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Implementation of Image Fusion by Using DDCT Based Hybrid Algorithm

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***Abstract* – In this paper various methods for Image fusion of source image data are analyzed and discussed. The main focus in this work is Image fusion algorithms based on structure. The central aspect in context modeling is different context templates, which are based on DDCT coefficients, local gradients and intensity of samples in the image. This work includes research on how to use DDCTstructure, prediction modeling and probability assignment in image fusion based on context modeling technique. The main advantage over current methods is increasing effectiveness of image fusion and developing new Image fusion methods based on context modeling for different type grayscale images: medical, astronomical, noisy natural images.**

***Keywords* – Digital Image Processing, DCT, Image Fusion.**

I. INTRODUCTION

The proliferation of digital technology has not only accelerated the pace of development of many image processing software and multimedia applications, but also motivated the need for better Image fusion algorithms. Image fusion plays a critical role in telemetric applications.

It is desired that either single images or sequences of images be transmitted over computer networks at large distances so as that they could be used for a multitude of purposes. For instance, it is necessary that medical images be transmitted so as that reliable, improved and fast medical diagnosis performed by many centers could be facilitated.

To this end, image fusion is an important research issue. The difficulty, however, in several applications lies on the fact that, while high Image fusion rates are desired, the applicability of the reconstructed images depends on whether some significant characteristics of the original images are preserved after the Image fusion process has been finished[1]
Image fusion is a fast paced and dynamically changing field with many different varieties of Image fusion methods available. Images contain large amount of data hidden in them, which is highly correlated.

A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. Research advances in wavelet theory have created a surge of interest in applications like image fusion. The investigation and design of computationally efficient and effective software algorithms for lossy image fusion forms the primary objective of this paper.

II. DISCRETE COSINE TRANSFORM

Image fusion is the process of combining multiple source images from sensor network into a single one, which contains a more accurate description of the scene, more informative and suitable for both visual perception and further processing [1]. In the multi-focus image fusion technique, several images of a scene captured with focus on dif-ferment objects are fused such that all the objects will be in focus in the resulting image. So far, several researches have been focused on image fusion which is performed on the images in the spatial and spectral domain [2–5].

The sharpness measure [3] is exploited to perform adaptive multifocal image fusion in wavelet domain and proved to give better fused results than other discrete wavelet transform (DWT) based multi-focus image fusion schemes. In automated battlefields, where the robots collect image data from sensor network, since the computational energy is much less than the trans-mission energy, data are compressed and fused before transmission [6].

III. PROPOSED METHODOLOGY

1. Directional Discrete Cosine Transform based Image Fusion

In this technique, initially Directional Discrete Cosine Transform is performed in the function F(x,y) where, the function F(x,y) gives the pixel intensities of the

corresponding pixel at (x,y).Now, different fusion rules are applied to the directional discrete cosine transform coefficients.Threemajor fusion ruleshave been used in this project under Directional Discrete Cosine Transform image fusion technique.
Those are:
• DDCTavg
• DDCTmax
• DDCTek

The input images were divided into non-overlapping square blocks and the fusion process was carried out on the corresponding blocks. The algorithm works in two stages. In first stage, modes 0 to 8 were performed on images to be fused. For each mode, the coefficients from the images to be fused are used in the fusion process. The same procedure is repeated for other modes. Three different rules are used in this fusion process:

- Averaging the corresponding coefficients (DDCTavg),
- Choosing the corresponding frequency band with maximum energy (DDCTek) and
- Choosing the corresponding coefficient with maximum absolute value (DDCTmax) between the images.

2 Mathematical Expression of DDCT Hybrid Method

Directional discrete cosine transform the 1DDCTX (k) of the sequence x(n)

$$X(k) = \alpha(n)\sum_{n=0}^{N-1} x(n)\cos\left(\frac{\pi(2n+1)k}{2N}\right), \quad 0 \le k \le N-1$$

$$\text{Where, } \alpha(k) = \begin{cases} \sqrt{\frac{1}{N}} & k = 0 \\ \sqrt{\frac{2}{N}} & k \neq 0 \end{cases}$$

having length N is defined to be:
The inverse DCT is defined to be:

$$x(n) = \sum_{k=0}^{N-1} \alpha(k)X(k)\cos\left(\frac{\pi(2n+1)k}{2N}\right), \quad 0 \le n \le N-1$$

3. Mode 3(diagonally down-left mode)

Consider an N×N image block as shown in Fig. 1D DCT is performed along diagonally down-left direction that is for all diagonal line (shown as dotted line) with n1+n2=m, m=0,1,...,2N−2. From Fig., it is known that there are 2N-1lines that are diagonal down-left 1D DCT's to be performed, there lengths are Nm=[1,2,...,N−1,N,N−1,...,2,1] and coefficients are arranged in column vectors.

4 .Mode 5 (Directional DCT for the vertical-down mode)
Consider N×N image block as shown in Fig a. Perform 1D DCT along the vertical-right direction (shown as dotted arrows) and the coefficients as shown in Fig b. On these coefficients, 1D DCT is performed horizontally and these coefficients are then pushed to the left and other mode show in a tabulated form.

Table 1. Left and other mode of DDCT.

Mode	Direction	Procedure
0	Vertically down	Apply 1D DCT column wise and then apply 1D DCT horizontally (each row)
1	Horizontally right	Transpose the image block, apply mode 0 procedure
3	Diagonally down-left	In Mode 3
4	Diagonally down-right	Flip the image block horizontally and then apply mode 3 procedure
5	Vertical-right	Explained in Mode 5
6	Vertical-right	Transpose the image block, apply mode 5 procedure
7	Vertical-left	Flip the image block horizontally and then apply mode 5 procedure
8	Horizontal-up	Transpose the image block, Flip the block horizontally and then apply mode 5 procedure

Principal Component Analysis (PCA):

- Organize the information into segment vectors. The subsequent framework Z is of measurement n×8.
- Compute the exact mean along every section. The exact mean vector M has a measurement of 8×1.
- Subtract the exact mean vector M from every section of the information framework Z.
- Find the covariance grid C of S i.e. C=XTX
- Sort the eigenvectors V and Eigenvalue D of C in decreasing order.
- Consider the first section of V which compares to bigger Eigen value to register to compute the principal components.

5. How to applied proposed algorithm:

In this section we will perform three different techniques for image fusion by DCT method.All the imagesthat is to be fused is divided into non-overlapping blocks. These blocks are made of sizeN×N as shown in Fig. DDCT coefficients are calculated for each of these blocks and corresponding fusion rules are applied to getthe fused DDCT coefficients of each block. Inverse DDCT is then

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applied over the fused coefficients so as to produce the fused block.

- **DDCT avg:**

Now, for the DDCT coefficients of the final fused image, we use these DDCT coefficients of the source images. Weighted average of the DDCT coefficients of the source image is found and this weighted average is assigned to the corresponding DDCT coefficient band of the final fused image.

- **DDCT max:**

Now, for the DDCT coefficients of the final fused image, we compare the DDCT coefficients of all the source images. The greatest values of the DDCT coefficients of the source image are found and this value is assigned to the corresponding DDCT coefficient band of the final fused image.

For an object that is better focused in the image, we will have sharp edge or corner detection that the bands where the object is not in focus. So using this fundamental rule we use the maximum DDCT values as maximum DDCT values correspond to the better and sharp values
for edge or corner detection.

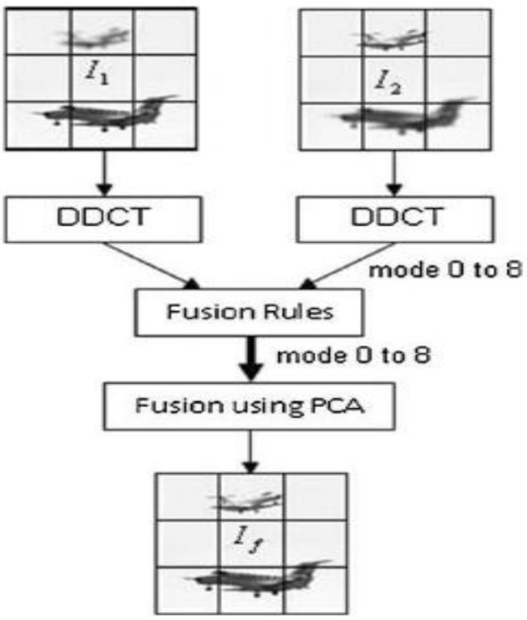

Fig 1 Image Fusion in DDCT Method.

- **DDCT ek**

For this image fusion rule, we need to calculate the energy of the DDCT coefficients. The energy of DDCT coefficients is given by the Ej. The quantity Ej is the mean amplitude over a jth spectral band and is computed.

IV. SIMULATION RESULTS

In this section of our paper, the algorithm is performed in three stages. Firstly, the traditional fusion algorithms are applied to the image dataset, then hybrid and finally the enhanced hybrid scheme which are evaluated using the quality metrics mentioned in the previous section.

Practical work and programs of fusion techniques are designed in MATLAB R2013a using the Image Processing Toolbox on windows 10 Laptop computer with Intel CORE I3 Processor, 3.0 GB RAM, and 500 GB Hard Disk.

The proposed hybrid image fusion methodology based on directional DCT and PCA along with the 2D filter used to enhance the output, has been performed using various multi-sensor images from standard image database.

The robustness of the proposed fusion technique is verified successfully with some multi-sensor images and multifocal image datasets shown below:

- **Test Dataset 1**

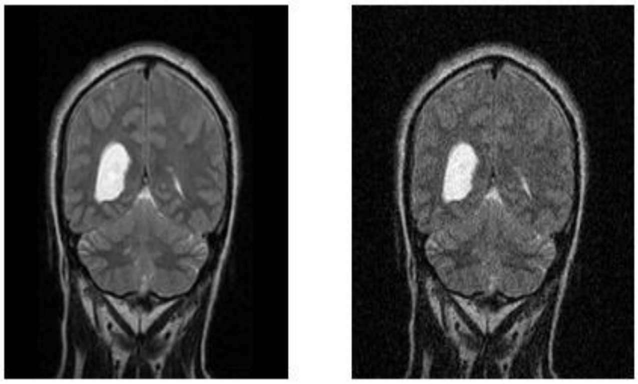

Fig. 2 Input Image 1 & Image 2(MRI Images).

Fig. 3 Input Image 1 & Image 2(Multifocus).

In this work, we have taken complimentary pair input images (data set-1& 3) to evaluate the fusion algorithm. The images are complementary in the sense that the top aircraft is out of focus and the bottom aircraft is in focus and vice versa in the second image. We get the fusion output results after performing the algorithms on the respective test datasets. The fusion outputs of the respective datasets are displayed below.

- **Output from Test Dataset 1**

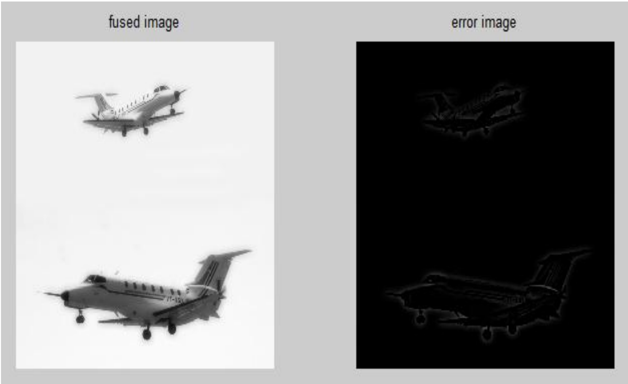

Fig. 4 Fig showing fused output image and error image for test dataset-1.

Fig. 5 Figure showing final filtered output of test dataset1
Output from Test Dataset 2.

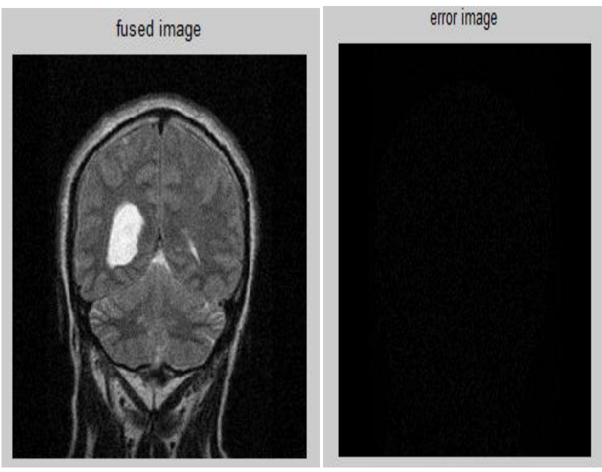

Fig. 6 Fig showing fused output image and error image for test dataset-2.

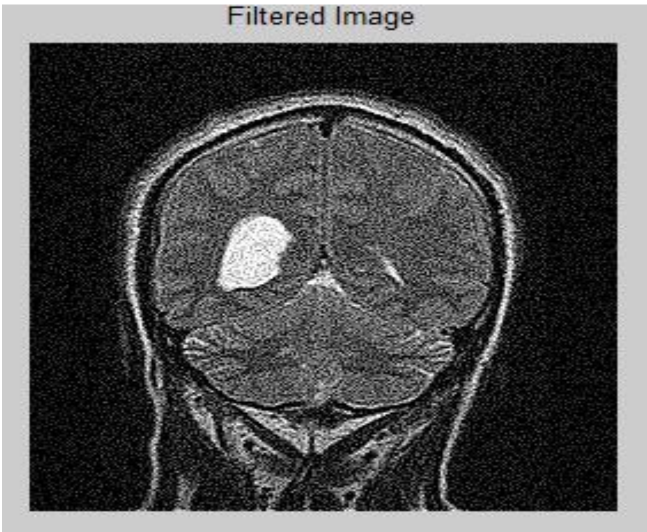

Fig. 7 Figure showing final filtered output of test dataset2.

- **Output from Test Dataset 3**

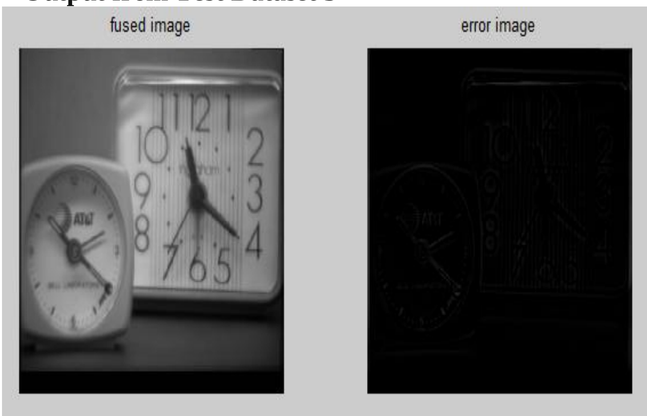

Fig. 8 Fig showing fused output image and error image for test dataset-2.

Fig. 9 Figure showing final filtered output of test dataset3

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We introduce here samples of the evaluated results.Table shows the experimental results of the proposed as well as enhanced proposed by using a filter on dataset 1,2 and3 respectively.

Table 2 Table showing results for Test Dataset1

Test Dataset1	**PROPOSED HYBRID(DDCT +PCA)**	**FILTERED OUTPUT**
RMSE	0.0369302	0.0090192
PSNR	62.4569542	68.5790592
ENTROPY	4.0203782	4.1674002
S.D.	0.1799232	0.2116122

Table 3Table showing results for Test Dataset2

Test Dataset2	PROPOSED HYBRID(DDCT +PCA)	FILTERED OUTPUT
RMSE	0.0310902	0.0156982
PSNR	63.2045872	66.1722932
ENTROPY	6.4667402	5.9552692
S.D.	0.1931052	0.2569302

Table 4 Table showing results for Test Dataset3

Test Dataset3	PROPOSED HYBRID(DDCT +PCA)	FILTERED OUTPUT
RMSE	0.0296042	0.0006842
PSNR	63.4172662	79.7814372
ENTROPY	7.2586932	7.3196532
S.D.	0.1933952	0.1976902

V. PERFORMANCE EVALUATION & DISCUSSION

The quantitative evaluation of this paper work using various multisensory image test datasets has been performed and the respective results are shown in the above tables. The performance comparison of the proposed fusion methodology using Directional DCT with PCA and its filtered output has been carried out successfully in terms of the performance evaluation metrics used such as Root Mean Square Error(RMSE), Peak Signal to Noise Ratio(PSNR), Entropy and Standard Deviation.

The obtained fusion results of the respective datasets showing the fused image, error image and the final filtered output image are also displayed above.

Looking at the obtained results, one can observe visually that the filtered output image has improved in quality over the fused output image. Also, the proposed algorithm performance is mostly similar to other commonly used fusion algorithms like DWT and PCA w.r.t. the performance metric results.

However, the addition of the 2D filter at the fused output has evidently improved the final enhanced fusion outcome visually as well as performance parameter wise. Large values of RMSE indicate the larger error in the fused image while larger PSNR values indicate a smaller difference between the original and reconstructed image. Entropy value of an image points towards the amount of information available on the image. More the entropy, better the image, in terms of S.D., lesser the S.D., better the image.

The final filtered outcome observes a significant decline in the RMSE parameter than the proposed hybrid outcome. The Entropy and PSNR values have also improved than the proposed methodology outcome. The Standard Deviation(S.D.) depicting the deviation of output compared to the input has also reduced marginally.

Table 5 Comparison between Base paper and proposed algorithm result.

Fused image AA 512× 512 Parameters	DWT +PCA	AWT+PCA	AWT+DTCWT	PROPOSED HYBRID(DDCT+PCA)
MSE of fused image	0.03326	0.03687	0.03745	0.0247432
PSNR of fused template	62.73	58.79	57.08	64.1962
Entropy	7.5944	7.5435	6.8150	4.00
Standard deviation	0.2834	0.3212	0.4389	0.1799
Output image Quality				

VI. FUTURE OF IMAGE FUSION

- Improved low bit-rate Image fusion performance.
- Improved lossless and lossy Image fusion.
- Improved continuous-tone and bi-level Image fusion.
- Be able to compress large images.

- Use single deImage fusion architecture.
- Transmission in noisy environments.
- Robustness to bit-errors.
- Progressive transmission by Robustness to bit-errors.
- Progressive transmission by pixel accuracy and resolution.

VII. CONCLUSION

A new image fusion scheme based on DDCT is proposed in this research which provides sufficient high Image fusion ratios with no appreciable degradation of image quality. The effectiveness and robustness of this approach has been justified using a set of real images.

The images are taken with a digital camera. To demonstrate the performance of the proposed method, a comparison between the proposed technique and other common Image fusion techniques has been revealed. From the experimental results it is evident that, the proposed Image fusion technique gives better performance compared to other traditional techniques.

Comparisons of results for DWT and DDCT based on various performance parameters: Mean Squared Error (MSE) is defined as the square of differences in the pixel values between the corresponding pixels of the two images. Graph of shows that for DDCT based image fusion,

As the window size increases MSE increases proportionately whereas for DDCT based image fusion shows that MSE first decreases with increase in window size and then starts to increase slowly with finally attaining a constant value and plot show required for compressing image with change in window size for DWT and DDCT respectively and indicate Image fusion ratio with change in window size for DWT and DDCT based image fusion techniques respectively.

Image fusion increases with increase in window size for DDCT and decreases with increase in window size for DDCT+PCA.

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