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REVIEW PAPER ON IMAGE FUSION

Krutika Chaudhari
Electronics and Communication engineering Dept.,SNPIT & RC, Bardoli, Gujarat, India 1

Abstract*: Image fusion fuses the information from several images of one scene to obtain a precise, complete and reliable image which is more appropriate for human visual perception or additional vision processing. The discrete cosine transforms (DCT) based method s of image fusion are more suitable and time -saving in real-time systems. Here improve the results by combining DCT with adaptive histogram equalization. The IR images have low definition and contain much noise which affects the quality o f the fused image. These based on the wavelet transform is proposed in this paper. Image fusion images are carried out based on discrete wavelet transform (D WT) and dual tree complex wavelet transform (DTCWT). This paper discusses the implementation of three categories of image fusion algorithms – the basic fusion algorithms, the pyramid based algorithms and the basic DWT algorithms, developed as an Image Fusion. The fused images were assessed using Structural Similarity Image Metric (SSIM)[1] , Laplacian Mean Squared Error along with seven other simple image quality metrics that helped us measure the various image features.*

Key Words: Adaptive histogram equalization, Discrete Cosine Transformation (DCT), Discrete Wavelet Transform, Image Fusion, infrared image Wavelet transform, Mean Square Error (MSE),Principle Component Analysis;, Proposed algorithm, Pyramid Methods Image Quality Metrics.

INTRODUCTION

Image fusion means the combining of two images into a single image that has the maximum information content without producing details that are non-existent in the image. With rapid advancements in technology , it is now possible to obtain information from multi source images to produce a high quality fused image with spatial and spectral information. Image Fusion is a mechanism to improve the quality of information from a set of images.

The process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images .Image fusion method can be broadly classified into two groups –

1.Spatial domain fusion method 2.Transform domain fusion. Some well-known image fusion methods are listed below[2]:-

(1)Intensity-hue-saturation (IHS) transform based fusion

(2)Principal component analysis (PCA) based fusion

(3) Multi scale transform base d fusion:- (a) High-pass filtering method (b) Pyramid

method:-

(i) Gaussian pyramid (ii) Laplacian Pyramid (iii) Gradient pyramid (iv) Morphological pyramid (v) Ratio of low pass pyramid

(c) Wavelet transforms:- (i) Discrete wavelet transforms (DWT) (ii) Stationary wavelet transforms (iii) Multi-wave let transforms

(d) Curvelet transforms. here we are using some of the Techniques from the above.

1. IMAGE FUSION ALGORITHMS

In this section we discuss the set of image fusion algorithms we considered, categorizing them under three subsections

1.1 Simple Fusion Algorithms

The trivial image fusion techniques mainly perform a very basic operation like pixel selection, addition, subtraction or averaging. These methods are not always effective but are at times critical based on the kind of image under consideration. The trivial image fusion techniques studied and developed as part of the project are

1.1.1 Average Method

Here, the resultant image is obtained by averaging every corresponding pixel in the input images.

1.1.2 Select Maximum/Minim um Method

A selection process if performed here wherein, for every corresponding pixels in the input images, the pixel with maximum/minimum intensity is selected, respectively, and is put in as the resultant pixel of the fused image.[3][4]

2. PRINCIPAL COMPONENT ANALYSIS.

Principal component analysis (PCA) is an important statistical tool t hat transforms multivariate data with correlated variables into one with uncorrelated variables [5]. PCA is used amply in all forms of analysis - from neuroscience to computer graphics - because it is a simple, non-parametric method of extracting relevant information from mystifying data sets. For images, it creates an uncorrelated feature space which can be used for further analysis instead of the original multispectral feature space. This technique is applied to the multispectral b ands. The PCA converts inter correlated M S bands into a new set of uncorrelated components. The first component is replaced by a high-resolution PAN for the fusion. The reverse PCA transform is performed to bring fused dataset back into the original multispectral feature space.

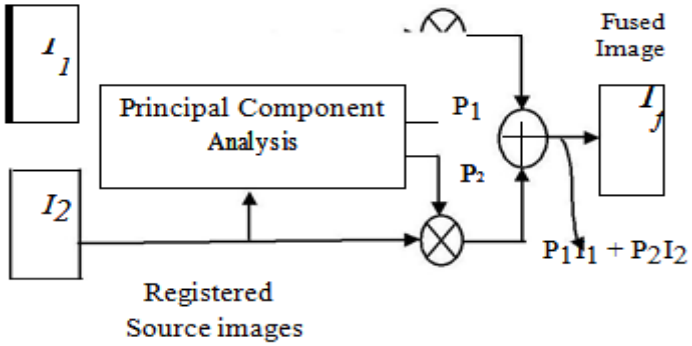

Figure 1. Image fusion using PCA[6]

Steps involved in PCA Fusion are:

(1) Input images size checking is done to ensure that source images are of same size.

(2) Then input images are arranged into column vectors. Let Z is the resulting column vector of dimension 2*N.

(3) Calculate the empirical mean along each column. The dimension of Empirical mean vector E_v is 1*2.

(4) Subtract E_v from each column of matrix Z. The resulting matrix X has dimension 2*N.

(5) Find covariance matrix C of matrix X.

(6) Compute the eigenvector and eigenvalue of C and sort them in decreasing eigenvalue.

(7) Consider first column o f vector which correspond to larger Eigen value to compute normalized component P1 an d P2.

The fused image is

$I_f\ (x,\ y) = P_1 I_1(x,\ y) + P_2 I_2\ (x,\ y)$ where P1 and P2 are the normalized components such as $P_1 = V(1)/\sum V$ and $P_2 = V(2)/\sum V$ where V is eigenvector and $P_1 + P_2 = 1$.

3. DISCR ETE COSINE TRANSFORM (DCT)

Discrete Cosine Transformation (DCT) is important to numerous applications in science, engineering and in image compression like MPEG etc.[7]. For simplicity, Discrete Cosine Transformation (DCT) can convert the spatial domain image to frequency domain image[8]. Figure 2 shows the process flow diagram for Discrete Cosine Transformation (DCT) fusion. Large DCT coefficients are concentrated in the low frequency regions; hence, it is known to have excellent energy compactness properties[6]. The images to be fuse d are divided into blocks of size NxN. DCT Coefficients are computed and fusion rules are applied to get fused DCT Coefficients. IDCT is applied to produce the fused image[6].

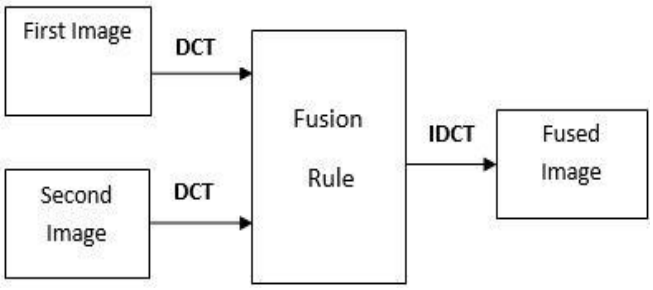

Figure 2. Image fusion process using DCT[6]

The definition of the two-dimensional DCT for an input image A and output image B is

$1 \le p \le M-1$
$1 \le q \le N-1$

Where

$$\alpha p = \begin{cases} 1/\sqrt{M}, & p=0 \\ \sqrt{2/M}, & 1 \le p \le M-1 \end{cases}$$

And

$$\alpha q = \begin{cases} 1/\sqrt{N}, & p=0 \\ \sqrt{2/N}, & 1 \le p \le N-1 \end{cases}$$

M and N are the row and column size of A, respectively[11]. If you apply the DCT to real data, the result is also real. T he DCT tends to concentrate information, making it useful for image processing applications. There are several circumstances in image processing where high spatial and high spectral resolution in one image is required. The main application of image fusion is merging the grey level high resolution panchromatic image and the coloured low resolution multispectral image**.** The image fusion techniques permit the integration of different information sources [7]

4. PROPOSED ALGORITHM

The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving in real-time systems. An efficient method for multi-focus images fusion is proposed. The proposed algorithm will integrate PCA and DCT to achieve the fusion process. In order to enhance the results histogram equalization on the output image is used. The overall objective is to improve the visibility of fused images. The figure 4 shows the flowchart of proposed algorithm

The proposed algorithm includes the following steps:

1. First of all two images which are partially blurred are passed to the system.
2. Apply RGB2PCA to convert given image in PCA plane.
3. Now differentiate PCA of image1 and image2 into their 3 planes as i mage is assumed to be in RGB.
4. For PCA(1) of Image 1 and Image 2 will be passed for fusion using DCT and PCA (2) and PCA (3) of image 1 and image 2 will determined new component by taking their average respectively.
5. Now concatenation of each output of step 4 will be done.
6. Now PCA2RGB will be applied to get original fused image.
7. Now Histogram equalization will be applied to get clearer image.[7]

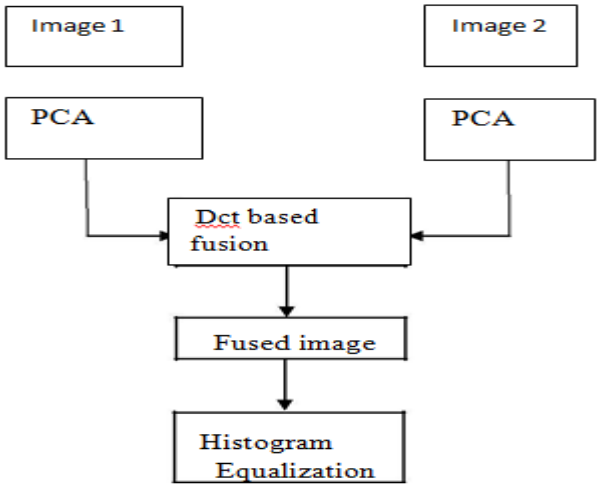

Figure 3. Flowchart of proposed algorithm.[7]

4.1 .EXPERIMENTAL RES ULTS

The proposed algorithm has been implemented in MATLAB using image processing toolbox. It is found that the integrated approach of DCT based fusion with adaptive histogram equalization produce quite better results than the existing DCT based fusion.

4.2. PERFORMANCE ANA LYSIS

The results in form of various parameters are shown in the tables below with the corresponding graphs:

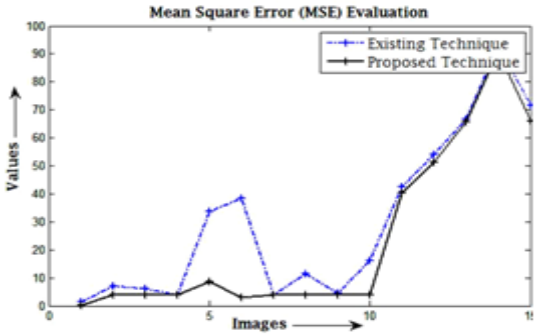

Figure 4. Plot of MSE reading[5]

From Table 1 it is clear that the MSE value for proposed algorithm is less than the values obtained by the existing algorithm. Thus the proposed algorithm is giving better value of MSE.

Tab le 1. Mean square error (MSE) evaluation

Image Name	Existing Technique	Proposed Algorithm
Img1	1.3484	0.0792
Img2	7.1875	3.9898
Img3	6.2145	3.9759
Img4	3.981	3.981
Img5	33.6584	8.6921

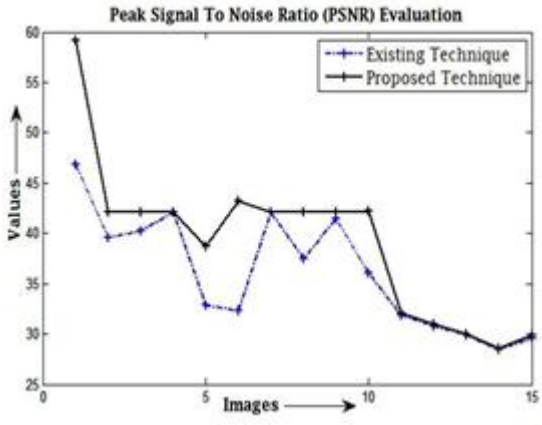

Figure 5. Plot of PSNR readings[5]

Table 2 it is shown that the PS NR value of proposed algorithm is much greater than that of the old algorithm. Thus the proposed algorithm is giving better results for PSNR value.

Table 2. Peak signal to noise ratio evaluation

Image Name	Existing Technique	Proposed Algorithm
Img1	46.8326	59.1434
Img2	39.5651	42.1213
Img3	40.1967	42.1364
Img4	42.1309	42.1309
Img5	32.8599	38.7395

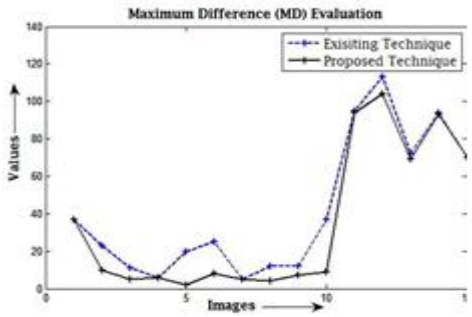

Figure 6. Plot of MD readings.[5]

Large value of MD means that image is of poor quality. In Figure 6 and table 3 the maximum difference values of proposed algorithm is lower than the MD values of the existing algorithm. Hence our proposed algorithm gives better results.

Table 3. Maximum difference (MD) evaluation

Image Name	Existing Technique	Proposed Algorithm
Img1	37	37
Img2	23	10
Img3	11	5
Img4	6	6
Img5	20	2

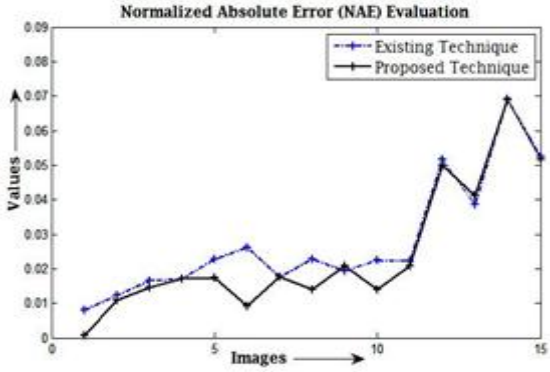

Figure 7. Plot of NAE readings [5]

Larger value of NAE indicates poor quality of the image. In Figure 7 and Table 4 the NAE values of new algorithm are less than the NAE values of the old algorithm. Therefore the proposed algorithm is giving better values for NAE.

Table 4. Normalized absolute error evaluation

Image Name	Existing Technique	Proposed Algorithm
Img1	0.0081	0.0006809
Img2	0.0123	0.011
Img3	0.0165	0.0145
Img4	0.0172	0.0172
Img5	0.0227	0.0173

5. DISCRETE WAVELET TRANSFORM (DWT)

Wavelets are finite duration oscillatory functions with zero average value [1 1]. They have finite energy. They are suited for analysis of transient signal. The irregularity and good localization properties make them better basis for analysis of signals with discontinuities.

Wavelets can be described by using two functions viz. the scaling function f (t), also known as „father wavelet" and the wavelet f unction or „mother wavelet ". Mother wavelet (t) undergoes translation and scaling operations to give self-similar wavelet families as given by Equation

$$\varphi\, a,b(t)=1/a^{\varphi}\,(t-b/a),(a,b\,\epsilon\, R),\ a>0$$

The wavelet transform decomposes the image into low-high, high-low, high-high spatial Frequency bands at different scales and the low-low band at the coarsest scale which is shown in figure8.

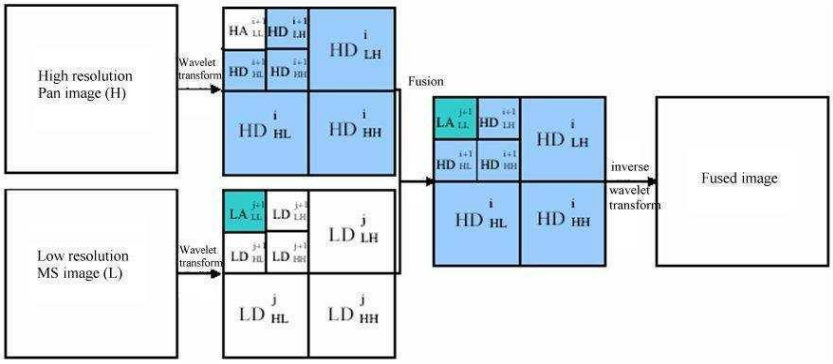

Figure8: Wavelet Based Image Fusion [11]

The wavelet-based approach is appropriate for performing fusion tasks for the following reason:

1) It is multi-scale approach well suited to manage the different image resolution.
2) DWT allows the image decomposition in different kinds of coefficients.
3) Fused image is achieved through the inverse discrete wavelet transform (IDWT).

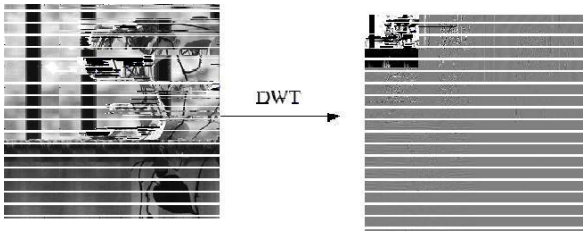

Figure 9. Example of a two level DWT[11]

$$I_{LL}(x,y)=\varphi(x)\varphi(y),$$
$$I_{LH}(x,y)=\varphi(x)\psi(y),$$
$$I_{HL}(x,y)=\psi(x)\varphi(y),$$
$$I_{HH}(x,y)=\psi(x)\psi(y)$$

6. DUAL T REE WAVELET TRANSFORM (DTCWT)

The biggest problem with the DWT is its shift variant nature caused by sub-sampling which occurs at each level. The DT CWT is an over-complete wavelet transform that provides both orientation selectivity and goo d shift invariance over the DWT. Two fully decimated trees are produced, one for the odd samples and the other for the even samples generated at the first level. The DTCWT has reduced over completeness compared with DWT. Besides, it increases the directional sensitivity and is able to distinguish between positive and negative. The DTCWT gives perfect reconstruction as the filters are chosen from a perfect reconstruction bi-orthogonal set. It is applied to images by separable complex filtering in two dimensions. The increased shift invariance and directional

sensitivity mean that the DTCWT gives improved fusion results over the DWT.

Table 1: Comparative Evaluation

Ref No	Technique	Feature
1	Dct based fusion method	1.Efficiency 2.Complexity Reduction and decomposition Image into serious of waveform. 3. Suited for real time application.
2	Comparative analysis of PCA, DCT , & D WT	1.DWT based are more favourable as they Provide better result for image fusion. 2.pixel averaging and maximum pixel Replacement approach used. 3.fused image is used combining information from the input image.
3	DT-CWT based fusion image	1. Improve the quality of image. 2. DT-CWT is using the DTCWT 3. Gives best result.

7. AP PLICATIONS OF IMAGE FUSION

Object identification:

The feature enhancement capability of image fusion is visually apparent in VIR/VIR combinations that often results in images that are superior to the origin al data. In order to maximize the amount of information extracted from satellite image data useful products can be found in fused images[10].

Intelligent Robots:

The Intelligent Robotics Group explores extreme environments, remote locations, and uncharted worlds. We conduct applied research in computer vision, geospatial data systems, human-robot interaction, planetary mapping and robot software [10]. Example - Stereo camera fusion, intelligent viewing control.

Medical Image:

Digital neutron and X-ray images fusion method based on contour let and IHS transformation is proposed[11]. The results show that our method preserves more image detail and hence provides more accurate information, which is superior to IHS and wavelet-IHS based fusion approaches. Example- MRI and X-Ray, surgery.

Manufacturing:

Manufacturing is the term used to refer to the process of using tools, machines and labour to produce goods that are either for use or for sale.

Remote Sensing:

Remote sensors collect data by detecting the energy that is reflected from Earth. It gathering data on an object or area from a considerable distance, as with radar or infrared photography, to observe the earth or a heavenly body. These sensor can be on satellites or mounted on aircraft .Example-

- Using various parts of the electro-magnetic spectrum
- Fusion technique are classified into photographic method and numeric al method[11]

CONCLUSION

- It is found that DCT based image fusion produced results but with lesser clarity, less PSNR value and more Mean square error. It is found that most of researchers have neglected image filtering and restoration which is must need of the image fusion. So the proposed work integrates adaptive histogram equalization with DCT based technique to give better results than the older techniques.
- Although selection of fusion algorithm is problem dependent but this review results that spatial domain provide high spatial resolution. But spatial domain have image blurring problem. The Wavelet transforms is the very good technique for the image
- fusion provide a high quality spectral content. But a good fuse d image have both quality so the combination of DWT & spatial domain fusion method (like PCA) fusion algorithm improves the performance as compared to use of individual DWT and PCA algorithm. Finally this review concludes that a image fusion algorithm based on combination of D WT and PCA with morphological processing will improve the image fusion quality and may be the future trend of research regarding image fusion.

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