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RESEARCH ARTICLE

DWT BASED IMAGE FUSION WITH EDGE ENHANCEMENT USING SOBEL OPERATOR

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ABSTRACT

If multiple images of the same scene are available, this can be achieved by image fusion. Image fusion is the process by which two or more images are combined into a single image retaining the important features from each of the original images. Contrast and edges are two important quality factors in image processing. Contrast and edge enhancement are frequently referred two of the most important issues in image processing. Edge is a collection of the pixels whose gray value has a step or roof change, and it also refers to the part where the brightness of the image local area changes significantly. Image edge is the most basic features of the image. When we observe the objects, the clearest part we see firstly is edge and line. In this paper a new fusion technique has been proposed based on the discrete wavelet transform. For edge enhancement we use sobel operator. The input image is decomposed into four frequency sub band images using DWT, and then sobel operator is applied on low-high, high-low, and high-high frequency sub band images for edge enhancement.

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INTRODUCTION

Due to imperfections of imaging devices (optical degradations, limited resolution of sensors) and instability of the observed scene (object motion, media disorder), acquired images are often blurred, noisy and may exhibit insufficient spatial and/or temporal resolution. Such images are not suitable for object detection and recognition. Image fusion (Sapkal and Kulkarni, 2012) is a process of combining multiple input images of the same scene into a single fused image, which preserves relevant information and also retains the important features from each of the original images and makes it more suitable for human and machine perception. Reliable detection requires recovering the original image. If multiple images of the scene are available, this can be achieved by image fusion. The goal of image fusion is to integrate complementary information from all frames into one new image containing information the quality of which cannot be achieved otherwise. The main condition for successful fusion is that all visible information in the input images should also appear visible in the fused image. When we observe the objects, the clearest part we see firstly is edge and line. According to the composition of the edge and line, we can know the object structure. So in order to increase the contrast and edge information in an image, it results in better visualization and content rich information in a resultant image. So the fused image obtained by fusion process outcome in image quality enhancement and better apparition.

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II. Discrete wavelet transform

Wavelet transforms are linear transforms whose basis functions are called wavelets. The wavelets used in image fusion can be classified into many categories such as orthogonal, bi-orthogonal etc. Although these wavelets share some common properties, each wavelet has a unique image decompression and reconstruction characteristics that lead to different fusion results. The Discrete Wavelet Transform (DWT) of image signals produces a non-redundant image representation, which provides better spatial and spectral localization of image information, compared with other multi scale representations. Recently, Discrete Wavelet Transform has attracted more and more interest in image processing. The DWT can be interpreted as signal decomposition in a set of independent, spatially oriented frequency channels. The signal S is passed through two complementary filters and emerges as two signals, approximation and Details. This is called decomposition or analysis. The components can be assembled back into the original signal without loss of information. This process is called reconstruction or synthesis. The mathematical manipulation, which implies analysis and synthesis, is called discrete wavelet transform and inverse discrete wavelet transform.

The information flow in one level of 2-D image decomposition is illustrated in Figure 1. Wavelet separately filters and down samples the 2-D data (image) in the vertical and horizontal directions (separable filter bank). The input (source) image is I(x, y) filtered by low pass filter L and high pass filter H in horizontal direction and then down sampled by a factor of two (keeping the alternative sample) to create the coefficient matrices $I_L(x,y)$ and $I_H(x,y)$.

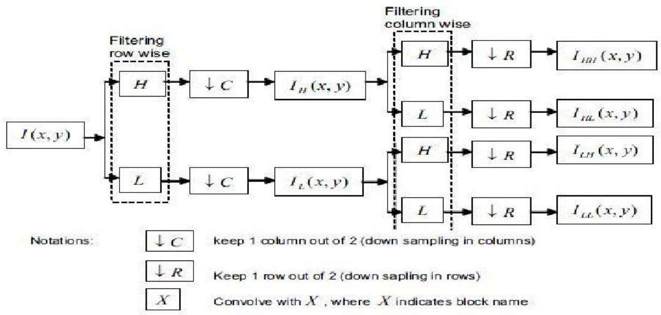


Figure 1. Decomposition Of DWT

The coefficient matrix $I_L(x,y)$ and $I_H(x,y)$ are both low pass and high pass filtered in vertical direction and down sampled by a factor of two to create sub bands (sub images) $I_{LL}(x,y)$, $I_{LH}(x,y)$, $I_{HL}(x,y)$, $I_{HH}(x,y)$ (Naidu and Raol, 2008). Direction characteristics of the sub-signals after wavelet transformation. Its frequency division characteristic is equal to high-and low dual-band filter The signal can be decomposed Images can be decomposed into a number of images with different spatial resolution, frequency characteristics and the flexibility in the choice of wavelets. The $I_{LL}(x,y)$, contains the average image information corresponding to low frequency band of multi scale decomposition. It could be considered as smoothed and sub sampled version of the source image I(x,y). It represents t$_{LH}$he approximation of source image I(x,y). I (x,y), $I_{HL}(x,y)$ and $I_{HH}(x,y)$ are detailed sub images which contains directional (vertical, horizontal and diagonal) information of the source image I(x,y).

III. Sobel operator

The Sobel operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define A as the source image, and G_x and G_y are two images which at each point contain the horizontal and vertical derivative approximations, the computations are as follows:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A \quad \text{and} \quad G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A \qquad \text{......(1)}$$

Where * here denotes the 2-dimensional convolution operation. The x-coordinate is defined here as increasing in the "right"-direction, and the y-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$G = \sqrt{{G_x}^2 + {G_y}^2} \qquad \text{......(2)}$$

Sobel operator is a kind of orthogonal gradient operator. Gradient corresponds to first derivative, and gradient operator is a derivative operator.

As compared to other edge operator, sobel has two main advantages (Wenshou Gao *et al.,* 2010):

1) Since the introduction of the average factor, it has some smoothing effect to the random noise of the image.
2) Because it is the differential of two rows or two columns, so the element of the edge on both sides has been enhanced, so that the edge seems thick and bright.

IV. Proposed approach

In this paper we are going to use sobel operator for edge enhancement. Figure 2 shows the flow diagram of proposed algorithm. First we apply DWT on input image so input image is decompose into four sub band images LL, HH, HL, LH. Out of these four sub band images LL part contain average image information and HH, LH, HL sub band contains horizontal, vertical and diagonal information. We use sobel operator on LH, HL, and HH sub band images in order to enhance the edge information of a decomposed images. The following step should be followed to get fused image using proposed methodology.

Step 1: In the very first step, input image A is taken for the analysis.

Step 2: Image is equalize using general histogram equalization technique.

Step 3: After equalization, compute the discrete wavelet transform.

Step 4: DWT of an image decomposed four sub band images referred to as (LL, LH, HL, and HH).

Step 5: Calculate G_x and G_y using convolution operation for each LH, HL, HH sub band images for edge enhancement.

Step 6: Further at each point in the image, the resulting gradient approximations are combined to obtain gradient magnitude.

Step 7: After calculating gradient magnitude for each LH, HL, HH sub band of input image A, new sub band images LH_A, HL_A, HH_A are reconstructed.

Step 8: Same procedure is applied on input image B which results in four another new sub band images.

Step 9: Select maximum rule is applied separately between each (LH_A, HL_A, HH_A) and (LH_B, HL_B, HH_B) sub band images to get final LH_F , HL_F , HH_F sub band images.

Step 10: Finally for each resultant sub band images are combined using IDWT to get final fused image F.

V. Experimental results

The Proposed technique is implemented on matlab 7 and tested on multi focus images. The various fusion methods implemented in this paper are Principal Component Analysis (PCA), Discrete Wavelet Transform (DWT), which are compared with Proposed Method. The Non reference image based performance parameters evaluated in this paper are Entropy and Standard Deviation and Mean, whereas reference based parameters evaluated are PSNR and MSE.

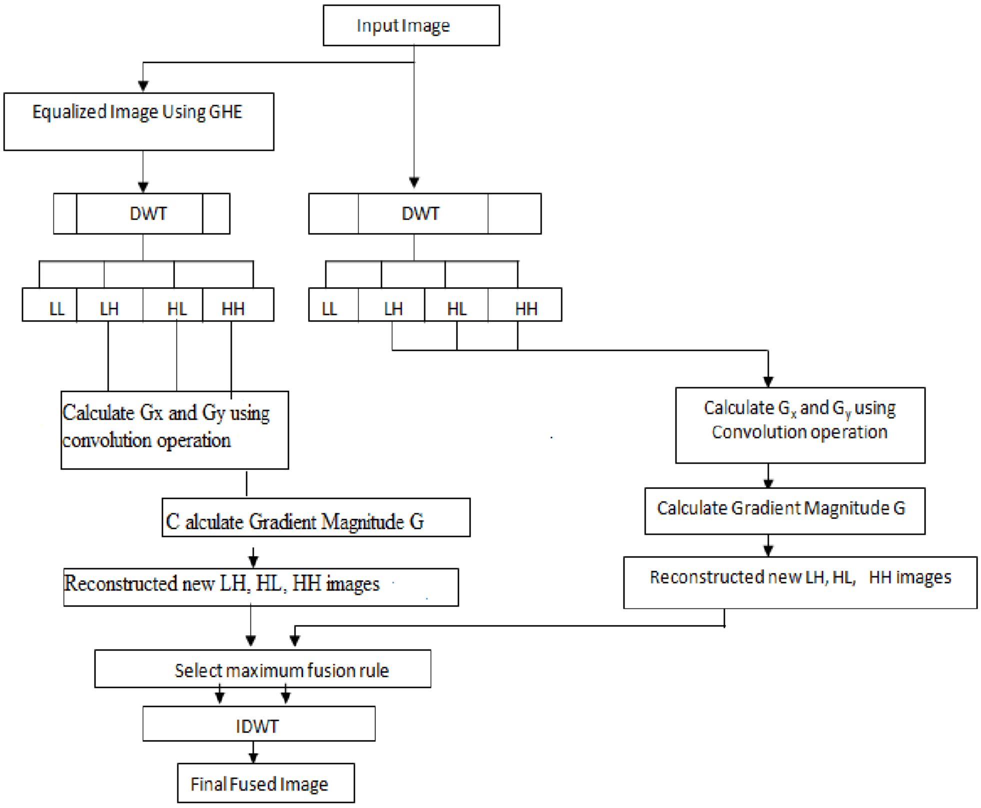
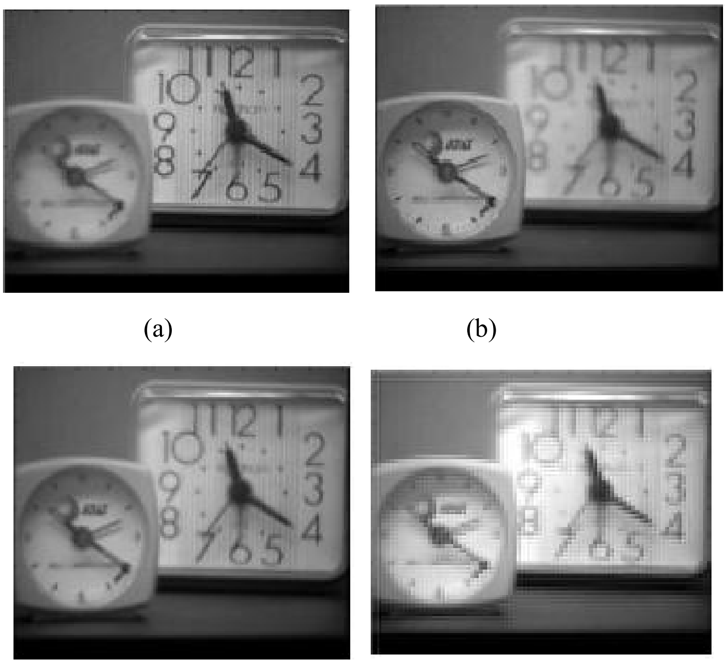


Figure 2. Flowchart for proposed approach



(a) (b)

(c) (d)

Figure 3. (a) Input Image 1, (b) Input Image 2, (c) Fused Image Using DWT, (d) Fused Image Using Proposed Approach

Table 1. Without Reference Image

Fusion Method	EN	SD	Mean
DWT	7.3501	52.4693	96.0749
Proposed	7.7400	68.1472	133.9951

Table 2. With Reference Image

Fusion Method	PSNR	M SE
DWT	14.4095	0.2567
Proposed	30.2242	0.2334

VII. Conclusion

In this paper, a new DWT based image fusion technique is proposed using Sobel Operator. Among the two fusion algorithms compared in this paper, proposed technique implemented shows better fused results. For each non reference based image quality metrics calculated. As shown in table 1 & 2 and from the Figure 3, proposed technique posses greater value as compared to the existing ones. Bigger the entropy is, the richer the information contained in final fused image the pictures quality is better. Standard deviation measures the contrast in the fused image. An image with high contrast would have a high standard deviation (Vasuki *et al.,* ?; Sruthy *et al.,* 2013). So the higher the standard deviation of a fused image is higher the contrast of an image, so the visibility of a fused image is enhanced. The mean value represents the average intensity of an image. Image with higher mean value represents higher intensity value image. Same ways for reference based image quality metrics, fused image posses higher PSNR value, which suggests better quality of reconstructed image, and lower MSE which represent the lower cumulative squared error between the original image and reconstructed image which represents better fused quality. The main objective of proposed technique was to enhance the edge information in the final fused image, which was comparatively achieved.

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