Comparative Analysis of Simple Image Fusion Method and Wavelet Based Image Fusion Method

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Abstract: Image fusion is the process of combining information from two or more images of a same scene into a single composite image that is more informative and more suitable for human perception and image processing task like segmentation. There are several approaches for achieving image fusion. For this purpose the images are transformed either in pixel(spatial) domain or wavelet(frequency) domain. This paper discusses the comparison of image fusion algorithm based on pixel domain and wavelet domain as the parameter of PSNR and RMSE and prove that wavelet approach is the best approach among them.

Index Terms: Multispectral image, PSNR, RMSE

I. INTRODUCTION

The fast development of technique of sensor requires more attention on information. Just one image is not require for getting higher information. More images are required for more clarity. So combine the different image with different information, that is called as image fusion [1] and that image is known as fused image which is more suitable for human perception and image processing task like segmentation [2]. It is possible to get different image of same scene because that scene if taken by different sensor. There are mainly two types of images. Panchromatic image which contain higher spatial resolution but lower spectral resolution. Another is multispectral image which contain higher spectral resolution but lower spatial resolution. In this case image fusion is the combine this two image and create higher resolution multispectral image.

In figure 1, image 1 contain lower spatial resolution. Image 2 have higher spectral resolution. When image 2 contain higher spatial resolution but lower spectral resolution using image fusion we get the image 3 which contain higher spatial resolution with higher spectral resolution. In remote sensing field colour information is provided by red, green, blue sensor but these have lower spatial resolution. Because of lower spatial resolution some detailed information are not clearly seen.

This information is recovered with different sensor which has higher spatial resolution. In Medical field PET (positron emission tomography) and MRI (magnetic resonance image)[3] give image of higher anatomical information with brain activity.

Image fusion takes place at a different level: pixel, feature and decision level. Pixel level [4] image fusion is performed on pixels of an image. In feature level main requirement is the extraction of features like pixel intensities, edges, and textures. Decision level image fusion combine image description to the fused image. This is a description of fusion by decision, such as when the classification results are obtained from single image.

Image fusion is categories into five ways.

1) Multiview image fusion
2) Multimodal image fusion
3) Multitemporal image fusion
4) Multifocus image fusion
5) Fusion for image restoration
In multiview, fusion [2] of same modality image taken at same time but at different condition and at different time.

In multimodal, fusion [2] of different modality images but taken at same time at same condition. Fusion. In multitemporal, images of same scene with same modality but at different time. In multifocus image fusion [3], fusion is like that every region is in focus with final fused image.

II: IMAGE FUSION ALGORITHM

There are Three types of Image fusion Algorithm [1]
1) Simple image fusion [5]
2) Pyramid based image fusion [5]
3) Wavelet based Image fusion [5]

Simple image fusion algorithm contains average method, Max/Min method and pyramid based method.

Average Method:

This method [5] is very simple method and implemented on the pixels of an original image. The fused image is the averaging of every pixel in the original image. In this method the value of pixel p(i,j) of each image is taken and added. For getting average this sum is divided by 2. This average value is assigned to corresponding pixel of used image. This process is repeated for all pixels.

\[ K(i,j) = \frac{x(i,j) + y(i,j)}{2} \]

Where \( x(i,j) \) and \( y(i,j) \) are two input image.

Max/Min method:

In this method [5] maximum or minimum intensity of pixels are selected. For getting Bright fused image, pixels of maximum intensity are selected and for getting Dark fused image, pixels of minimum intensity are selected. PCA (principle component analysis) is very complex method. Pyramid decomposition based image fusion used pyramid image. Image pyramid consist of set of low pass filter and band pass copies of an image. The image pyramid consists of an original image in which sample density and resolution decreased. The main drawback of this pyramid method is that, this method creates blocking effect in fused image. Every pyramid transform consist of three major phases.

1) Decomposition
2) Formation of the initial image for recomposition
3) recomposition.

Wavelet based image fusion contains Haar wavelet and Daubechies +wavelet. This fusion method is more popular than pyramid.

III: COMPARISON OF SIMPLE FUSION AND WAVELET BASED FUSION ALGORITHM

For image fusion, images are transformed into either spatial domain or frequency domain. In Simple image fusion algorithm images are transformed into spatial domain and in wavelet base algorithm images are trasformed into frequency domain. This section describes the comparison of this two algorithm with their experiment result.

Simple image fusion algorithm [6]:

In Simple Image fusion algorithm, fusion methods are applied directly on the pixels of the image. There is no need to transform the input images into another domain. Average, Max/Min and PCA methods are applied on pixels of the input Image.

Steps for simple image fusion is Explained as below.

Step 1: Read the set of multifocas image. Here I used the two standard test image of cameraman. One image as background and other as foreground.

Step 2: for mixing of two images use alpha factor. Use alpha factor 0.5 for equally mixing of two images. If Alpha factor is less than 0.5 then contribution of background is more than foreground and alpha factor is greater than 0.5 than contribution of foreground is more than background.

Step 3: Do the multiplication of alpha factor with element array of image and multiply complement of alpha factor with element by element of image array.

Step 4: In the Maximum method consider the maximum intensity value by comparison of pixel by pixel intensity value.

Step 5: this value is considered for final output.

Step 6: Display of fused image with all high intensity pixel value.

As explained above, consider average of pixels and maximum/minimum intensity of pixels of input image consider for getting the fused image. These algorithms are simple and fast but these methods have some limit. Main problem with this is Blurring effect, which affect on the contrast of the image. This all problems are solved with Wavelet based algorithm.

Wavelet based algorithm [6]:

Problems of simple algorithms are solved with
wavelet based image fusion [8]. This is Multi scale technique and provides good result as compared to simple based algorithm.

Flow Chart of wavelet based image fusion:

These methods have mainly two phases.

1) Decomposition

2) Reconstruction

In decomposition phase signal is passed through High pass filter and low pass filter which gives two components as approximation and Detail.

In Reconstruction this components are reconstructed back in to original image without loss of information.

Steps for image fusion [5]:

Step 1: First step is image registration. The input images are registered to assure that all pixels of input images are aligned.

Step 2 Decomposition: Apply Decomposition on the input images which give approximation and detail coefficients. In short this decomposition transforms the image into frequency domain. This decomposes the image into low frequency band and high frequency band. In 2 levels DWT low frequency band contain LL band. High frequency band contain LH, HL, HH bands. The low frequency band considered as smoothed and subsample version of original image. Most of the information is at LL band. The details of image like Edges, region boundaries, line are at high frequency band.

Step 3: This bands or coefficients are performed with fusion rules. Output of this step is fused coefficients

Step 4: Reconstruction: Final step is reconstruction. Inverse decomposition is applied on fused coefficient which gives fused image without loss of information.

Performance measure: The evolution of fusion algorithm is a non trivial task as it is very difficult to say which method is better as compared to other. Comparison of simple based and wavelet based algorithm done with the parameter of PSNR and RMSE. From this comparison we can prove that wavelet based algorithm is the best approach for image fusion.

RMSE (Root mean square error): RMSE is the main parameter to evaluate the image fusion methods. Here two images are considered for evaluate.

1) Reference image or ground truth image
2) Fused image.

RMSE is defined as

\[
RMSE = \sqrt{\frac{1}{I \times J} \sum_{i=1}^{I} \sum_{j=1}^{J} (R(i,j) - F(i,j))^2}
\]

where R(i, j) and F(i, j) are the reference and fused images, respectively, I and J are image dimensions, and N x M is the size of the image. It measure how much fused image differ from original image.

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>RMSE</th>
<th>PSNR(db)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelet based algorithm</td>
<td>5.5714</td>
<td>40.701</td>
</tr>
<tr>
<td>Simple image fusion</td>
<td>6.1004</td>
<td>40.3112</td>
</tr>
</tbody>
</table>
PSNR (Peak signal to noise Ratio): PSNR is defined as $\text{PSNR} = 10 \log \left( \frac{L^2}{\text{RMSE}} \right)$ Where L is the no of level in image

Here this table describe the comparison of simple and wavelet based algorithm as the parameter PSNR and RMSE.

This simple image fusion algorithm and wavelet based algorithm is performed on the standard test image cameraman

![Figure 4 Experiment Result for simple Algorithm](image)

![Figure 5 Experiment Result for Wavelet based Algorithm](image)

IV Conclusion

In this paper there is a comparison of wavelet based and simple image fusion algorithm. Result shows that wavelet based image fusion algorithm is better as compared to simple image fusion algorithm as parameter PSNR and RMSE. There is an improvement in PSNR in wavelet based algorithm.

REFERENCES