Wavelet Based Multi-Focus Image Fusion

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Abstract - Image fusion refers to extraction of complementary information and removal of redundancy from various images to obtain all relevant information in a single image. The motivation is to obtain information. In this project, our goal is to obtain a single image, which presents better performance under several popular evaluation criteria, by fusing two multi focused images of the same scene. Fusion in Spatial domain causes spatial degradation. So in this paper multi-focus images are fused in transform domain using maximum and minimum selection fusion algorithm. Finally parameters are calculated for analysis. This result generates a resultant image with superior information content in terms of subjective as well as objective analysis point of view.

Keywords - Image Fusion, Wavelet Transform, maximum and minimum selection.

I. INTRODUCTION

The image fusion is one of the important branches of data fusion. Data fusion techniques have been designed not only to allow integration of different information sources, but also to take advantage of complementary. As the number of sensors increase in an application, the more proportionate amount of image data is collected. A sensor grabs multiple images of a location and some of them will be considered for analysis. However, the considered images may not have good spatial and spectral resolution. To overcome this there is a need of image fusion.

Wavelet method is one of the most promising method of image fusion due to its simplicity and ability to maintain the time and frequency details of the image to be fused. Wavelet Fusion transforms the images from spatial domain to wavelet domain. The wavelet domain represents the wavelet coefficient of the source images.The objective of image fusion is to combine information from different source images of the same scene to achieve a new image which can provide much more visual information than the source images. Multi-focus fusion of images is the fusion of a 3D scene taken repeatedly with various focal length. The main idea is that the multi-focus image has varying local sharpness in different regions over an image. Due to the limited depth of focus in optical lenses, only objects at one particular depth in the scene are in focus and those in front of or behind the focus plane will be blurred. The image is decomposed using Wavelet transform. Then the coefficients obtained from the sub-images i.e. the decomposed sources images are fused according to the fusion algorithm. In present paper the maximum and minimum selection methods are implemented for fusion process.

II. PROPOSED METHOD

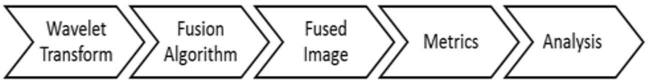


Figure 1: Proposed Model

A. Wavelet Transform

The principle of image fusion using wavelets is to merge the wavelet decompositions of the two original images using fusion methods applied to approximations coefficients and details coefficients. The low-frequency content is the most important part in the image. It is what gives the image its maximum energy or information. The high-frequency content, on the other hand, imparts flavor or nuance. In wavelet analysis, we often speak of approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. This filtering process looks like as below:

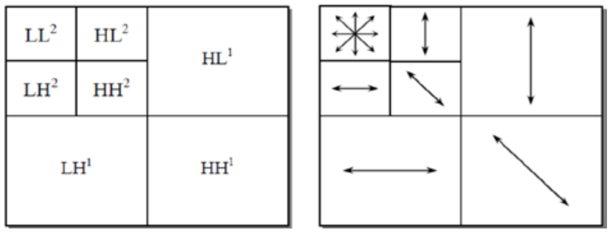


Figure 2: 2 Level Wavelet Decomposition

After one level of decomposition, there will be four frequency bands, namely Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH). The next level decomposition is just apply to the LL band of the current decomposition stage, which forms a recursive decomposition procedure. Thus, an N-level decomposition will finally have 3N+1 different frequency bands, which include 3N high frequency bands and just one LL frequency band. The 2-D DWT will have a pyramid structure shown in the above figure. The frequency bands in higher decomposition levels will have smaller size.

General process of image fusion using DWT

Step 1. Implement Discrete Wavelet Transform on both the input image to create wavelet lower decomposition.

Step 2. Fuse each decomposition level by using different fusion rule.

Step 3. Carry Inverse Discrete Wavelet Transform onfused decomposed level, which means to reconstruct the image, while the image reconstructed is the fused imageF.

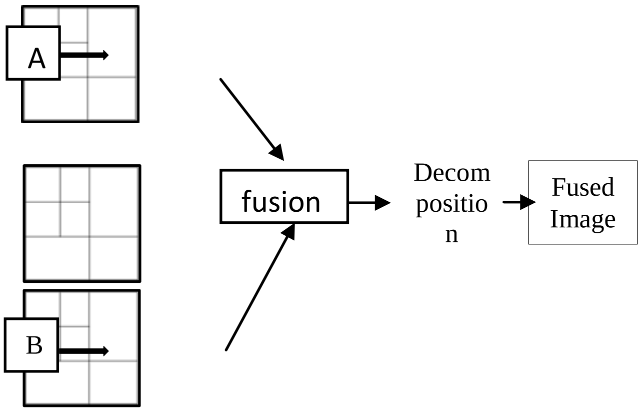


Figure 3:Wavelet Based image fusion

B. Fusion Algorithm

Maximum Selection:

The criterion of selection is self-explained by the name of the method. Of every corresponding pixel of the input images, the pixel with maximum intensity is selected and is put in as the resultant pixel of the fused image. Thus, effectively, every pixel of the fused image will be the pixel with maximum intensity of the corresponding position pixels in the input image.

$$F(i,j) = \sum_{i=0}^{m}\sum_{j=0}^{n} \max A(i,j)\ B(i,j)$$

A(i,j) and B(i,j) are input images and F(i,j) is the fused image.

Minimum selection:

The minimum selecting method, being yet another trivial image fusion method, is very similar to the Maximum Selection method; except for, here, the selection criteria differs as the pixel with minimum density is picked up. Thus, for every pixel position, the pixel of the fused image will be the pixel of the corresponding position from the input set of images having the least pixel intensity value. Similar to the Maximum Selection method, this method to either completely considers the information from an input image or discards it fully.

$$F(i,j) = \sum_{i=0}^{m}\sum_{j=0}^{n} \min A(i,j)\ B(i,j)$$

C. Performance parameters

As the number of image fusion techniques are increasing, there is a growing need for metrics. In recent years, a number of computational image fusion quality assessment metrics have therefore been proposed.The goals of the quantitative measures are normally used for the result of visual inspection due to the limitations of human eyes. The following optimal measures are implemented to judge the performance of fusion methods as follows:

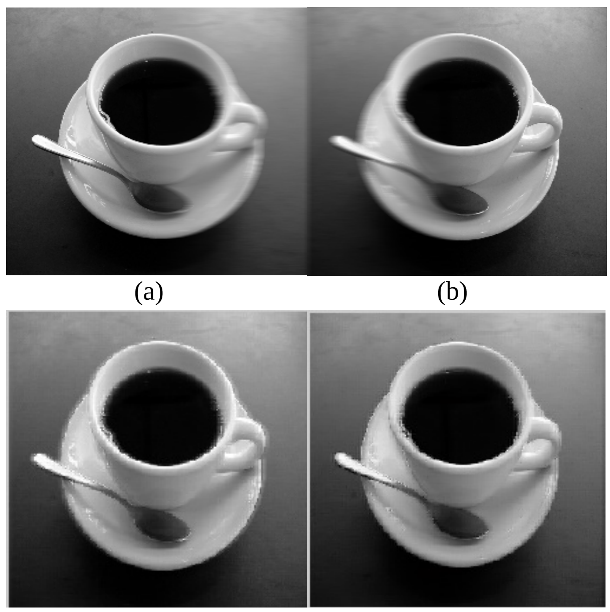
Peak Signal to Noise Ratio (PSNR):

PSNR is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. The PSNR is most commonly used as a measure of quality of reconstruction images.

Mean Square Error (MSE):

Mean square error is one of the most commonly used error projection method where, the error value is the value difference between the actual data and the resultant data. The mean of the square of this error provides the error or the actual difference between the expected/ideal results to the obtained or calculated result. MSE value will be 0 if both the images are identical.

III. EXPERIMENTAL RESULTS



(a) (b) (c) (d)

Figure 4: (a)- Left focus input image (b)- Right focus input image (c)- Fused image using maximum selection method (d)- Fused image using minimum selection method

Table 1: Comparison of Parameters

Methods\parameters	MSE	SNR	PSNR
Maximum selection	3.5802	35.7915	42.5917
Minimum selection	16.6375	22.4479	35.9199

IV. CONCLUSION

Image fusion is an important building block for augmented reality (object recognition) applications. In multi-focus image edge information is missing as it is blurred. Hence it is more important to evaluate how much structural and edge information has transferred from both source images (blurred) into the fused image. Most of the information of the source image is kept in the low frequency band and they inherited the properties of the original image. While the high frequency coefficient have large absolute values correspond to sharp intensity changes and present salient features in the image. Hence, to select the wavelet family that provides better frequency resolution is of immense importance.

Spatial frequency measures the overall activity level in an image. Some abrupt spatial changes in the image are represented by the high spatial frequencies in the image like edges. Edges are the salient features of an image which gives the information about the fine details. Low spatial frequencies; on the other hand, represents global information about the shape and the orientation of an image. Also it can be implemented for color image enhancement and retrieval. Important feature based parameters are considered for the quality analysis.

As our proposal does not involve physical deployment of sensors it saves a lot of money on sensor hardware.This approach also merges the spatial details of the two images. So the performance of this fusion method is improved greatly as compared to other methods. The new algorithm not only enhances the fused image's ability to express the spatial details but also can preserve spectral information of the source images in any system characteristics as adaptive method has been incorporate.

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