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Medical Image Fusion Techniques Based on Discrete Transform Domains

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Abstract- **Image fusion mainly focused on image enhancement for better visualization of technique. The Main objective is to perform image fusion using Wavelet Transform using Haar wavelet. Image fusion creates new images of CT(computed tomography),MRI(magnetic resonance image) and for further image processing tasks such as discrete transform domains. In applications such as remote sensing and medical imaging. In this project traditional fusion algorithms are evaluated using several quality metrics including at local contrast, standard deviation, entropy, structure similarity index, root mean square error(RMSE), peak signal to noise ratio(PSNR). DWT using Average method, minimum and maximum, PCA and Histogram equalization, SWT methods. The proposed algorithm is designed and implemented in MATLAB. Future develop is here that we can combine the fusion techniques to get out good contrast and high resolution images. The traditional image fusion have drawbacks and do not meet the needs of fusion. This can be eliminated by using the hybrid systems. Therefore in the future work we focus on improving conventional system by employing the hybrid system.**

Keywords— Image fusion, Principle component analysis(PCA), Discrete wavelet transform(DWT), Stationary wavelet transform(SWT), Peak Signal-to-Noise Ratio (PSNR),Root Mean Square Error(RMSE),Computed Tomography(CT),Magnetic Resonance Image(MRI)

I. INTRODUCTION

The Image fusion is to combine the original two input images to get a different form of multiple images pixels as an output in a fused form .There are different medical imaging technique in the image fusion and it has become a common term used within medical diagnostics and as well as for treatment. in discrete wavelet transform(DWT) it taken two input images these two input images applying discrete wavelet transform and apply through fusion rule and also observed inverse discrete wavelet transform (IDWT) image, and then calculated the quality parameters. . But, this method yields image with reduced contrast as unwanted side-effects. There are some more fusion methods such as select maximum, select minimum etc. that works on corresponding pixels of input images to get pixel of output image. But they produce less quality images as output. In Histogram equalization, foreground image which is a functional image displaying the normal information and background image which provides the ob normal information without functional activity are taken as an input and with these input, histogram equalization has to be found. then the histogram of these foreground and background image has to be displayed in the equalized form of images and finally the histogram of foreground and background image after equalization has been identified at fused image. The work of the edge detection also plays a major role in deciding the result of the final processed image. Principal component analysis (PCA) is an important statistical tool that transforms multivariate data with correlated variables into one with uncorrelated variables. This technique is applied to the multispectral bands. The reverse PCA transform is performed to bring fused dataset back into the original multispectral feature space. The Discrete Wavelet Transform is not a time invariant transform. In order to overcome the translational invariant of the Discrete Wavelet transform, Stationary Wavelet Transform is designed. In this transform, there is no down sampling occurs between levels. They provide better time-frequency localization and the design is simple. The basic idea is simple.

.II. METHODOLOGY

Image fusion is most used in the medical image processing. such as magnetic resonance image (MRI), computed tomography (CT).

1. **Image Fusion by average method**: Fusion of images using average method is the earliest method. In this method the fused image is formed, whose intensity of output pixel is the average intensity of all the corresponding pixels from the input images. But this method yields image with reduced contrast as unwanted side-effects.

2. **Image fusion by minimum method**: If grater the pixel values the more in focus the image. Thus in-focus regions from each input image by choosing the greatest value for each pixel and finally observed at in less focused output.

3. **Image fusion by maximum method**: If greater the pixel values the more in focus the image. Thus in-focus regions from each input image by choosing the greatest value for each pixel and finally observed at in highly focused output.

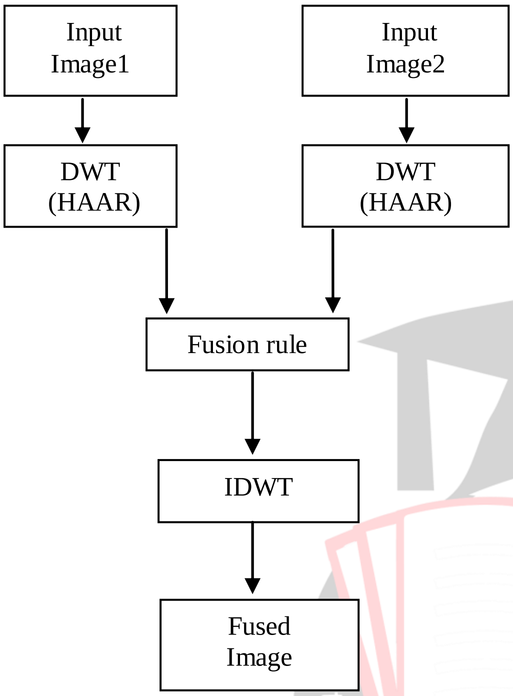

Fig 1. Proposed methodology flow chart.

4. **Histogram Equalization**: This technique is used to improve the contrast of the images and is used for image enhancement. Histogram equalization technique is applied on Foreground image (MRI) and Background image (CT). Histogram equalized form of both the foregound and background images are fused by any of the method mentioned by histogram equalization flow chart. Adaptive filtering techniques are applied on the fused images to remove the noise from the source images. Edge detection techniques are applied on the filtered images for edge detected form of fused image.

5. **Principal component analysis**: Principal component analysis (PCA) is an important statistical tool that transforms multivariate data with correlated variables into one with uncorrelated variables. The reverse PCA transform is performed to bring fused dataset back into the original multispectral feature space.

Steps involved in PCA Fusion are:

a) Taken two input images at CT and MRI. if two images are equal size.

b) Then input images are arranged into column vectors. Let Z is the resulting column vector of dimension 2*N.

c) Calculate the values of Empirical mean a long each column. The dimensions of Empirical mean vector E_v is 1*2.

d) Subtract E_v and column of matrix Z. The resulting matrix X has dimension 2*N.

e) Find the covariance matrix C of matrix X.

f) Compute the Eigen vector and Eigen value of C and sort them in decreasing Eigen value.

g) Consider first column of vector which correspond to larger Eigen value to compute normalized component P_1 and P_2.

The fused image is, $If(x, y) = P_{1I1}(x, y) + P_{2I2}(x, y)$ where P_1 and P_2 are the normalized components such as

$P_1 = V(1)/\sum V$ and $P_2 = V(2)/\sum V$

where V is eigenvector and $P_1 + P_2 = 1$.

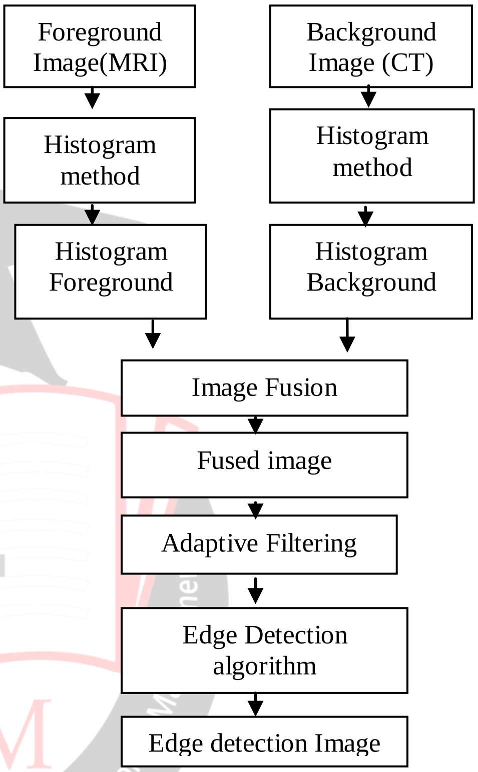

Fig. 2. Histogram equalization flow chart.

6. **Stationary Wavelet Transform:** In order to overcome the translational invariant of the Discrete Wavelet transform Stationary Wavelet Transform is designed. As it is a not time invariant and this transform is down sampling occurs . In this SWT transform, there is no down sampling occurs between levels. They provide better time-frequency localization and the design is simple. The basic idea is simple. Appropriate high pass and low pass filters are applied to the data at each level and it produces two sequences at the next level. There is no decimation step in SWT as in DWT therefore the new sequences have the same length as the original sequence and it provides redundant information. The advantages of Stationary wavelet transform is No sub sampling of input, Translation invariant, providing better time frequency localization, providing freedom to carryout design. There is no down sampling and therefore there is no loss of information and hence suitable for feature selection.

Steps involved SWT fusion are:

1.Taken two input images at computed tomography(CT),and magnetic resonance image(MRI).and get the resulting levels

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in these three(HL,LH,HH bands)details sub bands and one approximation level (LL)sub band. And a gain applies SWT transform for approximation sub bands.

2. Then taken the average LL sub band images.
3. Taken the absolute values of horizontal details of the image and subtract the second part of image from first.

D= (abs(H1L2)-abs(H2L2))>=0

4. Calculated the D from element wise multiplication. And horizontal details of the first image and then subtract another horizontal details of the second image multiplied by logical not of D from first.
5. Find the D for vertical and diagonal parts and obtain the fused vertical details of the image.
6. Fused image is obtained by the inverse of the stationary wavelet transform.

III. QUALITY PARAMATERS

The traditional fusion algorithms are applied to data set of CT and MRI images and evaluated. six fusion methods are implemented. They are AVERAGE METHOD, MINIMUM, MAXIMUM, PCA, HISTOGRAM EQUALIZATION, SWT are studied and Evaluated to obtain optimum fusion technique that achieves. As much advantages as possible. In table1 the evaluating procedure is given as follows.

1) DWT traditional fusion technique introduces local contrast, root mean square error (RMSE), PSNR, and standard deviation (SD) values this technique has better performance.
2) All the methods good entropy values.
3) PCA and histogram equalization methods have good PSNR.
4) SWT is better values of DWT at good contrast, good PSNR.
5)The main advantage of SWT is reduce sampling rate.
6)If there are no decimation step in the SWT as in DWT therefore the new image having the same length as the original image and it provides redundant information.
7)average method of the image fusion is better than the PSNR Values of SWT.

1. Local Contrast (C_{local}): It is an index for the image quality and purity of view. It is calculated using the equation

$$c_{local} = \frac{|\mu_{target} - \mu_{background}|}{|\mu_{target} + \mu_{background}|} \qquad (1)$$

Where μ_{target} the mean gray-level of the target is image in the local region of interest, and $\mu_{background}$ is the mean of the background in the same region. The larger value of C indicates more purity of the image.

2. Standard deviation: Standard deviation is used to measure the level of contrast in the fused image. The value of standard deviation is high for a well contrasted image.

3. Entropy: It is a measure of the amount of information contained in the image, and it takes values from 0 to 8, and it can be defined as:

$$E = -\sum_{i=0}^{n} p(x_i)\log p(x_i) \qquad (2)$$

4. RMSE: The root-mean-square error (RMSE). how much Amount of noise is observed between the two(input images)data sets. And it compares a predicted value and an observed or know value.

$$A = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(X-Y)^2} \qquad (3)$$

Where X and Y are original and fused image and n is the size of image.

5. PSNR: PSNR gives the peak signal to noise ratio of an image. It is simply the ratio of maximum possible power of a signal to its corrupted noise power. If the PSNR value is high then the distortion is less.

$$PSNR = 10\log 10\frac{max^2}{MSE} \qquad (4)$$

Where, '*max*' is the maximum possible power of image and *MSE* is the mean square error.

6. SSIM: It is a measure of the similarity between two regions w_x and w_y of two images x and y .

$$SSIM(x,\frac{y}{w}) = \frac{(2\overline{w_x}\,\overline{w_y} + c_1)(2\sigma_{w_x w_y} + c_2)}{(\overline{w_x}^2 + \overline{w_y}^2 + c_1)(\sigma^2_{w_x} + \sigma^2_{w_y} + c_2)} \qquad (5)$$

Where C_1 and C_2 are small constants. $\overline{w_x}$, $\overline{w_y}$ are the mean values of w_x and w_y. $\sigma^2 w_x$, $\sigma^2 w_y$ are the variance of w_x and w_y. $\sigma w_x w_y$ is the covariance between the two regions.

TABLE 1. QUALITY ASSESSMENT PARAMETERS.

S. NO	Average Method Using DWT	Maximum Method	Minimum Method	Histogram Equalization	PCA	SWT
Local Contrast	0.0215	0.1514	0.1555	0.0047	0.9808	0.0213
Standard Deviatio	68.3104	77.8914	65.6878	58.3035	68.2123	64.7830

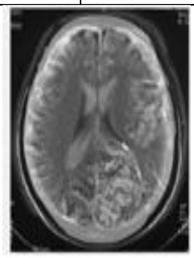
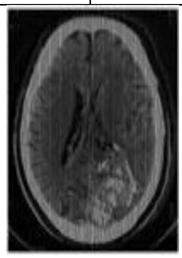
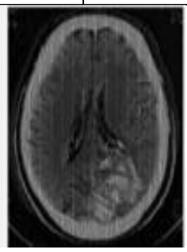
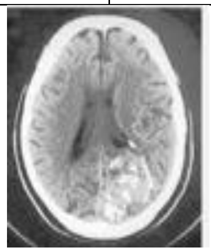
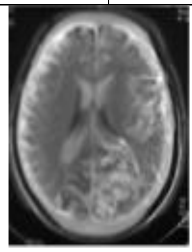
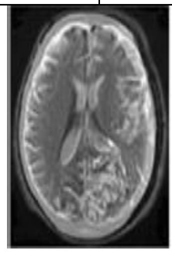
n												
Entropy	7.4507		7.5072		6.9173		7.0579		7.4729		7.4289	
RMSE	0.009	1.2403	0.006	1.5570	0.005	97.560	65.51	85.89	70.7383	70.738	0.1278	0.13
PSNR	52.293	13.643	50.3187	13.64	54.3789	13.6438	60.03	57.65	59.3365	59.336	112.03	112.03
SSIM	0.4496	0.99	0.4567	0.52	0.6417	0.34	0.57	0.01	1.903	0.04	0.5928	0.5
Output images	 IDWT		 IDWT		 IDWT		 Fused Image		 Fused image		 Fused image	

TABLE 2: COMPARISION BETWEEN FUSION TECHNIQUES.

S.NO	FUSION TECHNIQUES	ADVANTAGES	DISADVANTAGES
1.	Average method	It is a simple method of the image fusion.	In this technique reduce the resultant image quality by introducing noise into the fused image.
2.	Minimum method	Less focused image	It is a technique that affected from blurring effect which directly alter the contrast of the image.
3.	Maximum method	Highly focused image	Blurred image due to reduction of contrast.
4.	DWT	Better results from signal to noise ratio.	Less spatial resolution
5.	Histogram equalization	It is most effective technique for gray scale images but the color images.	But the color images it is a difficult task to work.
6.	PCA	It removes the redundancy present in an input image.	Lesser quality of fused image than any of the input image.
7.	SWT	The main advantage of reduce sampling rate.	It is a problem of spatial resolution.

TABLE 3:COMPARASION OF PROPOSED METHOD WITH EXISTING METHODS

DWT			
S. No	**Local contrast**	**RMSE**	**PSNR**
Ref [2]	0.7444	57.4253	12.9487
Ref [6]	0.567	48.4382	49.67
Ref [9]	0.062	49.4032	50.87
Proposed method	0.0215	1.2403	52.2939
SWT			
Ref[8]	0.890	28.578	62.042
Ref [15]	0.706	30.08	61.098
Proposed method	0.0213	0.1278	112.03

VI. RESULTS AND DISCUSSION

The results are compared with two objective methods using DWT and SWT. Initially the source images are decomposed by the Discrete wavelet transform and the Stationary wavelet transform. Subsequently their low frequency coefficients are fused with average fusion rule method. The final fused image is obtained by taking inverse transform. The Experimental results show that the Stationary wavelet transform method performs well than the Discrete wavelet transform as the information loss occurs due to down sampling in each of the DWT which caused in the relevant are minimized by SWT method.

V.CONCLUSION

This paper presents a simple DWT based pixel level image fusion method with maximum selection rule as it better selects the directional features from the wavelet coefficients. It is simple and cost little calculation. As Haar wavelet uses two wavelets instead of just one. So with this wavelet the symmetry and exact reconstruction are possible and experimental result shows that Haar wavelet bases are suitable for this simple fusion method of multi-focus images. We can conclude that the selection of the wavelet base may also be dependent on the quality of source images and fusion rule used. The system will be tested for multi-sensor, multi temporal and multi modal images. The effect of different advanced fusion rules on wavelet base selection will be performed. Also we get better result by using than Haar wavelet. Here we consider the quality parameters PSNR, RMSE, Standard Deviation, Standard Variance and Entropy and then finally conclude that by using which wavelet we get better result. Visual analysis show that stationary wavelet transform method appear better than discrete wavelet transform. After validating experimental result using entropy, Root mean square error, peak signal to noise ratio the statistical tools shows that the stationary wavelet transform is superior than discrete wavelet transform. In order to overcome the translational invariant of the Discrete Wavelet transform, Stationary Wavelet Transform is designed. as it is a not time invariant. In this SWT transform, there is no down sampling occurs between levels. They provide better time-frequency localization and the design is simple. The basic idea is simple. Future scope of this paper is the traditional image fusions have drawbacks and do not meet the needs of fusion. This can be eliminated by using the hybrid systems. Therefore in the future work we focus on improving conventional system by employing the hybrid system.

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