which forms a low pass sub band.

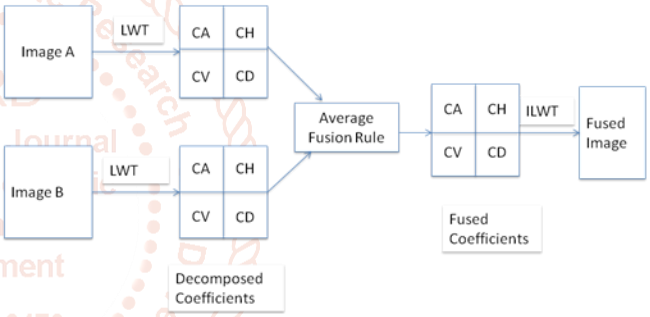


Fig.3 Lifting Wavelet transform

D. DWT-PCA based Image fusion

It is a hybrid image fusion technique in which transformation technique used is DWT and fusion selection rule used is PCA. This method provides the advantage of both DWT and PCA method. PCA [33] is widely used in image classification. PCA keeps key features in the original image and reduces the noise level. The PCA transformation matrix is formed by choosing the eigenvectors corresponding to the largest eigen values. This image fusion technique is explained in the Fig 3.3 given below. Firstly, DWT is taken for both the input images. In this, both the images are decomposed into four parts Low-Low, Low-High, High-Low, High-High frequency part. PCA selection rule is applied on Low-Low frequency components of both the images. Similar process is repeated for other frequency components also. At last inverse DWT is taken and we get resultant fused image.

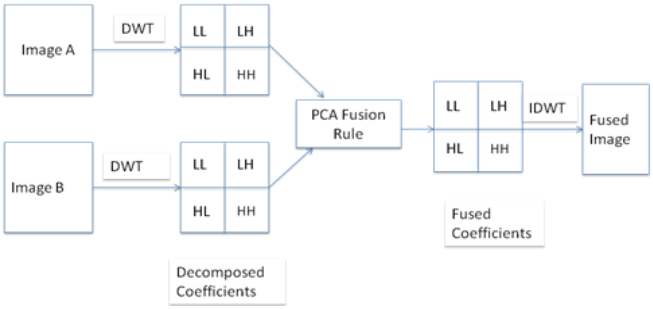


Fig.4 DWT-PCA based image fusion

E. LWT-PCA BASED IMAGE FUSION

It is a hybrid image fusion technique in which transformation technique used is LWT and fusion selection rule used is PCA. This method provides advantage of both LWT and PCA method. PCA is widely used in image classification. PCA keeps key features in the original image and reduces the noise level. The PCA transformation matrix is formed by choosing the eigenvectors corresponding to the largest eigen values. This image fusion technique is explained in the Fig 3.4 given below. Firstly, LWT [34] is taken for both the input images. In this, both the images are decomposed into four parts Approximation, Horizontal, Vertical, Diagonal frequency part. PCA selection rule is applied on approximation-approximation frequency components of both the images. Similar process is repeated for other frequency components also. At last inverse LWT is taken and we get resultant fused image.

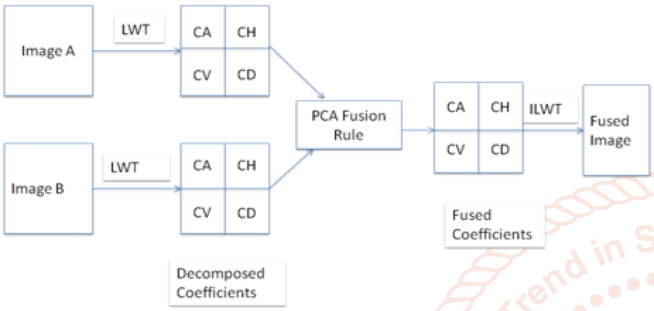
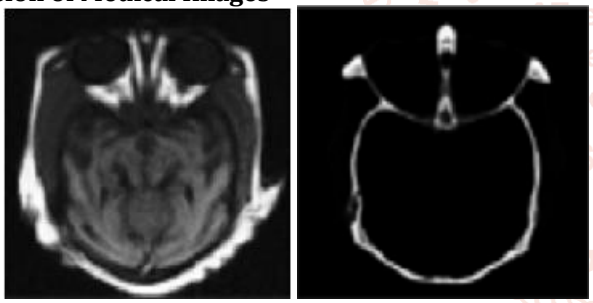


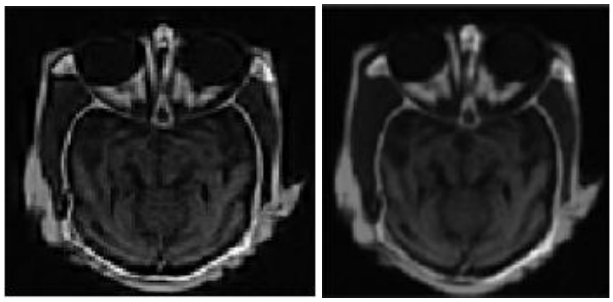
Fig.5 LWT-PCA based image fusion

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

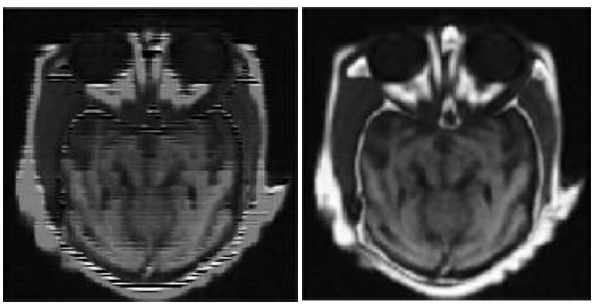
Fusion of Medical Images



a) MRI **b) CT**

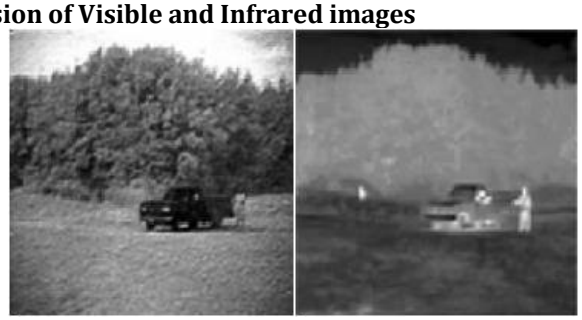


c) DWT **d) LWT**

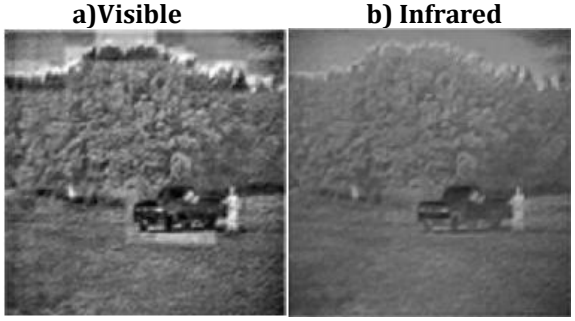


e) DWT-PCA **f) LWT-PCA**

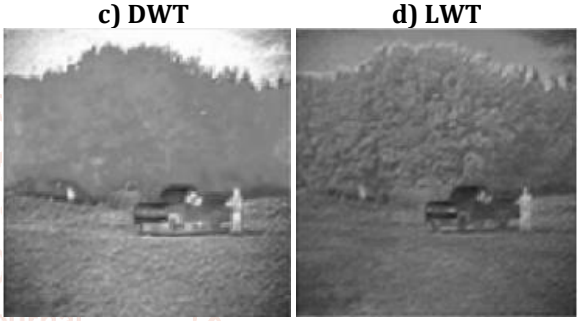
Fusion of Visible and Infrared images



a)Visible **b) Infrared**

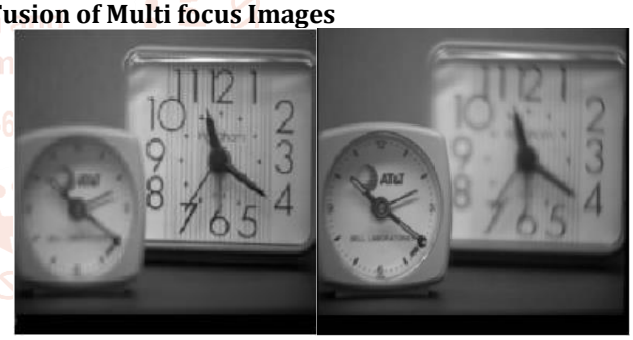


c) DWT **d) LWT**



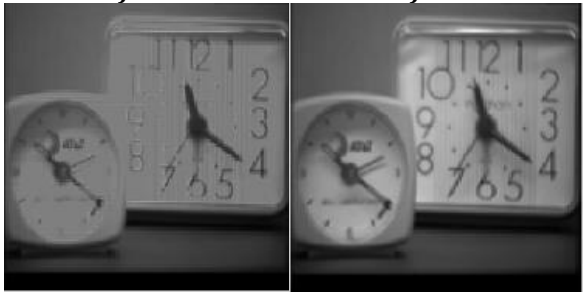
e) DWT-PCA **f) LWT-PCA**

Fusion of Multi focus Images



a) Clock A **b) Clock B**

c) DWT **d) LWT**



e) DWT-PCA **f) LWT-PCA**

Fusion of Over and Under Exposed Images

a) Under Exposed **b) Over Exposed**

c) DWT **d) LWT**

e) DWT-PCA **f) LWT-PCA**

IV. CONCLUSION

The proposed method concludes that LWT-PCA provides computationally efficient and better qualitative and quantitative results among DWT, LWT, DWT-PCA and LWT-PCA. This paper presents the comparison of various fusion methods like DWT, LWT, DWT-PCA and LWT-PCA in terms of various performance measures. PCA is widely used in image classification. PCA keeps key features in the original image and reduces the noise level. It is proven that the lifting scheme cuts computation complexity in half than the conventional WT-based algorithm. LWT contains more details than the conventional WT-based one and the fusion algorithm based on LWT has the advantage of perfect reconstruction property. The advantage of lifting wavelet transform is that it clearly identifies the detail information in the image. It transforms the coarser signal into detailed signal. It is an efficient method for calculating the filtering operations.

FUTURE SCOPE

In future, the image quality can be increased to a greater extent by using various other fusion rules like variance and energy. Other wavelet based schemes like DT-CWT can also be used for image fusion which may yield better quality image quantitatively as well as qualitatively.

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