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RESEARCH ARTICLE

A NEW HYBRID FUSION TECHNIQUE FOR GRAYSCALE IMAGES & COMPARATIVE ANALYSIS

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ABSTRACT

Image Fusion is a process of combining the relevant information from a set of images into a single image, where the resultant fused image will be more informative and complete than any of the input images. The Proposed image fusion technique includes following steps: first, discrete wavelet transform is applied to obtain the wavelet coefficients of the source images. The coefficients are processed with different fusion rules like maximum pixel, average pixel and region based masking and addition selection rule to get the primary fused image, which is again processed with the region based fusion rules to get the secondary fused image. The primary and secondary images are processed again with most efficient fusion rule Principal Component Analysis to get the final fused image. The performance of the proposed image fusion scheme is evaluated with peak to signal noise ratio (PSNR), Normalized cross correlation (NCC), entropy (EN). The fusion performance of the proposed method compared with some common individual DWT and PCA Method.

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 given images[1][2]. 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 [3] [2]. Image Fusion is a mechanism to improve the quality of information from a set of images. Important applications of the fusion of images include medical imaging, microscopic imaging, remote sensing, computer vision, and robotics .Use of the Simple primitive technique will not recover good fused image in terms of performance parameter like peak signal to noise ratio (PSNR), Normalized cross correlation (NCC). Recently, Discrete Wavelet Transform (DWT) and Principal Component Analysis (PCA), and Combination of DWT with PCA techniques have been popular fusion of image [4][5][6]. These methods are shown to perform much better than simple averaging, maximum, minimum.

Literature Survey

Image Fusion applied in every field where images are ought to be analyzed. For example medical image analysis microscopic imaging, analysis of images from satellite, remote sensing Application computer vision, robotics etc [7][8]. Image fusion method can be broadly classified into two groups –

1. Spatial domain fusion method
2. Transform domain fusion

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In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired result. The fusion methods such as averaging, Brovey method, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches. Another important spatial domain fusion method is the high pass filtering based technique. The disadvantage of spatial domain approaches is that they produce spatial distortion in the fused image. Spectral distortion becomes a negative factor while we go for further processing such as classification problem [8]. In frequency domain methods the image is first transferred in to frequency domain. It means that the Fourier Transform of the image is computed first. Spatial distortion can be very well handled by frequency domain approaches on image fusion. The multi resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion [8][13].

Image Fusion Algorithms

To obtain an image with every object in focus a multi-focus image fusion process is required to fuse the images giving a better view for human or machine perception. Pixel-based, region-based and wavelet based fusion algorithms were implemented [9].

(a) Simple Average

It is a well documented fact that regions of images that are in focus tend to be of higher pixel intensity. Thus this algorithm is a simple way of obtaining an output image with all regions in focus. The value of the pixel P (i, j) of each image is taken and added. This sum is then divided by 2 to obtain the average. The average value is assigned to the corresponding pixel of the output image which is given in equation (1). This is repeated for all pixel values.

$$K (i, j) = \{X (i, j) + Y (i, j)\}/2 \qquad (1)$$

Where X (i , j) and Y (i, j) are two input images.

(b) Select Maximum

The greater the pixel values the more in focus the image. Thus this algorithm chooses the in-focus regions from each input image by choosing the greatest value for each pixel, resulting in highly focused output. The value of the pixel P (i, j) of each image is taken and compared to each other. The greatest pixel value is assigned to the corresponding pixel [7][9].

Discrete Wavelet Transform (DWT)

Wavelets are finite duration oscillatory functions with zero average value [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 function or 'mother wavelet'. Mother wavelet (t) undergoes translation and scaling operations to give self similar wavelet families as given by Equation (2)

$$\psi_{a,b}(t)=\frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right), (a, b\epsilon R), a > 0 \qquad (2)$$

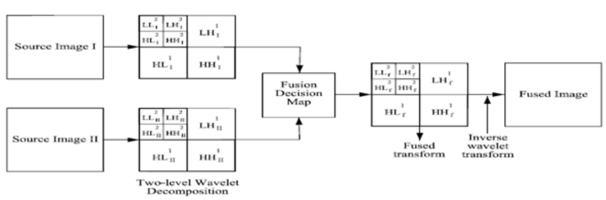


Fig. 1: Wavelet Based image fusion

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 Fig1. The L-L band contains the average image information whereas the other bands contain directional information due to spatial orientation. Higher absolute values of wavelet coefficients in the high bands correspond to salient features such as edges or lines [1][7][10]. The basic steps performed in image fusion given in fig. 1.

Principal component analysis (PCA)

PCA is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is used extensively in image compression and image classification. The PCA involves a mathematical procedure that transforms a number of correlated variables into a number of uncorrelated variables called principal components. It computes a compact and optimal description of the data set. The first principal component accounts for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. 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. [11].

Proposed Algorithm

In the process of image fusion, the choice of fusion rule is very important for the quality of the fusion result. In this paper a new method of image fusion based on multi-fusion schemes is proposed. Fig.2 show the steps involve in proposed image fusion algorithm. The process of the algorithm is given below-

(1) Read the two source images A and B to be fused.
(2) Perform independent wavelet decomposition of the two images to get approximation (LL) and detail (LH , HL , HH) coefficients.
(3) The low-frequency coefficients are fused based on average method. LL_A , LL_B Are the low frequency coefficients of input images A and B.

$$LL_f^1 = avg(LL_A(i, j), LL_B(i ,j))$$

(4) The high-frequency coefficients are fused based on taking the largest absolute value of pixels.

$$LH_f^1 = \max (abs (LH_A (i,j) ,LH_B(i,j)))$$
$$HL_f^1 = \max (abs (HL_A (i,j) ,HL_B(i,j)))$$
$$HH_f^1 = \max (abs (HH_A (i,j) ,HH_B(i,j)))$$

(5) The inverse wavelet transform is applied to obtain the fused image F1.
(6) Again, The low-frequency (LL^f) and high-frequency (LH^f, HL^f, HH^f) coefficients are extracted for same set of input images A and B.
(7) The low-frequency coefficients are fused based on taking the largest absolute value of pixels.

$$LL_f^1 = \max (abs (LL_A (i,j) ,LL_B(i,j)))$$

(8) A small window of size 3X3 is selected from the detail sub bands the type of filter mask used is square.
(9) Perform region level fusion of details by applying 3X3 square filter mask to detail coefficients. The resultant coefficients are added from each sub band.

LH mask LH mask LH

$$LH_f^l = mask(LH_A^l) + mask(LH_B^l)$$
$$HL_f^l = mask(HL_A^l) + mask(HL_B^l)$$
$$HH_f^l = mask(HH_A^l) + mask(HH_B^l)$$

LH_f^l , LH_A^l , LH_B^l are vertical high frequencies.
HL_f^l, HL_A^l , HL_B^l are horizontal high frequencies,
HH_f^l, HH_A^l , HH_B^l are diagonal high frequencies.

(10) We obtain the final fused transform LL_f^l corresponding to approximations through pixel rules and the vertical, horizontal and diagonal details LH_f^l, HL_f^l ,HH_f^l by mask based fusion where l =1,2,..., L.

(11) The inverse wavelet transform is applied to obtain the fused image F2.

(12) The Principal component analysis (PCA) is applied to fused images F1 and F2 to obtain the final fused image F. PCA based image fusion method combine the images via weighted averaging. For two images F1 and F2 the fused result is given by

$$f= \lambda_1 *A +\lambda_2*B \tag{3}$$

where λ_1, λ_2 are Eigen values .

Performance Measures

The performance of proposed algorithm is measured by Peak signal to noise ratio (PSNR) Entropy& Normalized Cross correlation (NCC) that are being discussed here briefly.

5.1 Peak Signal to Noise Ratio (PSNR)

PSNR is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation [2][9]. The PSNR measure is given by:-

$$PSNR(dB) = 20log \frac{255\sqrt{3MN}}{\sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}(B'(i,j)-B(i,j))^2}} \tag{4}$$

Where, B - the perfect image, B' - the fused image to be assessed, i – pixel row index, j – Pixel column index, M, N- No. of row and column

Entropy (EN)

Entropy is an index to evaluate the information quantity contained in an image. If the value of entropy becomes higher after fusing, it indicates that the information increases and the fusion performances are improved. Entropy is defined as:-

$$E = -\sum_{i=0}^{L-1} p_i \, log_2 \, p_i \tag{5}$$

Where L is the total of grey levels, $p = \{p_0, p_1, \ldots\ldots p_{L-1}\}$ is the probability distribution of each level [9].

Normalized Cross Correlation (NCC)

Normalized cross correlation are used to find out similarities between fused image and registered image is given by the following equation (6)

$$\mathrm{NCC} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij}*B_{ij})}{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij})^2} \tag{6}$$

EXPERIMENTAL RESULTS AND ERFORMANCE COMPARISON

The proposed algorithm is being implemented on different images but here result for clock and JEC images are presented only. Performance evaluation is done by taking Peak Signal-to-Noise Ratio (PSNR), Normalization cross correlation (NCC) and Entropy. Comparison with existing algorithm (DWT, Region based & PCA) is also done. Fig 1(a-f),Fig 2 (a-f) Show two input images and result of different fusion method and proposed method for clock and JEC college. It is clear the proposed method gives better result than existing fusion method. Table1 and Table2 show that the PSNR value obtained is 30.8539 db and 39.9989 db for proposed hybrid method which is higher than other fusion method for clock image and JEC College respectively.

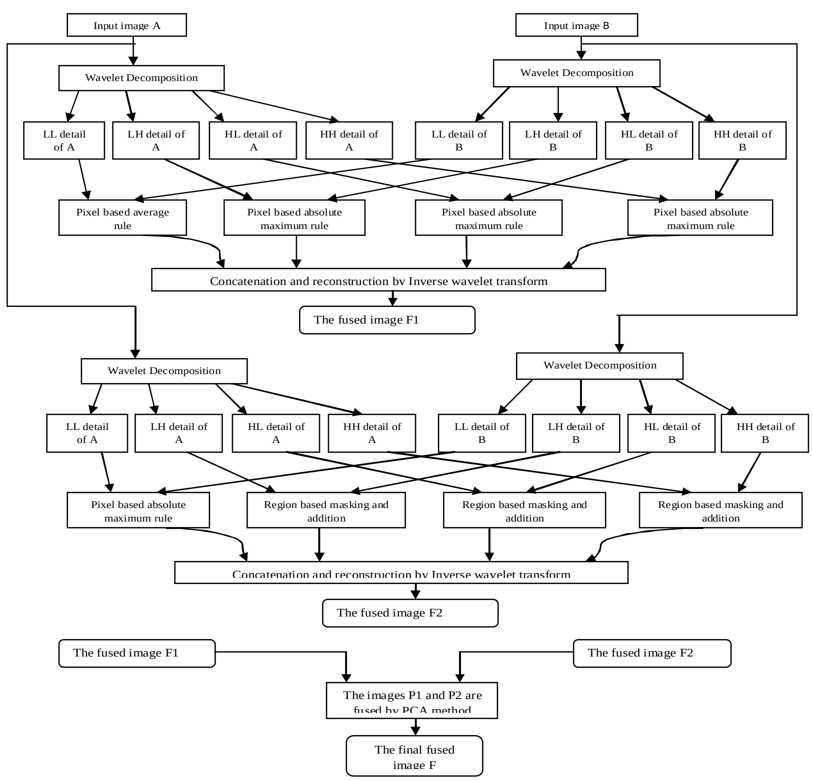
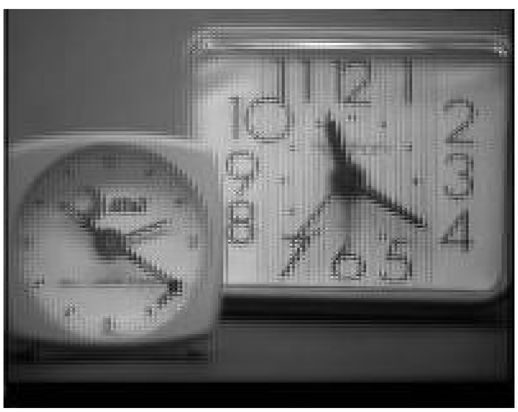


Fig. 2: Block diagram of Proposed Image Fusion Algorithm

1(a) Input image 1

1(b) Input image 2



1(c) DWT Pixel based [1]

1(d) DWT region based [6]

1(e) PCA method [11]

1(f) Proposed method

2(a) Input image 1

2(b) Input image 2

2(c) DWT Pixel based [1]

2(d) DWT region based [6]

2(e) PCA method [11]

2(f) Proposed method

Table 1. Statistics results of different fusion methods for clock image

Fusion method	PSNR	RMSE	NCC	ENTROPY
DWT pixel based method	29.9154	8.1427	0.9664	7.3517
DWT region based method	30.1779	7.9003	0.9691	7.3814
PCA method	30.5911	7.5333	0.9696	7.3443
Proposed method	30.8539	7.3088	0.9656	7.4358

Table 2. Statistics results of different fusion methods for JEC college image

Fusion method	PSNR	RMSE	NC	ENTROPY
DWT pixel based method	33.2073	5.5741	0.9962	7.3127
DWT region based method	33.2946	5.5184	0.9981	7.3587
PCA method	36.9986	3.6026	0.9992	7.3058
Proposed method	37.0980	3.6024	0.9992	7.3059

Conclusion

Image fusion is used to combine information from different images. It is widely recognized as an efficient tool for improving overall performance in image based application. This paper successfully implemented a new hybrid image fusion algorithm. It combines DWT based, Region based and PCA based algorithm. The comparison with individual algorithm proves the superiority of proposed algorithm. The variations in performance of fusion rules for different test images show that the choice of an optimum fusion rule depends mainly on the type of images to be fused. In future similarly by combining more than one algorithm new hybrid algorithm can be designed and also can be implemented for color images.

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