A NEW STATISTICAL APPROACH FOR IMAGE FUSION TECHNIQUE

Akhil Kumar Das[1], Debasis Mandal[2]

[1] Assistant Professor, Computer Science & Engineering,
Uttar Banga Krishi Viswavidyalaya, West Bengal, India,
dasakhi@gmail.com

[2] Assistant Professor, Computer Science & Engineering,
IMPS College of Engineering & Technology, West Bengal, India,
debimps07@gmail.com

Abstract:--- Image Fusion is an emerging area of research in image processing and computer vision. This paper proposes an algorithm which is statistical based and it overcomes the shortcomings of the traditional image fusion algorithms. This algorithm is applied for fusing benchmark images and then the results are compared with the results of some traditional fusion methods in terms of image quality. The results shows that the quality of the fused image by the proposed algorithm produces better result than the traditional image fusion techniques.

Key term: Image Fusion, Principal Component Analysis, Wavelet Transform, Luminance, Contrast, Correlation Coefficient, Entropy, Mutual Information.

I. INTRODUCTION

Image Fusion is the process of combining relevant information from two or more images into a single image. The resulting image happens to be more informative than each of the individual images. Image Fusion is utilized in various applications like medical imaging and satellite imaging, robot vision, digital camera etc...

Image fusion techniques fall into two groups - i. Discrete wavelet transform based and ii. Statistical based. In Statistical based image fusion techniques there are various techniques such as principal component analysis (PCA) based and histogram (IHS) transform based. There are also other image fusion methods like Laplacian Pyramid Method.

Satellite Image Fusion: Several methods are there for merging satellite images. In satellite imagery we can have two types of images

Panchromatic images: An image collected in the broad visual wavelength range but rendered in black and white.

Multispectral images: Images optically acquired in more than one spectral or wavelength interval. Each individual image is usually of the same physical area and scale but of a different spectral band.

The SPOT PAN satellite provides high resolution (10m pixel) panchromatic data. While the LANDSAT TM satellite provides low resolution (30m pixel) multispectral images. Image fusion attempts to merge these images and produce a single high resolution multispectral image.

The standard merging methods of image fusion are based on Red-Green-Blue (RGB) to Intensity-Hue-Saturation (IHS) transformation. The usual steps involved in satellite image fusion are as follows:

1. Register the low resolution multispectral images to the same size as the panchromatic image.
2. Transform the R,G and B bands of the multispectral image into IHS components.
3. Modify the panchromatic image with respect to the multispectral image. This is usually performed by histogram matching of the panchromatic image with Intensity component of the multispectral images as reference.
4. Replace the intensity component by the panchromatic image and perform inverse transformation to obtain a high resolution multispectral image.

Medical Image Fusion: Image fusion has recently become a common term used within medical diagnostics and treatment. The term is used when patient images in different data formats are fused. These forms can include magnetic resonance image (MRI), computed tomography (CT), positron emission tomography (PET), and single photon emission computed tomography (SPECT). In radiology and radiation oncology, these images serve different purposes. For example, CT images are used more often to ascertain differences in tissue density while MRI images are typically used to diagnose brain tumors.

For accurate diagnoses, radiologists must integrate information from multiple image formats. Fused, anatomically-consistent images are especially beneficial in diagnosing and treating cancer. Companies such as Keosys, MIMvista, IKOE, and BrainLAB have recently created image fusion software to use in conjunction with radiation treatment planning systems. With the advent of these new technologies, radiation oncologists can take full advantage of intensity modulated radiation therapy (IMRT). Being able to overlay diagnostic images onto radiation planning images results in more accurate IMRT target tumor volumes.

II. REVIEW OF PREVIOUS TECHNIQUE

A. IHS BASED IMAGE FUSION: In IHS (Intensity-Hue-Saturation) fusion method, three bands of a multispectral image are transformed from RGB domain into IHS color space. The Panchromatic component is matched to the intensity of the IHS image and replaces the intensity component. After the matching the Panchromatic image replaces the intensity in the original IHS image and the fused image is transformed back into the RGB color space.

B. CLASSICAL CS METHOD: Component subtraction (CS) based image fusion technique incorporates both the methods of IHS and PCA. A classical CS fusion is done by a forward specific feature space transform and an inverse transformation. In this method first the MS image is resized to the size of PAN image. Then transform the MS image into a specific feature space where the histogram of the first component of specific feature space is similar to the low spatial- resolution PAN image. Then this first component is substituted by the PAN image to match the histogram. Lastly inverse transform of the new MS image create the fused image.

C. PCA-NSCT METHOD: This method combines the (NSCT) and the PCA techniques. A good insight to the PCA-NSCT fusion algorithm is given in.

Both the images are registered to each other with high precision, involving geometric and radiometric corrections. Application of PCA to the MS image and obtaining the PC1, PC2,PC3,.…,PCn components. Generation of a new PAN image whose histogram matches to that of the PC1 image. Decomposition the PC1 and PAN images using NSCT to get the NSCT low-frequency approximation coefficients. Weighted average of the corresponding coefficients of the PAN and PC1 is done, followed by the construction of the fused sub bands coefficients. Application of the inverse NSCT to the approximation and detail coefficients to reconstruct the new fused component. The PCA-NCST technique produces good results compared to the other existing techniques. The drawback of this technique lies on the fact that it is a complex procedure in terms of computational resources compared to normal PCA, as it combines both the PCA and NCST.

D. GRAM-SCMIDT METHOD: Gram -Schmidt method, as described by its inventors Laben and Brower (2000), the spatial resolution of the MS image is enhanced by merging the high resolution Pan image with the low spatial resolution MS bands. According to this method a lower spatial resolution Pan image is simulated. The Gram-Schmidt transformation is performed on the simulated lower spatial resolution Pan image and the plurality of lower spatial resolution spectral band images. The simulated lower spatial resolution Pan image is employed as the first band in the Gram-Schmidt transformation. The statistics of the higher spatial resolution Pan image is adjusted to match the statistics of the first transform band resulting from the Gram-Schmidt transformation to produce a modified higher spatial resolution Pan image. The modified higher spatial resolution Pan image is substituted for the first transform band resulting from the Gram-Schmidt transformation to produce a new set of transformed bands.

E. WAVELET TRANSFORM METHOD: In Wavelet Transform Method 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. This process is repeated for each band until all bands are transformed. A reverse wavelet transform is applied to the fused components to create the fused multispectral image.

F. AWL METHOD: The AWL method is one of the existing multi resolution wavelet-based image fusion techniques. It was originally designed for a three-band red-green-blue (RGB) multispectral image. In this method, the spectral signature is preserved because the high resolution panchromatic structure is integrated into the luminance L band of the original low resolution multispectral image. Therefore, this method is only defined for three bands.

III. PROPOSED IMAGE FUSION ALGORITHM

The proposed algorithm is PCA based. identifying patterns in data, and expressing the data in such a way as to highlight their similarities and dissimilarities. PCA fusion rule is, to find the principal axis Eigen value of the approximation images, calculate the corresponding eigenvector, and the perform fusion on these approximation images according to the principal eigenvector. But there is a disadvantage in these traditional PCA based image fusion. In traditional PCA based algorithm [1] it may happen that all the principal components are selected from the same region of the image.

This drawback is taken care in our proposed modification of the PCA algorithm. Our technique is a window based approach over the existing PCA. Here first we divide the images into some static window blocks. Then we find the principal eigenvector for each window block and perform fusion on two corresponding window blocks of the two images to be fused. This assures that the principal component will be selected from each of the window blocks.

The proposed Algorithm for image fusion is discussed as below

Step 1: Creation Window block for the images.

Each of the images is split into *n* window blocks and the number of blocks for both images must be same.

Step 2: Generation of data vectors for window blocks:

The row and the column of every window block is arranged to create data vector, i.e. for *n* window block for first image creates the data vector X1, X2,…, Xn and for second image creates the data vector Y1, Y2,…, Yn.

Step 3: Finding the covariance matrix for the window blocks.

The covariance between the two images is calculated by means of covariance matrix matrix (C) from the image data vectors of Step2. For the i^{th} window block of both the images the covariance is calculated as follows:

$$C = \begin{bmatrix} COV(X_1X_1) & COV(X_1Y_1) \\ COV(Y_1X_1) & COV(Y_1Y_1) \end{bmatrix}$$

Step 4: Determining the eigenvectors and the principal eigenvector.

The Eigen value of all the Eigen vectors are calculated from the covariance matrix. The eigenvector that has the maximum value for each of the window blocks is called the principal Eigen vector. i.e. the principal Eigen vector for all window blocks are $(x 1,y1)^T$, $(x2,y2)^T$ … $(xn,yn)^T$.

Step 5: Calculation of the approximate weight for every window block.

The approximate weight of every window blocks is calculated by the following formula as given below. For the i^{th} window blocks

W (Ai) = xi/(xi + yi) and W (Bi) = yi/(xi + yi);

here Ai and Bi represents the i^{th} window block of the two images and (xi, yi) are the corresponding principal Eigen vectors.

Step 6: Summing two corresponding window block of images.

Adding of the approximation weight of two corresponding window blocks and generating a new fused window block. i.e. i^{th} fused window block

F= A*W (Ai) + B*W (Bi).

Step 7: Aggregation of all fused window blocks.

Arranging all the fused window blocks and getting the final fused image.

IV. IMAGE QUALITY MEASURE

To check the quality of fused image we have chosen eleven quality criteria. The image qualities are being defined as follows:

Correlation Coefficient: It measures the degree of correlation between the fused and the reference images.

Entropy: It measures the richness of information in the fused image.

Mutual Information: It measures the information shared between the fused image and the reference image using histograms.

Mean Square Error: It measures the spatial distortion introduced by fusion process.

V. EXPERIMENTAL RESULTS AND ANALYSIS

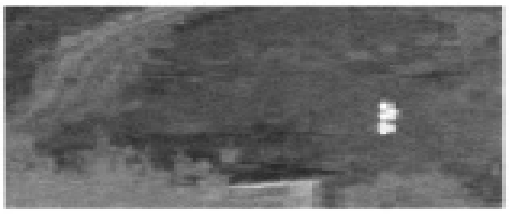
From the experimental results as shown in Table 1 it can be observed that the values of entropy, mutual information, correlation coefficient of the fused image generated by our algorithm are greater than values for the fused image generated by the other fusion algorithm. The error parameters like the Mean Square Error have lesser values for our algorithm than the other fusion algorithm. These results clearly show that our image fusion produces better result than traditional fusion methods.

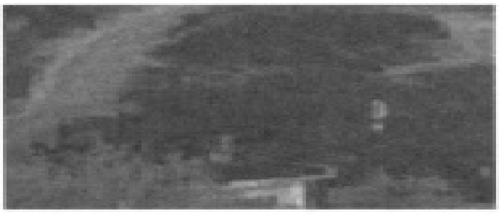
We also Compare our proposed modified PCA based method with traditional PCA based method. For these experiment we take different two image sources. The quality result is shown in table 2. From these result we can say that quality index of fused image by proposed method is better than fused image by traditional method.

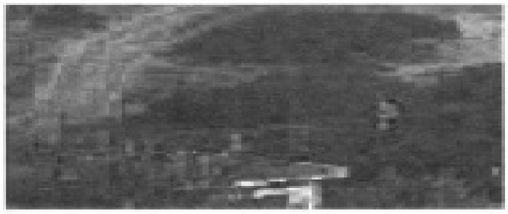
Table 1

	IHS based	Wavelet based	Gram Scmidt	PCA NCST	Modified PCA
Entropy	0.694	0.705	0.608	0.696	0.713
Correlation Coefficient	4.500	4.900	4.700	4.900	5.000
Mutual Information	1.449	1.899	1.392	1.256	7.413
Mean Square Error	18.879	20.961	20.456	18.211	5.262

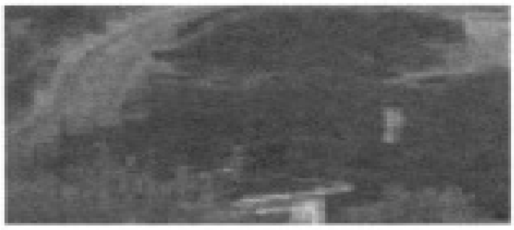

(a)


(b)


(c)

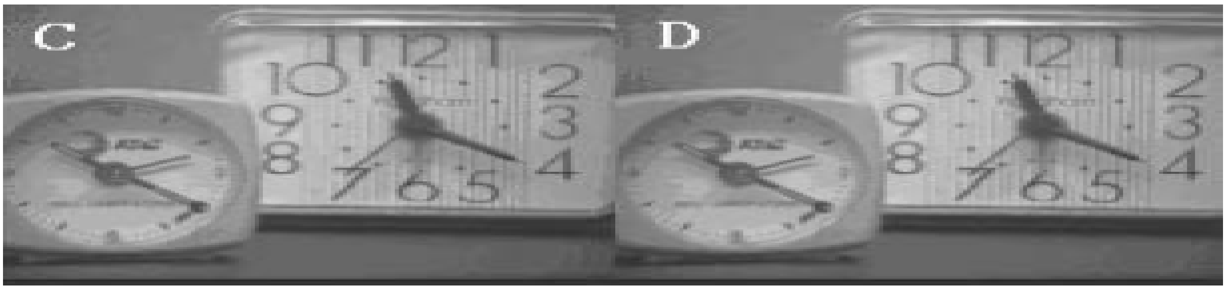

(d)


(e)


(f)


(g)

(a) Image A
(b) Image B
(c) IHS based fusion
(d) Wavelet based fusion
(e) Gram Scmidt fusion
(f) PCA NCST fusion
(g) Modifeied PCA based fusion



A.) Image A B.) Image B C.) Fused Image by Traditional PCA D.) Fused Image by Modified PCA

Table 2:

	PCA based	Modified PCA based
Entropy	0.71	0.73
Correlation Coefficient	4.9	5.0
Mutual Information	7.077	7.208
Mean Square Error	5.58	5.26

VI.CONCLUSION

This paper presents an algorithm which is statistical based. We have compared the quality of our technique with that of traditional PCA based fusion, wavelet based fusion, CS method and Gram Scmidt method . From the experimental results it is observed that the result image have better qualities in terms of information content as well as lower values of error measure compared to the traditional PCA. In future we would like to investigate our algorithm for medical and satellite image but we give the few little idea about the medical image and satellite image.

REFERENCES

[1] Y. Zheng, X. Hou, T. Bian, Z. Qin - Effective Image Fusion Rules Of Multi-scale Image Decomposition , Procedings of the 5th International Symposium on image and signal Processing and Analysis(2007) pp362-366.

[2] S. Gupta, K. P. Ramesh, E. P. Blasch – "Mutual Information Metric Evaluation for PET/MRI Image" Fusion. IEEE NAECON Conf., July 2008, pp 305 – 311.

[3] S. Li, Z. Li, J. Gong – "Multivariate statistical analysis of measures for assessing the quality of image fusion . International Journal of Image and Data Fusion", Volume 1, Issue 1 March 2010 , pp 47 – 66.

[4] N. Cvejic, A. Łoza, D. Bull, and N. Canagarajah – "A Novel Metric for Performance Evaluation of Image Fusion Algorithms" World Academy of Science, Engineering and Technology 7 2005 pp 80 -85.

[5] Y. Zhu, P. K. Varshney and H.Chen – "Evaluation of ICA Based Fusion of Hyperspectral Images for Color Display" . World Academy of Science, Engineering and Technology 7 2005

[6] A. Haq, A. M. Mirza and S. Qamar – "An Optimized Image Fusion Algorithm for Night-time Surveillance and Navigation" Proceedings of IEEE symposium , sept2005 , pp 138 – 143

[7] M. F. Yakhdani and A. Azizi – "Quality assessment of image fusion techniques for multisensory High resolution satellite images" (case study: irs-p5 and irs-p6 Satellite images) .

[8] Y. Zheng - "Pyramid, DWT and Iterative DWT - Multi-scale Fusion Algorithm Comparisons." 12th international conference on image fusion , 2009 pp 1260 –1267.

[9] S. G. Nikolov, D.R. Bull, C. N. Canagarajah, M. Halliwell, P. N. T. Wells - "Image fusion using a 3-d wavelet transform." Image Processing and its Applications, Conference Publication No. 465 0 IEE 1999 pp 235-239.

[10] L. I Smit – "A tutorial on Principal Component Analysis", 2002, pp 1 -27.