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Image Fusion Parameter Enhancement Using Dual Tree Discrete Wavelet Transform

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Abstract – 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. Today the image fusion techniques are like DWT or pixel based. The conventional techniques are not that efficient and they did not produced the expected results as the edge preservance, spatial resolution and the shift invariance are the factors that could not be avoided during image fusion. In this work image fusion is done using DTDWT technique. The results show that the resulting system is better in performance than the traditional systems in terms of PSNR, MSE, RMSE parameters.

Index Terms – Image fusion, Principle Component Analysis, Dual Tree Discrete Wavelet Transform (DT-DWT), Wavelet Transform (WT), Peak Signal to Noise ratio (PSNR), Mean Square Error (MSE), Root Mean Square Error (RMSE).

1. INTRODUCTION

Image fusion is combining different features of different modality into a single composite image. Fused image is generated using two images. We can get better output image that is validated by parameters like PSNR, MSE etc. We can get even better output image if we fused three or more images instead of two. Image fusion is to reduce uncertainty and minimize redundancy. It 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. Till date the image fusion techniques were like DWT or pixel based.

These conventional techniques were not that efficient and they did not produced the expected results as the edge preservance, spatial resolution and the shift invariance are the factors that could not be avoided during image fusion. This work deals with the error reduction of fused image using Dual Tree Discrete Wavelet Transform (DT-DWT). The image obtained after fusion using proposed technique will be of better quality than the images fused using conventional techniques.

DT-DWT based image fusion technique has been developed to compose a resultant image with better perceptual as well as quantitative image quality indices. The proposed technique shows superior result as compared to traditional image fusion algorithms. The dual tree discrete wavelet transform (DT-DWT) that uses two sets of critically sampled filters that form Hilbert transform pairs is popular.

The proposed system improves the Peak Signal to Noise ratio (PSNR), Mean Square Error (MSE) and Root Mean Square Error (RMSE).

2. DUAL TREE DISCRETE WAVELET TRANSFORM (DT-DWT)

The classical discrete wavelet transform (DWT) provides a means of implementing a multiscale analysis, based on a critically sampled filter bank with perfect reconstruction. However, questions arise regarding the good qualities or properties of the wavelets and the results obtained using these tools, the standard DWT suffers from the following problems described as below:

1. *Shift sensitivity:* It has been observed that DWT is seriously disadvantaged by the shift sensitivity that arises from down samples in the DWT implementation.

2. *Poor directionality:* an m-dimension transform (m>1) suffers poor directionality when the transform coefficients reveal only a few feature in the spatial domain.

3. *Absence of phase information:* filtering the image with DWT increases its size and adds phase distortions; human visual system is sensitive to phase distortion. Such DWT implementations cannot provide the local phase information.

In other applications, and for certain types of images, it is necessary to think of other, more complex wavelets, which gives a good way, because the complex wavelets filters which can be made to suppress negative frequency components. The complex wavelet transform has improved shift-invariance and directional selectivity. This analyzes the signal by two different DWT trees, with filters chosen so that at the end, the signal returns with the approximate decomposition by an analytical wavelet.

The dual-tree structure has an extension of conjugate filtering in 2-D case. Because of the existence of two trees the second noise coefficients moments from such decomposition can be precisely characterized. The DT-DWT ensures filtering of the results without distortion and with a good ability for the localization function and the perfect reconstruction of signal. Moreover, the dual-tree DWT can be used to implement 2D wavelet transforms where each wavelet is oriented, which is especially useful for image processing.

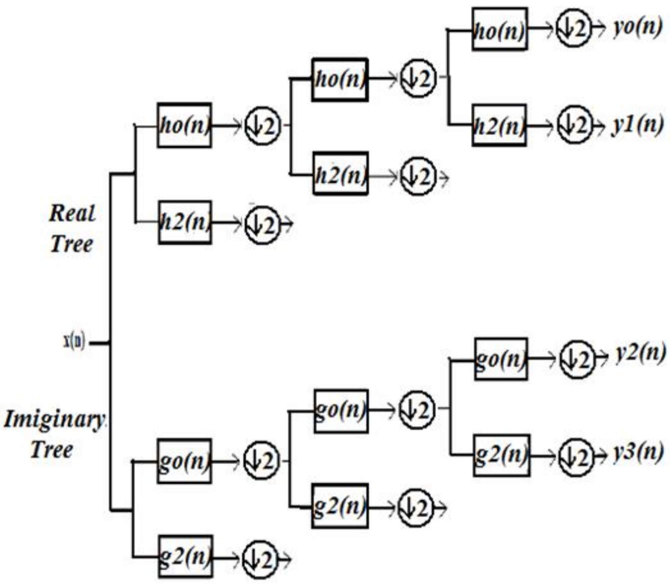

Figure 1: Implementation of Dual-Tree Discrete Wavelet Transform.

3. PARAMETERS UNDER CONSIDERATION

The image quality indices try to figure out the some or the combination of the various factors that determine the quality of the image. Some of the parameters analyzed in this work are

1. Peak Signal to Noise Ratio (PSNR) :

PSNR stands for the peak signal to noise ratio. It is a term used to calculate the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation It is most commonly used as a measure of quality of reconstruction in image compression etc.. Because many signals have a very wide dynamic range, (ratio between the largest and smallest possible values of a changeable quantity) the PSNR is usually expressed in terms of the logarithmic decibel scale.

The mathematical representation of the PSNR is as follows:

$$PSNR = 20\log_{10}\left(\frac{MAX_f}{\sqrt{MSE}}\right)$$

2. Mean Square Error (MSE):

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{ij} - B_{ij}\right)^2$$

Where *m* is the height of the Image implying the number or pixel rows.

*n*is the width of the image, implying the number of pixel columns.

A_{ij}being the pixel density values of the perfect image.

B_{ij}being the pixel density values of the fused image.

Mean square error is one of the most commonly used error projection method where, the error value is the value difference between the actual data and the resultant data. The mean of the square of this error provides the error or the actual difference between the expected/ideal results to the obtained or calculated result.

Here, the calculation is performed at pixel level. A total of m*n pixels are to be considered. A_{ij}will be the pixel density value of the perfect image and B_{ij}being that of the fused image. Thedifference between the pixel density of the perfect image and the fused image is squared and themean of the same is the considered error. MSE value will be 0 if both the images are identical.

3. Root Mean Square Error (RMSE)

A commonly used reference based assessment metric is the RMSE. The RMSE will measure the difference between a reference image, R, and a fused image, F, RMSE is given by the following equation

$$RMSE = \sqrt{\frac{1}{MN}\sum_{n=1}^{M}\sum_{n=1}^{N}(R(m,n) - Fm,n))^2}$$

where R(m, n) and F(m, n) are the reference and fused images, respectively, and M and N are image dimensions. Smaller the value of the RMSE, better the performance of the fusion algorithm.

4. STEPS INVOLVED IN THE PROPOSED ALGORITHM

Steps involved in the proposed system are:

1. The reference image and the two images to be fused are read.
2. These images are converted to double data.
3. The images are fused using DT-DWT first and then by PCA.
4. Original images and the output fused images with DT-DWT and PCA are generated at the output.
5. Comparison of fused image outputs by DTDWT and PCA is done with respect to reference image based on PSNR, MSE and RMSE parameters.

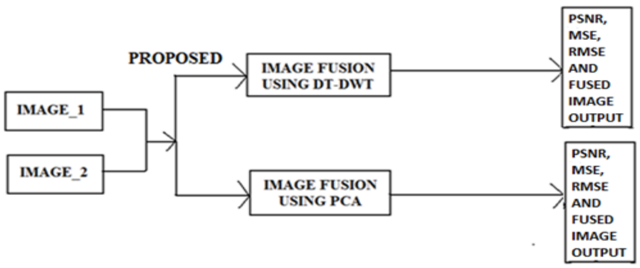

Figure 2: Simulation flow chart

5. SIMULATION RESULTS

The proposed system simulation outputs are as under.

Figure 3: Original image1 and image2.

Figure 4: Fused image output using PCA

Figure 5: Fused image output using DTDWT.

The figure 3 shows the original images are to be fused. Figure 4 and 5 shows the fused images outputs using Principle Component Analysis (PCA) and Dual Tree Discrete Wavelet Transform (DTDWT) respectively. From image outputs it can be seen that the image fusion output image with DTDWT is much better than that with PCA.

Table1: Various error parameters values obtained by image fusion using PCA and DTDWT.

S.NO	METHODS	PSNR	MSE	RMSE
1	PCA	28.55	90.81	9.53
2	DTDWT	41.07	5.08	2.25

Table 1 shows values of PSNR, MSE and RMSE obtained by image fusion using PCA and DTDWT. From the table it can be seen that parameters obtained of fused image with DTDWT are enhanced as compared to that with PCA. Hence the quality of fused image with DTDWT is higher as compared to PCA.

6. CONCLUSION

The objective of this work is to develop a enhanced image fusion system using Dual Tree Discrete Wavelet Transform (DT-DWT) which can improve parameters in the fused image in comparison to other prevalent traditional image fusion methods like PCA. In the proposed system outputs are derived for image fusion using DTDWT and PCA. The output fused images with both the methods are compared on the basis of PSNR, MSE and RMSE parameters. The results show that the proposed system is better than the existing system and hence it can be concluded that the proposed system parameters has been enhanced.

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