Multi Focus Image Fusion Techniques

Samiha Naik
M.Tech(Perusing),
J.D.C.T., Indore.
naiksamiha16031988@gmail.com

Tanvi Limbachiya
B.E. (Perusing),
B.M.C.E.T., Surat
tanvi3limbachiya@gmail.com

Usha Kakadiya
B.E. (Perusing),
B.M.C.E.T., Surat
kakadiyausha@gmail.com

Vilas Satasiya
B.E. (Perusing),
B.M.C.E.T., Surat
Sonalsatasiya17@gmail.com

Abstract- The single image required high spectral information and high quality for human visual perception but sensor or instrument may be not capable to provide our demand. We solved this problem using fusion process. Multi focus image fusion is a process of combining information of two or more images which capture at different direction or different angle of same scene and resultant quality of image is higher than the input image. The main goal of this paper is to implement the various method such as pixel level fusion (simple average, simple minimum, simple maximum), Discrete Wavelet transform based fusion, Principal component analysis (PCA) , Laplacian Pyramid fusion and to determine which method provide better result for human visual perception.

*****

I. INTRODUCTION

In multi-focus image fusion, the images of the same scene from the same sensor are combined to create an image in which all the objects are in focus. Important applications of the fusion of images include medical imaging , remote sensing, computer vision robotics and satellite. The process of image fusion takes place either in spatial domain or in transformed domain. In spatial domain, the pixel values are directly deal with pixel intensity. Pixel level image fusion is direct take pixel intensity value so result is depending on input images. Then in maximum or average of the corresponding pixel values of the two registered images is calculated and is taken as the corresponding pixel value of the fused image. Advantage of spatial domain is that it is very simple method. The main disadvantage of spatial domain is quality of result may be not desirable. Overcome of this problem we preferred transform domain. In transformed domain, the input images are first transformed using wavelet decomposition or pyramid decomposition using some fusion operation and the fused image is obtained by taking the inverse transform. Transform domain provide accurate result.

II. IMAGE FUSION TECHNIQUES

A. Pixel Based Methods

It represents fusion of visual information of the same scene, from any number of registered image, obtained using different sensors. There are various pixel based methods are available, some of them are listed below:

Averaging Approach : This is the simplest approach, wherein, intensity of the output pixel is the average intensity of all the corresponding pixels from the input images. Due to the averaging operation, both the good and the bad information are minimized, arriving at a mean image.

Select Maximum Approach: In this method, the pixel with maximum intensity from the corresponding spatial locations from all the images to be fused selected as the resultant pixel of the fused output image. The advantage of this method is that there is no compromise made over the good information.

Select Minimum Approach: It considers the pixel with the lowest intensity values and ignore all other values. The images with the dark shades generate good fused image with this method.

ISSN: 2321-8169
2029 - 2033

B. Principal Component Analysis (PCA)

Principal component analysis [4,6,7] is a vector space transform, often used to reduce dimensionality. PCA is the simplest true eigenvector-based multivariate analysis. It involves ways for identifying and to show patterns in data, in such a way as to highlight their similarities and differences, and thus reduce dimension without loss of data. The information flow diagram of PCA-based image fusion algorithm is shown in figure 1. The input images $I_1(x, y)$ and $I_2(x, y)$ are arranged in two column vectors and their empirical means are subtracted. The resulting vector has a dimension of n x 2, where n is length of the each image vector. Compute the eigenvector and Eigen values for this resulting vector are computed and the eigenvectors corresponding to the larger eigen value obtained [7] .

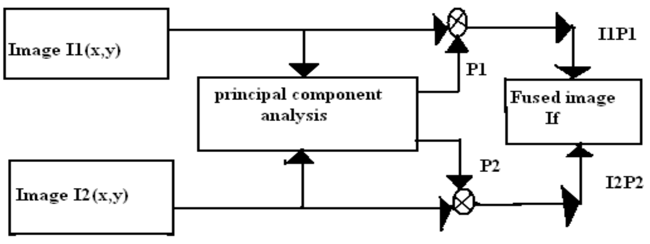

Figure 1: Information Flow Diagram Of PCA

The fused image is: $I_f(x,y) = P_1I_1(x,y) + P_2I_2(x,y)$ … (1)

The following steps should be followed for PCA algorithm to get fused image: Organize the data into column vectors. The resulting matrix Z is of dimension 2 x n. Compute the empirical mean along each column. The empirical mean vector M_e has a dimension of 1 x 2. Subtract the empirical mean vector Me from each column of the data matrix Z. The resulting matrix X is of dimension 2 x n. Find the covariance matrix C of X i.e. $C=XX_T$ mean of expectation = cov(X). Compute the eigenvectors V and Eigen value D of C and sort them by decreasing Eigen-value. Both V and D are of dimension 2 x 2. Consider the first column of V which corresponds to larger Eigen value to compute P1 and P2 as:

$$\rho_1 = \frac{V(1)}{\Sigma V} \quad \rho_2 = \frac{V(2)}{\Sigma V} \qquad \ldots(2)$$

C. Discrete Wavelet Transform (DWT)

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.

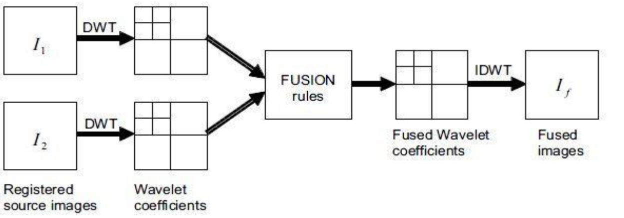

Figure 2: Block Diagram Of DWT

The figure 2 shows the block diagram of DWT. For getting final fused image using DWT, following steps should be followed: Consider two registered input image I_1 and I_2 which are too be fused. Apply DWT to both I_1 and I_2, and their coefficients in pixel p are $DI_1(p)$ and $DI_2(p)$, respectively. The output DWT coefficient in pixel p is DI_3 (p) given by using "choose-max" selection rule i.e. choosing maximum DWT coefficient between I_1 and I_2. Perform Inverse DWT toDI_3. Finally the fused image is displayed.

D. Laplacian Pyramid

It can be seen that the purpose of Laplacian decomposition is to decompose the original image into different spatial frequency bands, and to the different decomposition layers with different spatial resolutions, it can effectively merge the characteristics or details of the different images together by using different operators.

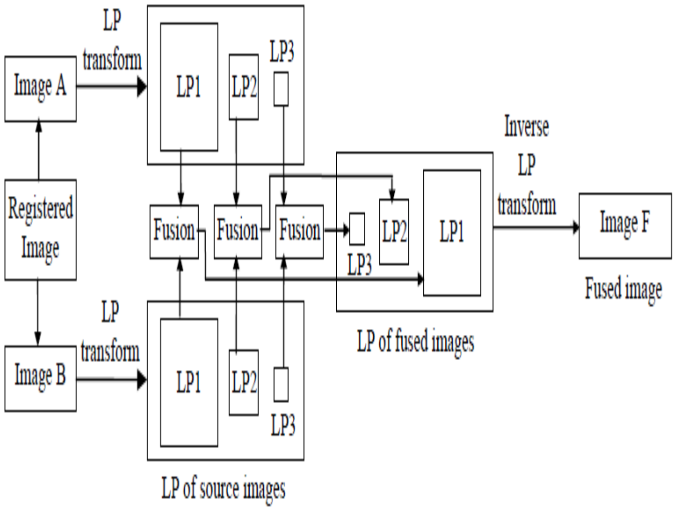

Figure 3: Block Diagram Of Laplacian Pyramid

The figure 3 shows the block diagram of image fusion using Laplacian Pyramid method. The basic steps of image fusion based on Laplacian Pyramid transform are as follows. Suppose A and B are original images of registration, F is the fused image. To perform Laplacian pyramid decomposition for the images to be fused separately and establish Laplacian Pyramid for each image.

To fuse the image pyramid layers decomposed separately, different layers can be used to mix with different fusion operators, the Laplacian pyramid of fused image can be obtained ultimately. To perform pyramid inverse transform on the new fused Laplacian pyramid, the reconstructed image will be fused image. In this approach, we can obtain an optimum fused image which has richer information in the spatial domain.

III. PERFORMANCE EVALUATION

The performance parameters are essential to determine the possible benefits of fusion as well as to compare results obtained with different algorithms. Table 1 shows the details of different performance parameters. Table 2 shows the different values of parameters for different fusion algorithms.

IV. RESULTS

In this section we take 2 input images and then shows fused output image using different approaches. Figure 4 shows fused image using different algorithms.

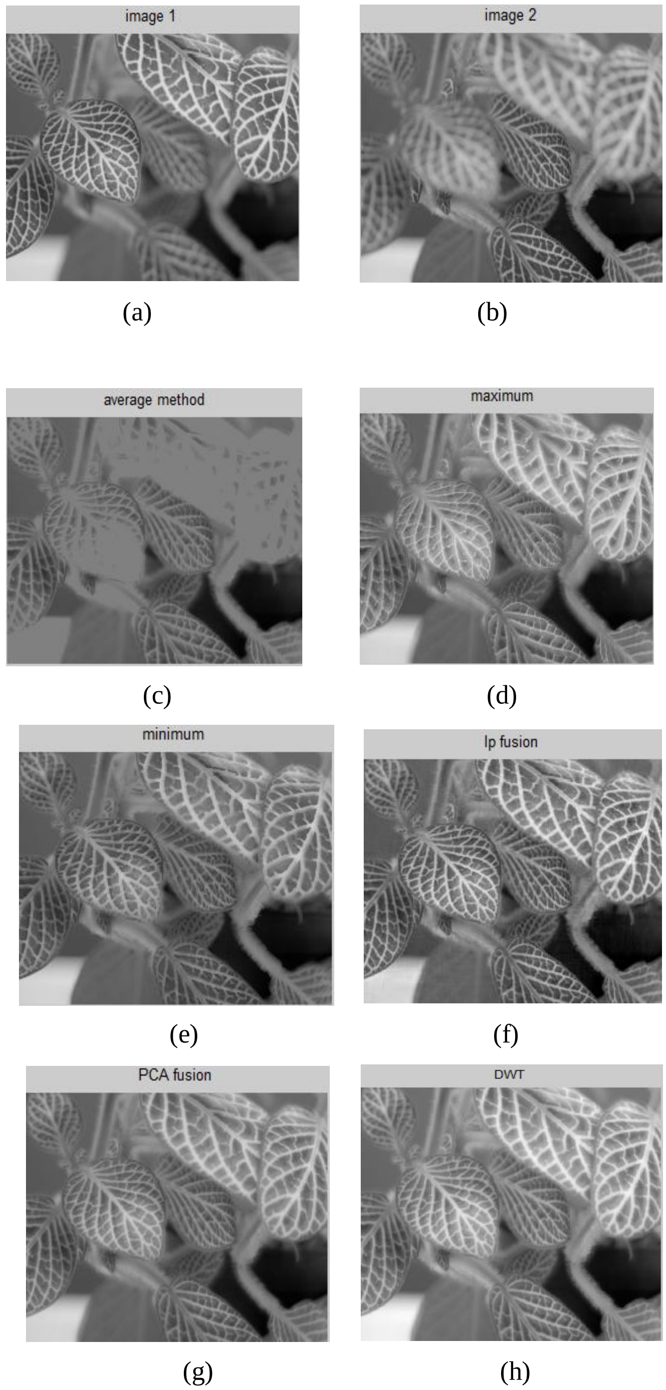

Figure 4 (a) Input image 1 ; (b) Input Image 2; (c) Fused Image Using Averaging Approach; (d) Fused Image Using Maximum Approach; (e) Fused Image Using Minimum Approach; (f) Fused Image Using Laplacian Pyramid; (g) Fused Image Using PCA Approach; (h) Fused Image Using DWT Approach

V. CONCLUSION

There are two types of multi focus image fusion methods, the spatial domain and the frequency domain. This paper proposed a frequency domain integrated approach to fusion multi focus images. From the results shown in figure 4

ISSN: 2321-8169
2029 - 2033

and analysis of different performance parameters for different fusion methods, we can say that fused image using pixel-based technique has good contrast for maximum method result and have a lower contrast in case of average as well as minimum method for input images with different levels of contrast. Using multi wavelet transform, PCA and Laplacian Pyramid and performance parameter analysis has been done for the several test image and found better results. If we discuss about parameters, higher entropy shows higher information content in fused image; standard deviation is higher than it indicates better quality of fused image; Spatial frequency gives overall information of fused image; Higher value of average gradient gives better clarity of fused image and execution time shows time required for execution of program of given algorithm. As shown in table 2, for some parameters DWT gives better result & for some parameters Laplacian Pyramid gives good result.

Table 1: Details Of Different Performance Parameters

Parameters	**Formula**	**Function**
Entropy	$E = -\sum_{i=0}^{L-1} pilog_2pi$	It used to evaluate the information quantity contained in an image
Spatial Frequency	SF=$\sqrt{((RF)^2 + (CF)^2}$ Where RF=$\sqrt{\frac{1}{MN}\sum_{m-1}^{m}\sum_{n-2}^{n}[F(m,n) - F(m,n-1)]^2}$ CF=$\sqrt{\frac{1}{MN}\sum_{n-1}^{n}\sum_{m-2}^{m}[F(m,n) - F(m-1,n)]^2}$	It is find the overall information level in the regions (activity level) of an image.
Execution time	Tic(start) Toc(stop)	It is find to required to execute the program
SD(standard deviation)	$\sigma = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(F(x_i,y_j) - \mu)^2}{M \cdot N}}$ $\mu = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}F(x_i,y_j)}{M \cdot N}$ µ = image gray mean value.	It gives Quality information of fused image.
Average Gradient	AG=$\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}F(i,j)*\sqrt{\frac{di^2+dj^2}{2}}$	It is used for clarity details and texture of the image

Table 2: Comparative Analysis Of Parameters For Different Fusion Techniques

Fusion Methods	SF	EN	SD	AG	Execution time (sec)
DWT	15.0309	7.415	41.184	6.7054	2.33663
PCA	15.031	7.2294	41.3009	6.6742	1.02293
Pixel Averaging method	15.024	7.1357	41.3008	6.5721	1.47803
Minimum method	14.1516	7.1343	40.0877	6.502	1.91756
Maximum method	14.1721	7.1365	40.0924	6.2379	2.17206
Laplacian pyramid method	15.8302	7.4038	43.0164	6.573	2.4134

REFERENCES

[1] “QingpingLi,junping Du”“ “Region-based multi focus image fusion using the local spatial frequency” CCDC-IEEE,vol,.25, pp(3792-3795),2013.

[2] “Dr .M.Sumathi,R.Barami”“ “Qualitative Evaluation of pixel level Image fusion Algorithms”“PIC-IEEE,vol.21.

[3] “N. Aishwarya PG student Y. Asnathvictyphamila””multi-focue image fusion variance”ICCSP-IEEE,pp(_352-355).

[4] “Amarchamankar” “multi focus image fusion using fuzzy logic” IFSC-IEEE,vol.13,2013.

[5] Abdul basit siddiqui””block based future level multi focus image fusion” IEEE,2010

[6] Y. Chai, H.F. Li, Z.F. Li, Multi focus image fusion scheme using focused region detection and multi resolution, Optics Communications, vol.284 (19), 4376-4389, 2011.

[7] P.J. Burt, A gradient pyramid basis for pattern selective image fusion, in: Proceedings of the Society for Information Display Conference, pp. 467-470, 1992.

[8] “Image fusion using Laplace pyramid transform” “Harihara sudhan vishwanathan”IIRT,ISSN-2417-5310, 2014.

[9] “Deepak Kumar Sahu” “M.P.Parsai” “ Different Image Fusion Techniques” ISSN: 2249-6645 , IJMER, Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-4298-4301.

[10] “Kusum Rani” “Reecha Sharma” “Study of Different Image fusion Algorithm” ISSN 2250-2459 ,IJTEAE, ISO 9001:2008 Certified Journal, Volume 3, Issue 5, May 2013.