A NOVEL IMAGE FUSION TECHNIQUE USING MULTI-RESOLUTION SINGULAR VALUE DECOMPOSITION

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ABSTARCT: *Image fusion is the process of combining two or more images with specific objects with more clarity. Usually in focusing one object remaining objects will be less highlighted. Hence to get an image highlighted in all regions, a different means is required, this is what is done in Image Fusion. In remote sensing, the increasing availability of Space borne images and synthetic aperture radar images gives a motivation to different kinds of image fusion algorithms. Hence a few transform domain fusion techniques are proposed in which the source images will be decomposed, then integrated into a single data and reconstructed back into the time domain. Here new transform techniques like singular value decomposition will be utilized for image fusion. MSVD based image fusion outperforms the existing ones like Laplacian Pyramid, wavelets. The quality assessment metrics are calculated for and proposed techniques, it has been found that the new image fusion technique outperformed the existing existing ones.*
Keywords: Image fusion, Laplacian Pyramid, SVD, Wavelet.

I. INTRODUCTION

Extracting more information from multi source images is an attracting thing in remotely sensed image processing which is recently called data fusion. There are many image fusion methods so far WS, PCA, WT, GLP etc. Among these methods WT and GLP methods can preserve more image spectral characters than others. So here we adopt wavelet method (as it is proposed to improve the geometric resolution of the images) [1-3].

Image fusion is the process of combining two or more fusion images into composite images with extended information content. The recent rapid developments in the field of sensing technologies multi-sensor systems have become a reality in a growing number of fields such as remote sensing, medical imaging, machine vision and the military applications. The result of the use of this techniques is a great increase of the amount of data available. Image fusion provides an effective way of reducing this increasing volume of information while at the same time extracting all useful information from the source images.

Multi-sensor data often presents complementary information about the region surveyed, so image fusion provides an effective method to enable comparison and analysis of such data.
The aim of image fusion, apart from recognition in applications such as remote sensing and medical imaging[2][4-6]. For example, visible band and infrared images may be fused to aid pilots landing aircraft in poor visibility. Multi-sensor images often have different geometric representations which have to be transformed to a common representation for fusion.

Multi-sensor registration is also affected by the differences in sensor images. However image fusion does not necessarily imply multi-sensor sources there are interesting applications for both single-sensor and multi-sensor image fusion system[7][8].

1. Single Sensor Image Fusion System:

An illustration of a Single sensor image fusion system is shown in Figure,the sensor shown could be a Visible-band Sensor such as a digital camera. This sensor captures the real world as a sequence of images [9] .

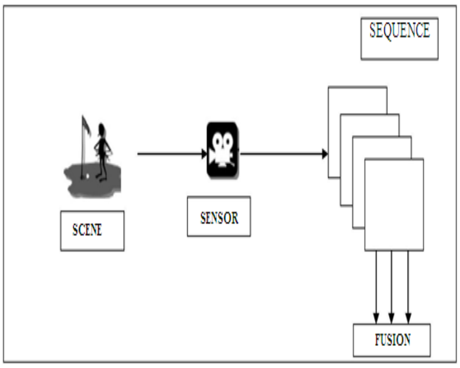

Fig 1: Single -sensor Image Fusion System

The collection is then fused in a single Image and used both with the aid of using a human operator or with the aid of using a laptop to perform a little task. For instance in item detection, a human operator searches the scene to discover items such introduces in a safety area [10-12].

2. Multi-sensor Image Fusion System:

Multi-sensor image fusion system overcomes the limitations of a single sensor fusion by combining the images from these sensors to form a composite image. Multiple images of same scene will be taken by two or more capturing devices and then to be fused. It is sufficient to each capturing device to capture one image with better focus on one possible object. All the objects in the scene will be focused well, because of more capturing devices.

The multi-sensor image fusion system is more efficient compare to the single sensor image fusion system[14]. The multi sensor image fusion technique is more accurate. The multi sensor image fusion system is shown in below figure.

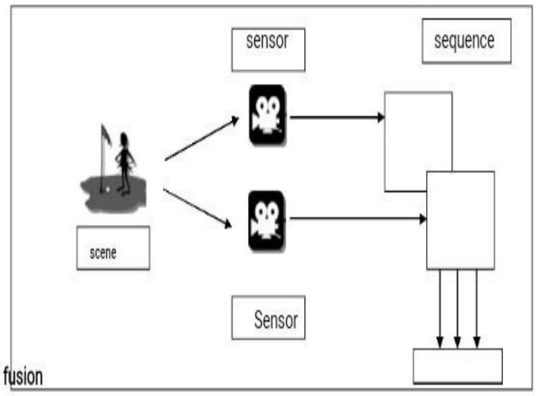

Fig.2 Multi-sensor Image Fusion System

Visible - band sensor such as the digital camera is appropriate for a brightly illuminated environment such as daylight scenes but is not suitable for poorly illuminated situations found during night, or rain [13].

3.Performance evaluation:

The performance of image fusion algorithms can be evaluated when the reference image is available. Here mainly we consider two performance evaluations. They are:

- Peak Signal to Noise Ratio (PSNR)
- Root Mean Square Error (RMSE)

$$PSNR = 20log\frac{L^2}{\frac{1}{MN}\sum_{X=1}^{M}\sum_{Y=1}^{N}(If(X,Y)-Ir(X,Y))^2} \quad (1)$$

where, L in the number of gray levels in the image This value will be high when the fused and reference images are alike and higher value implies better fusion.

$$\text{RMSE}=\sqrt{\frac{1}{MN}\sum_{X=1}^{M}\sum_{Y=1}^{N}(If(X,Y)-Ir(x,y))^2} \quad (2)$$

It is computed as the root mean square error (RMS E) of the corresponding pixels in the reference image I_r and the fused image I_f. It will be nearly zero when the reference and fuse images are alike and it will increase when the dissimilarity increases [12].

II. LITERATURE SURVEY

*1.*Laplacian Pyramid Based Image Fusion:

Laplacian pyramid algorithm, can be performed with two or more than two input images, but we consider only two input images. The algorithm decomposes the input image using 2D-DWT. The lower approximations are subjected to Laplacian pyramid algorithm. The SF algorithm combined with wavelet fusion algorithm is used for higher approximations. The new sets of detailed and approximate coefficients from each image are then added to get the new fused coefficients.

The final step performs Inverse DWT with the new coefficients to construct the fused image. The Laplacian Pyramid [6] implements a pattern selective approach to image fusion,so that the composite image is constructed not a pixel at a time,but a feature at a time. The basic idea is to perform a pyramid decomposition on each source image, then integrate all these decompositions to form a composite representation, and finally reconstruct the fused image by performing an inverse pyramid transform [14].

The first step is to construct a pyramid for each source image. The fusion is then implemented for each level of the pyramid using a feature selection decision mechanism. The feature selection method selects the most salient pattern from the source and copies it to the composite pyramid, while discarding the least significant salient pattern. In order to eliminate isolated points after fusion, a consistency filter is applied.

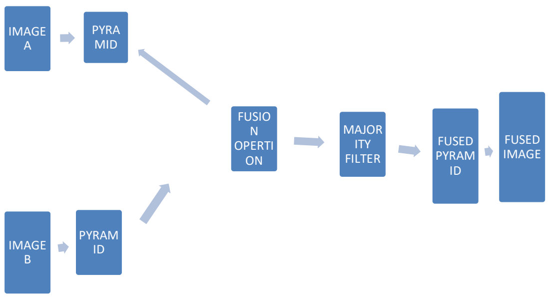

Fig 3: Laplacian Pyramid Technique

The fused image is almost should be similar to reference image so that the error is almost zero. It shows that fused image contains all the information coming from complementary source image. Therefore, PSNR=37.31, RMSE=12.16. Here the PSNR value is low and RMSE is high, this is the drawback of Laplacian pyramid.

2. *Wavelet based technique:*

In Wavelet technique, two input images are considered and wavelet transform technique is applied on it. Then we get the fused and error images are developed by using fusion technique. Wavelet transform gives high PSNR value 39.49 and low RMSE value 7.361 compared to Laplacian Pyramid technique.

III. PROPOSED SYSTEM

1. Multi-Resolution Singular Value Decomposition:

Multi-Resolution singular value decomposition is similar to Wavelet transform where signal is filter separately by lowpass and high pass finite impulse response [FIR] filter and the output of each filter is decimated by a factor of two to achieve first level of decomposition. The decimated lowpass filtered output is filter separately by lowpass and highpass filter followed by declimation by a factor of two provide second level of decomposition.

$$X1 = \begin{bmatrix} X(1) & X(3) \ldots \ldots X(N)1 \\ X(2) & X(4) \ldots \ldots X(N)1 \end{bmatrix} \qquad (3)$$

Denote the scatter matrix

$$T1=X1.X1T \qquad (4)$$

Let u1 be the Eigen vector matrix that brings T1 into diagonal matrix.

Let $X = [x(1), x(2),..., x(N)]$ represent a 1D signal of length N and it is assumed that N is divisible by $2K$ for $K \geq 1$ 21-26. Rearrange the samples in such a way that the top row contains the odd number indexed samples and the bottom contains the even number indexed samples, resultant matrix called data matrix,

The diagonal matrix is $S^1_2 = \begin{bmatrix} S1(1)^2 & 0 \\ 0 & S2(1)^2 \end{bmatrix}$ (5)

The K-level MSVD for i=1,2,….k-1 $\boxed{X_l = \begin{bmatrix} \phi_{l-1}(1) & \phi_{l-1}(3) & \bullet & \bullet & \bullet & \bullet & \phi_{l-1}(2N_{l-1}) \\ \phi_{l-1}(2) & \phi_{l-1}(4) & \bullet & \bullet & \bullet & \bullet & \phi_{l-1}(2N_l) \end{bmatrix}}$ as follows:

The Algorithm for Multi-Resolution Singular Value Decomposition is as follows:

A. Algorithm:

1.Main Function:

Step 1: IM* Read reference image.
IM1* Read the first image.
IM2*Read the second image.
Step 2: Apply the two input images to the fusion function which gives the resultant image.
Step 3: [X1, U1] * MSVD(IM1)
Step 4: [X2, U2] * MSVD(IM2)
Step 5: Prepare LL, LH, HL and HH components (of an image say X) from the corresponding parts of the images X1 and X2 by using the following rule.
i) For LL component take average of that of X1 and X2.
ii) For the remaining components take from X1 or X2 whichever is high.
Step 6: U * ½ (U1 + U2)
Step 7: imf* IMSVD(X, U)
Step 8: Calculate RMSE and PSNR between the reference and resulting image.

2.MSVD Function:

Input: Image – x
Outputs: MSVD coefficients – Y, Unitary matrix (U in SVD) .
Step 1: m, n * size(x)/2 4Step 2: A* Zero matrix of order 4xm*n Step 3: A * x (reshape x into the format of x) Step 4: [U,S] *svd(x)
Step 5: T *U*A
Step 6: Y.LL * First row of T (reshaped into mxn matrix)
Y.LH * Second row of T (reshaped into mxn matrix)
Y.HL * Third row of T (reshaped into mxn matrix)
Y.HH *Fourth row of T (reshaped into mxn matrix)

3.IMSVD Function:

Inputs: MSVD coefficients – Y, Unitary matrix (U in SVD) .
Output: Fused Image – X
Step 1: m, n * size(Y.LL)
Step 2: mn* m*n
Step 3: T * Zero matrix of order 4xm*n
Step 4: T * Y (each of four components as rows, so that T is a matrix of order 4xm*n)
Step 5: A =U*T
Step 6: X =Zero matrix of order 2mx2n
Step 7: X = A (by reshape)

IV. SIMULATION RESULTS

National Aerospace Laboratories (NAL) indigenous aircraft (SARAS), considered as a reference image *Ir* to evaluate the performance of the proposed fusion algorithm. The complementary pair input images *I*1 and *I*2 are taken to evaluate the fusion algorithm and these images are shown in Fig.4(top left) and 4(top right).

It is discovered that the fused photos of each MSVD and wavelet are nearly comparable for those photos. The purpose may be due to taking the complementary pairs. One can see that the fused picture preserves all beneficial statistics from the supply photos.

Fig. 4 Simulation Results with MSVD

a) Top-left input image 1 b) Top-right input image2 c) Fused input images d) Fused Error images.

V. PERFORMANCE METRICS

It is observed that the fused images of both MSVD an wavelet are similar for these images. The performance metrics for evaluating the image fusion algorithms are shown in table.

Table1: Comparison of different Fusion Techniques

S.no.	Technique	PSNR	RMSE
1	Laplacian pyramid	37.314	12.162
2	Wavelet technique	39.415	7.361
3	MSVD	41.060	5.133

In the above table we show that MSVD gives better performance than wavelets. A novel image fusion algorithm by MSVD ha been presented and evaluated. The performance of thi algorithm is compared with well-known image fusion technique by Wavelets. Image Fusion by MSVD performs almost similar to wavelets. It is computationally very simple and it could be we suited for real time applications. By observing the basis vectors depend on the data set.

Here we have implemented several techniques such as Laplacian pyramid, Wavelet and MSVD based image fusion techniques. We have compared the output results with PSNR and RMSE values. After comparing the results of these three techniques, we said that the **MSVD is the best technique because it has high PSNR and low RMSE values,** Compared to wavelet and Laplacian pyramid, Laplacian has the low PSNR value high RMSE than the wavelet.

VL. CONCLUSION

A novel image fusion technique using DCT based Laplacian pyramid has been presented and its performance evaluated. It is concluded that fusion with higher level of pyramid provides better fusion quality. The execution time is proportional to the number of pyramid levels used in the fusion process.

This technique can be used for fusion of out of focus images as well as multi model image fusion. It is very simple, easy to implement and could be used for real time applications. MATLAB code has been provided for quick implementation of the proposed algorithm. Pixel-level image fusion using wavelet transform and principal component analysis are implemented in MATLAB. Different image fusion performance metrics with and without reference image have been evaluated.

The simple averaging fusion algorithm shows degraded performance. Image fusion using wavelets with higher level of decomposition shows better performance in some metrics while in other metrics. A novel image fusion algorithm by MSVD has been presented and evaluated. The performance of this algorithm is compared with well-known image fusion technique by wavelets, It is concluded that MSVD performs the best.

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