Empirical Study on Hybrid Wavelet Based Approach for Image Fusion

[1]Gagandeep Kaur[*], [2]Anand Mittal
[2]Assistant Professor
[1,2] Department of Computer Science Engineering,
Guru Kashi University, Talwandi Sabo,
Punjab, India

Abstract— Image Fusion is a sub-field of image processing .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. Image fusion techniques can improve the quality and increase the application of these data. This paper presents a literature review on some of the image fusion techniques for image fusion like, primitive fusion (Averaging Method, Select Maximum, and Select Minimum), Discrete Wavelet transform based fusion, Principal component analysis (PCA) based fusion etc. Comparison of all the techniques concludes the better approach for its future research.

Keywords—Discrete Wavelet Transform (DWT), Mean Square Error (MSE), Normalized correlation (NC), Peak signal to noise ratio (PSNR), Principal Component Analysis (PCA).

I. 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. 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 . 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 correlation (NC), and Men square error (MSE). Recently, Discrete Wavelet Transform (DWT) and Principal Component Analysis(PCA),Morphological processing and Combination of DWT with PCA and Morphological techniques have been popular fusion of image. These methods are shown to perform much better than simple averaging, maximum, minimum.

Image fusion is of significant importance due to its aplications in medical sciences,forensic and defense departments.The process of image fusion is performed for multi-sensor and multi-focus images of the same scene.An image often contains physically relevant features at many different scales or resolutions. Multi-scale or multi-resolution approaches provide a means to exploit this fact.After applying certain operations on the transformed images, the fused image is created by taking the inverse transform. Image fusion is generally performed at three different levels of infoemation representation including pixel level,feature level and decision level. In pixel-level image fusion,simple mathematical operations such as max(maximum) or mean(average) are applied on the pixel values of the source image to generate fused image. However these techniques usually smooth the sharp edges or leave the blurring effects in the fused image.In feature level multi-focus image fusion, the source images are first segmented into different regions and then the feature values of these regions are calculated.

II. IMAGE FUSION TECHNIQUES

The process of image fusion the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images .Image fusion method can be broadly classified into two groups:
1. Spatial domain fusion method
2. Transform domain fusion

In spatial domain techniques, we directly deal with the image pixels. The pixel values are manipulated to achieve desired result. 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. All the Fusion operations are performed on the Fourier transform of the image and then the Inverse Fourier transform is performed to get the resultant image. 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. 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.

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. Some other fusion methods are also there such as Laplacian- pyramid based, Curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion.

There are various methods that have been developed to perform image fusion. Some well-known image fusion methods are listed below:-

(1) Intensity-hue-saturation (IHS) transform based fusion

(2) Principal component analysis (PCA) based fusion

(3) Multi scale transform based fusion:- (a) High-pass filtering method

(b) Pyramid method:-(i) Gaussian pyramid (ii) Laplacian Pyramid (iii) Gradient pyramid (iv) Morphological pyramid (v) Ratio of low pass pyramid

(c) Wavelet transforms:- (i) Discrete wavelet transforms (DWT) (ii) Stationary wavelet transforms (iii) Multi-wavelet transforms

(d) Curvelet transforms

III. Literature Review

Dr. NikolaosMitianoudis et.al (2003)[8] studied about the Image fusion theory and applications. Image fusion is the process that combines information from multiple images of the same scene. The result of image fusion is a new image that retains the most desirable information and characteristics of each input image. The main application of image fusion is merging the gray-level high-resolution panchromatic image and the colored low-resolution multispectral image[1].

G. Pajares and J. M. Cruz et.al (2004)[7]the Wavelet based image fusion. As multi-resolution analysis has become one of the most promising methods in image processing, the wavelet transform has become a very useful tool for image fusion. It has been found that wavelet-based fusion techniques outperform the standard fusion techniques in spatial and spectral quality, especially in minimizing color distortion[3].

T. Stathak, et.al (2008)the image fusion algorithms and applications.The paper uses two examples of image fusion to some basic fusion schemes, including intensity-hue-saturation (IHS) transform fusion, principal component analysis (PCA) fusion and wavelet-based fusion schemes. One example is the fusion of panchromatic (PAN) and multispectral (MS) images. The fused image is requested to combine the high-resolution spatial information of the PAN and the color information of the MS image [19].

Krista Amolins et.al (2007)[9] the wavelet based image fusion techniques. we only introduce the discrete wavelet transform (DWT) based fusion schemes because DWT is the basic and simplest transform among numerous multi-scale transform and other type of wavelet based fusion schemes are usually similar to the DWT fusion scheme. Wavelets are used for time frequency localization, and perform multi-scale and multi- resolution operations. Discrete wavelet transform (DWT), transforms a discrete time signal to a discrete wavelet representation.

NayeraNahvi.OnkarChand Sharma et.al (2014) Image Fusion is a process of combining the relevant information from a set of images, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images. This paper discusses implementation of DWT technique on different images to make a fused image having more information content. As DWT is the latest technique for image fusion as compared to simple image fusion and pyramid based image fusion, so we are going to implement DWT as the image fusion technique in our paper. Other methods such as Principal Component Analysis (PCA) based fusion, Intensity hue Saturation (IHS) Transform based fusion and high pass filtering methods are also discussed. A new algorithm is proposed using Discrete Wavelet transform and different fusion techniques including pixel averaging, min-max and max-min methods for medical image fusion.

ShaveetaMahajan ,ArpinderSingh et.al (2014)[10]The image fusion is becoming one of the hottest techniques in image processing. Many image fusion methods have been

developed in a number of applications. Many image fusion methods have been developed in a number of applications. Themain objective of image fusion is to combine information from multiple images of the same scene in order to deliver only theuseful information. The discrete cosine transforms (DCT) based methods of image fusion are more suitable and time-saving inreal-time systems using DCT based standards of still image or video. DCT based image fusion produced results but with lesser clarity, less PSNR value and more Mean square error. Therefore the overall objective is to improve the results by combining DCT with PCA and non-linear enhancement. The proposed algorithm is designed and

implemented in MATLAB using image processing toolbox. The comparison has shown that the proposed algorithm provides an significant improvement over the existing fusion techniques.

Veni Maheshwari1, SeemaBaghla et.al (2013)[11] explains image fusion is to combine information from multiple images of the same scene in order to deliver only the useful information. The discrete cosine transforms (DCT) based methods of image fusion are more suitable and time-saving in real-time systems using DCT based standards of still image or video[20].

Poonam Bhojani1, Hardik Dhamecha2.Et.al (2014)[12] digital cameras and smart phones have been widely used to acquire photographs. However, digital cameras and smart phones have a limited dynamic range, which is much lower than that our eyes can perceive. So, the pictures taken in high dynamic range scenes often exhibit under-exposure or over-exposure artifacts in shadow or highlight regions. Here, an image fusion based approach, in which a single acquired image is used, isproposed for enhancement of image. First, a function following the F-stop concept in photography is used to generateseveral pseudo images having different intensity. Then image classification is done to distribute the whole image intothree different classes according to the luminance value of each pixel to improve the exposure value of each pixel.After that, an image fusion method, which blends pixels in distinct luminance classes using different fusion functions,is proposed to produce a fused image in which every image region can be properly exposed and the contrast of animage is improved too. This technique improves the every pixel of an image because every calculation is done pixelby-pixel.

IV.   IMAGE FUSION ALGORITHMS

Due to the limited focus depth of the optical lens it is often not possible to get an image that contains all relevant objects in focus. 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.

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   (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.

C. DISCRETE WAVELET TRANSFORM (DWT)

Wavelets are finite duration oscillatory functions with zero average value. 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.

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

(2)

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 fig: 2. 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. The basic steps performed in image fusion given in fig. 1.
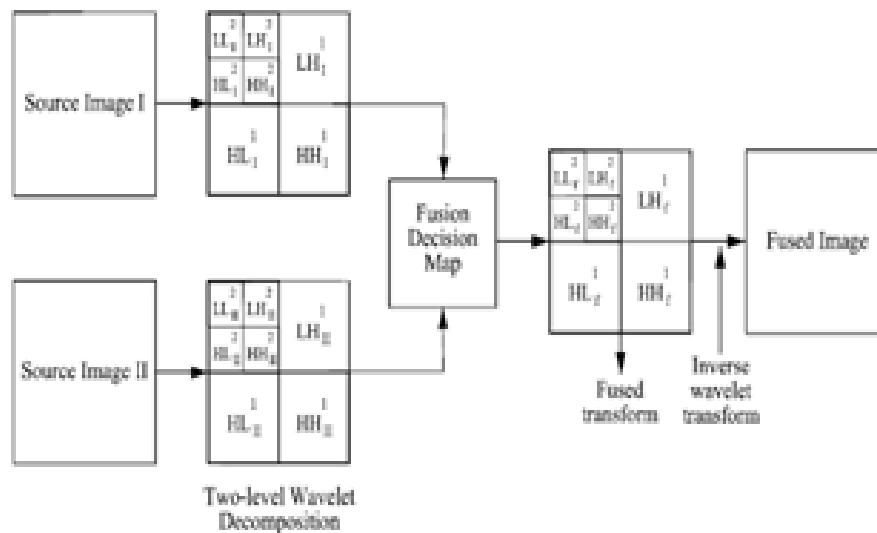

Fig1: Preprocessing of image fusion

Fig. 2: Wavelet Based image fusion

The wavelets-based approach is appropriate for performing fusion tasks for the following reasons:-
(1) It is a multi scale (multi resolution) approach well suited to manage the different image resolutions. Useful in a number of image processing applications including the image fusion.
(2) The discrete wavelets transform (DWT) allows the image decomposition in different kinds of coefficients preserving the image information. Such coefficients coming from different images can be appropriately combined to obtain new coefficients so that the information in the original images is collected appropriately.
(3) Once the coefficients are merged the final fused image is achieved through the inverse discrete wavelets transform (IDWT), where the information in the merged coefficients is also preserved.

D. 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. The PCA is also called as Karhunen-Loève transform or the Hotelling transform. The PCA does not have a fixed set of basis vectors like FFT, DCT and wavelet etc. and its basis vectors depend on the data set.

V. Conclusion

Aim of this project to study the concept of image fusion in image processing. Discrete wavelet transform (DWT) was performed on source image. Because DWT is the basic and simplest transform among numerous multi-scale transform and other type of wavelet based fusion schemes are usually similar to the DWT fusion scheme.

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