Abstract: In this paper, a new technique is introduced to develop fused image with help of the spatial frequency. First, the image is divided into several blocks by using manual segmentation technique. The spatial frequencies of each individual blocks is calculated. Place the blocks which are having high spatial frequencies into corresponding blocks of another image called fused image. Experimental results indicate the superiority of the proposed method for multifocus images.

Keywords: Image fusion, spatial frequency, discrete wavelet transform

1. INTRODUCTION

Image fusion is one of the best processes for combining images, obtained from sensors of different wavelengths simultaneously viewing of the same scene, to form a composite image. This composite image is known as fused image. The resultant fused image is very clear and perceptible to viewers [3]. The advantage of image is to improve capability by complimentary information and improving reliability by redundant information. To do process on images, the images should be registered [1]. Register the images, which are taking from the cameras to do operation image fusion. The image fusion used to increase relevant information related to particular task or information [1, 2]. Image fusion can be done by using different techniques. Image fusion method can be categorized into two types, namely as Spatial domain fusion method and Transform fusion method. Spatial domain fusion method is a simplest fusion method compare with the other methods [2]. This method is directly deal with pixels. Here the source images taken by pixel-by-pixel, but it had some undesirable side effects such as reduced contrast. In Transform domain technique, first the image transferred into frequency domain and applied all fusion operations on it, finally applied inverse forier transform to get resultant fused image.

Image fusion reduced uncertainty and minimizes redundancy in the output image [5]. In recent years a new mathematical approach method was introduced for getting accurate and cleared fused image with the help of wavelet transform technique. Wavelet transforms used in graphics, imagery and in medical images. Image fusion algorithm based on wavelet transform, which faster developed was a multi resolution analysis image fusion method [4]. This technique had good timing frequency characteristics. It was successfully applied in image processing field.

The information was given in this paper, in section 2): Brief introduction to image fusion. In section 3), the spatial frequency. In section 4), proposed method to form a fused image. In section 5) experimental results for proposed method.

2. IMAGE FUSION

In recent days image fusion became more important in image analysis and computer vision [6]. This image fusion refers to image processing techniques that produce a enhanced fused image by combining all images from two or more sensors [7]. The resultant fused image having accurate information which was related to all source images very clear and perceptible to viewers.

Objectives of image fusion scheme:
- extract all complimentary information from all source images
- do not introduce artifacts which will distract human observers

An important step in image fusion is registration that means corresponding pixel positions in the source images must refer to the same location [6]. A lot of work has been done in the area of multi-focus image fusion. Several algorithms proposed for image fusion for various applications [9]. Image fusion can be done as simply taking pixel-by-pixel average of source images, but the resultant image having drawbacks like reduced contrast. Basically image fusion has two methods, which are used to produce an accurate fused image, are spatial domain fusion and frequency domain fusion [8]. The fusion methods such as Brovey method, principal component analysis and IHS based methods are spatial domain approaches. The main disadvantage of spatial domain
approach is that they produce spatial distortion in the fused image. Some methods such as discrete wavelet transform, laplacian pyramid based, curvelet transform based methods show a better performance in spatial and spectral quality of the fused image compared to the spatial methods of fusion.

In generally, depending on the stage at which the combination mechanism takes place, image fusion can be categorized into three types, namely as Pixel level, Feature level, and Decision level [11]. Work on directly with pixels of the output images which were obtained by sensors. At same time in feature level fusion, on the other hand works on the image features extracted from the source images. In the decision level fusion, it involves at high level, and merges the interpretations of different images obtained after image understanding [10].

Related research fields of image fusion:
- computer vision
- automatic object detection
- image processing
- parallel and distributed processing
- robotics
- remote sensing

3. SPATIAL FREQUENCY

Spatial frequency is used to measure overall activity level in image. The images divide into blocks having the size as X × Y. Spatial frequency was originated from human visual system, indicates the overall active level in image. The use of spatial frequency has led to an effective objective quality index for image fusion [6,13].

Consider the image having the blocks of having size X × Y, where X is known as number of rows and Y is known as number of columns. For Calculating spatial frequency need to find row frequency and column frequency.

The row frequency can be calculated by using the formula given below,

\[
RF = \frac{1}{XY} \sum_{y=0}^{Y-1} \sum_{x=0}^{X-1} [F(x, y) - F(x, y-1)]^2
\]

(3.1)

Where F(x, y) is the gray value of pixel at position (x, y) of image F.

The column frequency can be calculated by using the formula is given below,

\[
CF = \frac{1}{XY} \sum_{y=0}^{Y-1} \sum_{x=0}^{X-1} [F(x, y) - F(x-1, y)]^2
\]

(3.2)

The total spatial frequency of image is

\[
SF = \sqrt{(RF)^2 + (CF)^2}
\]

(3.3)

4. PROPOSED METHOD

The fusion process can be done by using the following steps.

**Step 1:** Consider two multi focus images A & B to be fused.

**Step 2:** Apply manual segmentation on respective images A & B to compute spatial frequency of selective block of the image \( SF_i^A \) and \( SF_i^B \)

Where \( i \) is number of blocks

**Step 3:** Compare the spatial frequency of each block of image with the following condition

\[
SF_i = \begin{cases} 
A_i^A & \text{if } SF_i^A \geq SF_i^B \\
B_i^A & \text{if } SF_i^A < SF_i^B
\end{cases} 
\]

(4.1)

**Step 4:** The \( SF \) gives the final fused image.

![Figure 1: Schematic diagram for proposed image fusion method](image)

5. EXPERIMENTAL RESULTS

Experiments have been conducted on three sets of images using Mat lab 7.8.0 (R2009a) version. The consider images are named as Pepsi, clock and disk images having sizes like as 256x256, 128x128 and 480x640 respectively. In figs 2,3,4 (a) and (b) images are original source images. (c) is the fused image by using the basic average DWT transform technique (d) is the fused image by proposed method.

The parameter, mutual information used to compare the results obtained by basic average DWT transform with proposed method. The mutual information is a metric defined as the sum of mutual information between each input and fused image. Considering the two input images A and B , and a resulting fused image \( F \)

\[
I_{FA}(f, a) = \sum_{f,a} p_{FA}(f,a) \log \frac{p_{FA}(f,a)}{p_f(f)p_A(a)} 
\]

(5.1)

\[
I_{FB}(f, b) = \sum_{f,b} p_{FB}(f,b) \log \frac{p_{FB}(f,b)}{p_f(f)p_B(b)} 
\]

(5.2)

Thus the fused image fusion performance measure can be defined as

\[
MI_{FA}^{AB} = I_{FA}(f, a) + I_{FB}(f, b) 
\]

(5.3)

This indicates that the proposed measure reflects the total amount of information that the fused image \( F \) contains that of A and B. For both criteria, the bigger the value, the better is the fusion result. The values of figs: 2-4 are listed in table 1. Based on the table, we can observe that the proposed method provides better performance over...
basic average wavelet transform technique in terms of mutual information.

![Figure 2](image1)

Figure 2: a). Source image A. b). Source image B. c). Fused image by using basic average DWT. d). Proposed method.

![Figure 3](image2)

Figure 3: a) source image A. b) Source image B. c) Fused image using basic average DWT. d) Proposed method.

![Figure 4](image3)

Figure 4: a). Source image A. b). Source image B. c). Fused image by using basic average DWT. d). Proposed method.

Table 1: The fusion methods performance measures based on mutual information

<table>
<thead>
<tr>
<th>Technique</th>
<th>Mutual information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pepsi</td>
</tr>
<tr>
<td>DWT</td>
<td>3.0880</td>
</tr>
<tr>
<td>Proposed method</td>
<td>3.440</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In this paper, a new technique proposed to obtain fused image. The performance of proposed method is compared with basic DWT technique. In Mutual Information of proposed method is higher than basic method. The proposed method is computationally efficient and simple. The scope of this work can be extended with automatic segmentation to get more efficient fused image.

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**References**


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