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Discrete Cosine Transform with Laplacian Pyramid based Multi Focus Image Fusion

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Abstract—*In this paper, we present an image fusion approach based on Laplacian pyramid image decomposition and the Discrete Cosine Transform (DCT). The proposed approach combines multi-focus, low-quality images to generate a higher-quality picture. The suggested approach generates a Laplacian pyramid of pictures, which is then followed by DCT at different resolutions. Finally, the original fused im- age is obtained by the rebuilding process. The proposed technique produced good results in terms of picture quality, as well as substantial improvements in the API, entropy, PNSR, and standard deviation.*
Keywords— *Image fusion, multi focus image, Gaussian pyra- mid, Laplacian pyramid, Discrete Cosine Transform (DCT).*

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I. Introduction

Image fusion is the very popular research area among the researcher from the last few decades. Many researchers are working in the field of image fusion, and it is still very challenging and has a large scope of the improvements. Due to the limited range of focusing length, lighting condition, the image capturing position, and the imaging system limitations we are not able to get quality images from the sensors (camera). The main objective of the image fusion process is to get the information the different image source and combined information to obtain quality image, to improve the vision for the human and for the machine to get more accurate perception about the image[14]. Applications area, like medical image analysis image fusion play a vital role, which provides the additional information for the diagnosis[11]. through the image fusion multi model image are combine and and gives the composite image. For example CT, MRI, and PET image are fused for the better analysis and for more information[2]. spatial and frequency are the two domain in which the iamge fusion are mainly work. In this paper we have work in the frequency domain. In this work first images are decomposed by the laplacian pyramid then discrete cosine tranform which transfer the image in the frequency domain and reverse process id applied to get the fused image.

II. Related work

Pyramid Fusion Algorithm is a fusion method in the transform domain. Different types of pyramid based fusion techniques are Laplacian Pyramid [4], Ratio-of-lowpass Pyramid [15], Morphological Pyramid[7], FSD Pyramid [1] and Gradient Pyramid [3] difference can be used for the image fusion using different fusion rules. In pyramid approach, pyramid levels derived from the down sampling of source images are integrated at pixel level depending on fusion rules. By recreating the fused image Pyramid fused image is generated. An image pyramid is made of set of low pass or band pass copies of an image where every copy shows pattern information of various scale. If pyramid fusion algorithm is used at each level of fusion then the pyramid formed will be the half the size of pyramid which will be formed in the forth coming level and higher levels will focuses upon the lower spatial frequencies. Motivation behind this is to design the pyramid transform of fused image from the pyramid transforms of the source images after which fused image is generated by taking inverse pyramid transform.

Ratio pyramidal technique is also similar to FSD pyramid but it is different in decomposition phase because after low pass filtering in the input image matrices the pixel wise ratio is calculated but not like FSD where subtraction is performed. All the other steps are followed as in FSD pyramid.

In **Gradient Pyramid** the decomposition process involves two low pass filters, this is also includes four directional filters like horizontal filter, vertical filter, diago. nal filter which are applied on to the input image matrices. Remaining steps are just like the steps of FSD pyramid method.

In **Morphological Pyramid** the decomposition phase is made of two levels of filtering which are implemented on the input image matrices that are for image opening and image closing. Image opening is defined as the Combination of image attrition suffixed by image expansion. To remove noise from the image a combination of image opening and image closing used. Here restore process is same as the FSD technique omitting the steps of involving low pass filter on the image matrix.

In [5] auther proposed a hybrid Integer wavelet transform (IWT) and discrete cosine transform (DCT) based image fusion technique. This hybrid method minimize the fraction loss and maximize the visible quality of the image.

III. Proposed Methdology

In this section we are describing our proposed work to improve the quality of the multi focus images. Proposed image fusion is based on the Laplacial pyramid and discrete cosine transform. In the following sections we will discuss the proposed method in details and Step by step description of the of the proposed method is given in the following algorithm:

Input : Two blur versions of the images

Output: Fused image

Step 1. Gets two blur images as the input.

Step 2. Set the decomposition levels and initialize the laplacian function by setting parameters value.

Step 3. Apply Discrete Cosine Transform (DCT) for the fusion of the images at the multiple resolutions.

Step 4. Expand (up sampled) the images up to the maximum level 5.

Step 5. Fused the decomposed images.

Step 6. Reduce (down sample) the fused image to get the original image using the inverse DCT

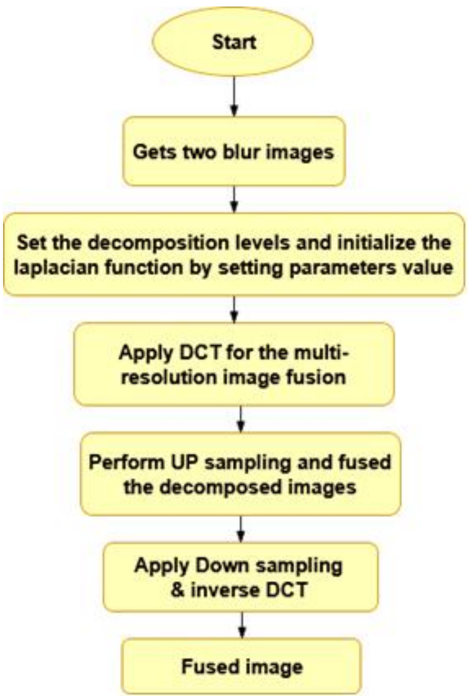

Figure 1: Block diagram for proposed methodology

3.1 Laplacian Pyramid

In the Laplacian pyramid[4] first, images are down sampled for getting the next level where spatial density and the resolution of the image are reduced. Let the L0, L1, L2, L3,, Ln are the levels of the image. L1 level is obtain by the down sampling of the L0 image, L2 level is obtain by the down sampling of the L1, and so on. This down sampling can be obtained by the reduction function (R) as follows:

$$L_k = R(L_{k-1})$$

For the image reconstruction up sampling [6](expand) is perform which gives the original image. Expand function (E) is used for the image reconstruction, which perform reverse operation of the reduction function (R). Mathematically expand function is defined as:

$$L'_k = E(L'_{k-1})$$

Image recontraction from the pyramid images is done using

$$L_{k+1} = R(L_k)$$

$$l_k = L_k - E(L_{k+1})$$

3.2 Discrete Cosine Transform (DCT)

Discrete cosine transforms [10] very useful transform which has various applications in the science and engineering for compression of the images. DCT has properties like Decorrelation, Energy Compaction, and Separability.

It transforms the image from spatial domain to frequency domain. Discrete cosine transforms.

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Lambda(i).\Lambda(j).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] cos\left[\frac{\pi.v}{2.M}(2j+1)\right].f(i,j)$$

Where

$$\Lambda(\xi) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for}\xi = 0 \\ 1 & \text{otherwise} \end{cases}$$

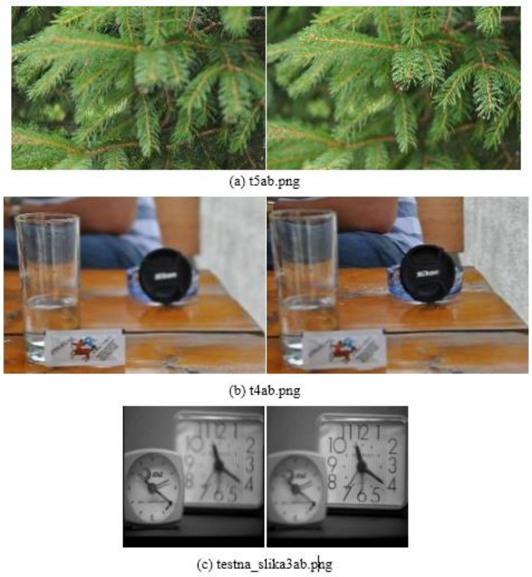

Figure 2 Multi focus pair images from the multi focus image data set

3.3 Proposed Image Fusion method

This section gives the details of the proposed image fusion method and overview of the proposed method is depicted in the block diagram shown in the figure 1. Proposed method is based on the Laplacian and Gaussian pyramid based image decomposition, and the Discrete Cosine Transform (DCT). Proposed method fusion the low quality images and gives an improved quality image. In the proposed algorithm first laplacian pyramid is generated for the images. Followed by Laplcian pyramid of the fused I generated by the DCT at the multiple resolutions. Finally reconstruct combined the images to get the original fused image.

3.4 Multi focus Image Data Set

For the performance analysis of the proposed method is applied on the publically available Multi focus image data set [13]. In which image are captured by the NIKON D5000 camera. Multi focus image dataset has 27 pair of image in the .png format. Sample images from the multi focus data set are given in the figure 2. For evaluating the methods performance, we pick 6 image pairs from the dataset namely: p27ab.png, p30ab.png, t3ab.png, t4ab.png, t5ab.png and testnaslika3ab.png. We have also compared our results with the existing fusion method based on principal component analysis (PCA)[8] and Stationary Wavelet Transform (SWT)[9]. Performance is measured on the PSNR, API, Entropy and the Standard Deviation based performance parameters.

3.5 Performance Analysis parameters

For the evaluation of the performance[12] the following performance numerical parameters are used.

1) Average pixel intensity(API):

Average pixel intensity is mathematically represents
by the following equation:

$$API = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} f(i,j)}{mn}$$

API gives the contrast information of the image. If the API is high then in means quality is improve in the fused image.

2) Entropy (E):

Entropy defines the randomness or amount of the information present in the image. Mathematical definition of the entropy is as:

$$Entropy = \sum_{k=0}^{255} p_k \log_2 p_k$$

3) Peak Signal to Noise Ratio (PSNR):

Peak signal to noise ratio (PSNR) which mathematically define below in equation as:

$$PNSR = 10\log_{10}\left(\frac{L^2}{RMSE}\right)$$

Where L represents the number of the gray levels in the image and RMSE is represent the root mean square error. PSNR is high when the fused image and reference image are not same. Higher value of the PSNR represents the better fusion.

4) Standard Deviation (SD):

Standard Deviation which is mathematically defined by the equation mentioned below and gives the deviation from the mean of the image pixel values.

$$SD = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(f(i,j) - F)^2}{mn}}$$

IV .Results and Discussion

In this chapter we will discuss the implementation of the proposed method, experimentation setup, image data set and the performance evaluation of the proposed image fusion method. Here three images of different size have been considered for the experiments and experiments results comparison of the proposed method with existing method PCA and SWT is shown in the table 1, 2, and table 3, in which observe that simulation result is much better

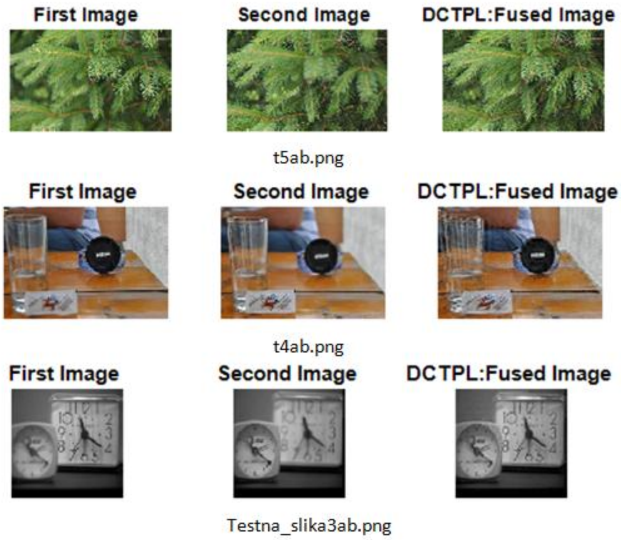

Figure 3 Resultant fused image image obtain from the proposed

Table 1 Performance evaluation and comparison for the t4ab.png

Parameters	PCA	SWT	Proposed Method
API	115.48	115.41	**117.92**
Entropy	7.91	7.53	**9.09**
PSNR	42.64	42.61	**55.61**

Table 2Performance evaluation and comparison for the t5ab.png

Parameters	PCA	SWT	Proposed Method				
API	88.97	88.48	**91.51**				
Entropy	7.23	7.33	**8.85**				
PSNR	38.86	38.96	**40.12**				

Table 3 Performance evaluation and comparison for the t5ab.png

Parameters	PCA	SWT	Proposed Method				
API	98.46	98.45	**101.27**				
Entropy	7.29	7.31	**8.92**				
PSNR	38.68	39.06	**51.81**				

for the proposed method on the basis of the API, Entropy, PSNR and SD performance parameter. API, entropy and PSNR value is higher in for the proposed method in the all images.

V. Conclusion and future work

In this research work we, proposed an image fusion method based on the Laplacian and Gaussian pyramid based image decomposition, and the Discrete Cosine Transform (DCT). Proposed method performed fusion of low quality images and produced an improved quality image. In the proposed algorithm first Laplacian pyramid is generated for the images. Followed by Laplacian pyramid of the fused is generated by the DCT at the multiple resolutions. Finally, reconstruct combined the images to get the original fused image. Our proposed method has shown the satisfactory results in terms of the quality of the image and gives the significant improvements in the API, entropy, PNSR and the Standard deviation compared to the exiting method such as PCA and SWT. This method gives the satisfactory results which tested on the multi focus images dataset. Our proposed method is still need to test on the other public ally available datasets. In future, this work may be improved by the use complex fusion rules and its combination may be explored to enhance the robustness.

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