Image Enhancement Based on Fusion Using Cross Bilateral filtering

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***Abstract**: The images are widely used in various applications such as medical field. The quality of images should be improved so that better image analysis can be predicted. For that, image fusion concept is one of the popular techniques, where images are improved using more than one similar images. In this paper, a technique is proposed based on the concept of image fusion. In proposed technique, two input images are used where cross bilateral filter is used. The cross bilateral filter is used in such a way so that most of the image features can be obtained and fused. The proposed scheme is tested on various images. In experimental evaluation, the PSNR and mean square error are obtained to analyze the experimental results. From result analysis, it was analyzed that most of the times; the proposed scheme is giving better outcomes.*

***Keywords**: Bilateral filter; Image fusion; PSNR.*

1. Introduction

Digital images are very important in various applications such as medical field and others. If the quality of images are not up to mark then these kinds of images are referred as degraded images. These degraded images may have blurring problems which is not good for image analysis. There are various solutions to sort out this problem. Image fusion is one of the solutions to solve the problem of blurring [1].

The application of wavelet transform to multimodality medical image fusion was proposed by **[2].** The result of image fusion is a single image which is more suitable for human and machine perception or further image-processing tasks. **In [3-5],** proposed a method for fusing multi-exposure images of a static scene taken by a stationary camera into an image with maximum information content. An image is considered best-exposed within an area if it carries more information about the area than any other image. Information content will be measured using entropy. The method partition the image domain into uniform blocks and for each block selects the image that contains the most information within that block. A novel approach for solving the perceptual grouping problem in vision was rather than focusing on local features and their consistencies in the image data, **in [6-8]** approach aims at extracting the global impression of an image. **In [9-10],** proposed a novel approach for solving the perceptual grouping problem in vision. Rather than focusing on local features and their consistencies in the image data, our approach aims at extracting the global impression of an image. They treat image segmentation as a graph partitioning problem and propose a novel global criterion, the normalized cut, for segmenting the graph. The normalized cut criterion measures both the total dissimilarity between the different groups as well as the total similarity within the groups. **In [11-13],** described an adaptive and parameter-free image fusion method for multiple exposures of a static scene captured by a stationary camera.

With the motivation from directional wavelet transforms, the proposed scheme is designed to get the enhanced image from degraded images. This paper has the following structure: section 2 is about cross bilateral filtering, section 3 gives information on the proposed algorithm employed for the fusion process, section 4 represents the results and discussion and section 5 concluded the paper.

2. Cross bilateral filter:

Bilateral filtering is a local, nonlinear and non-iterative technique which combines a classical low-pass filter with an edge-stopping function that attenuates the filter kernel when the intensity difference between pixels is large. As both gray level similarities and geometric closeness of the neighboring pixels are considered, the weights of the filter depend not only on Euclidian distance but also on the distance in gray/color space. The advantage of the filter is that it smoothes the image while preserving edges using neighboring pixels. It can be mathematically expressed as:

$$A_F(p) = \frac{1}{W} \sum_{q \in S} G_{\sigma_s}(\| p - q \|) \times G_{\sigma_r}(|A(p) - A(q)|) A(q) \quad (1)$$

Where, $G_{\sigma_s}(\| p - q \|) = e^{-\frac{\|p-q\|^2}{2\sigma_s^2}}$ is the geometric closeness,

$$G_{\sigma_r}\left(|A(p)-A(q)|\right) = e^{-\frac{|A(p)-A(q)|^2}{2\sigma_r^2}}$$

is gray level similarity and $W = \sum_{q \in S} G_{\sigma_s}(\| p-q \|)\, G_{\sigma_r}(|A(p)-A(q)|)$ is the normalization constant.

3. Proposed Methodology

We have proposed a new approach for efficient and reliable image fusion in multi-focus images, which is a challenging task due to blurring effect. The propose scheme is processed using following steps:

Step 1: Two input images (X and Y) are taken which are defocused.

Step 2: Over the both input images, cross bilateral filter.

Step 3: Subtract outcome of step 2 with both input images.

Step 4: Over both subtracted images, DCT is performed.

Step 5: Apply Inverse Discrete Cosine Transform (IDCT) to obtain filtered image.

Step 6: Perform addition on both outcome images of Step 3 and Step 5.

Step 7: The final outcome is obtained using average on the both outcome images (outcomes of Step 6).

4. Results of Experiment and Analysis

The proposed method is tested on various images of size 512×512. The results are tested using images as shown in figs. 1(a)-(b), 2(a)-(b) and 3(a)-(b). In fig. 1-2, the images 1(a) and 2(a) are highly concentrated on the right part and 1(b) and 2(b) highly concentrated on left part. Whereas in fig. 3 (a) the image is focused on the front leaves and 3(b) is focused on background leaves. The noisy images are obtained by adding salt and pepper noise. Over the input images, the fusion is performed based on cross bilateral filter and DCT as discussed in proposed methodology. The resultant fused images of proposed scheme are shown in figs. 1(c), 2(c) and 3(c). The visual quality of results is good in compare of input images. To measure the quality of proposed scheme in terms of MSE and PSNR, the results are compared with existing schemes, as shown in table 1. For comparison, the existing schemes are DWT with maximum, DWT with minimum, DWT with average and DWT with PCA.

(a) **(b)** **(c)**

Figure 1: Clock images: (a) first input image (b) second input image (c) fused image

(a) **(b)** **(c)**

Figure 2: Pepsi images: (a) first input image (b) second input image (c) fused image

(a) **(b)** **(c)**

Figure 3: Leaves images: (a) first input image (b) second input image (c) fused image

Table 1: PSNR and MSE

Input Images	Fusion methods	PSNR with first input image	PSNR with second input image	MSE with first input image	MSE with second input image
Clock (512x512)	DWT + maximum method	34.95	33.19	29.46	29.42
	DWT + minimum method	33.18	34.90	29.32	29.87
	DWT + average method	36.22	36.92	29.58	29.11
	DWT + PCA	36.04	36.90	29.35	29.33
	Proposed Method	37.01	37.10	28.61	29.01
Pepsi (512x512)	DWT + maximum method	35.91	37.10	29.77	29.08
	DWT + minimum method	36.99	35.89	29.37	29.73
	DWT + average method	39.04	39.42	29.41	29.22
	DWT + PCA	39.66	39.31	29.71	29.01
	Proposed Method	39.49	39.44	28.17	28.77
Leaves (512x512)	DWT + maximum method	28.69	31.34	30.21	29.34
	DWT + minimum method	31.33	28.61	29.71	29.23
	DWT + average method	32.82	32.88	30.32	29.24
	DWT + PCA	32.58	32.84	29.34	29.24
	Proposed Method	33.17	33.25	28.24	28.03

The Mean Square Error (MSE) is one of the most important criterions used to evaluate the performance of image quality. It measures the average of the squares of the errors. Here, the error is a difference between the original and estimated values, which define the values of the original image, differ from the processed image. As the MSE increases, image quality decreases. Therefore, our approach is to minimize the MSE of images.

$$MSE = \frac{1}{mn}\sum_{x=0}^{\infty}[I(i,j) - P(i,j)]^2$$

Where, *I(i, j)* is the input image of size $m \times n$ and *P(i, j)* is processed image.

Peak Signal to Noise Ratio (PSNR) is the ratio between the maximum possible value of a signal and the power of distorting noise that affects the quality of its representation. The PSNR is usually expressed in terms of the logarithmic decibel scale. Higher PSNR value indicate high quality image and our approach is to increase the PSNR.

$$PSNR = 10\log_{10}\left(\frac{255^2}{MSE}\right)$$

5. Conclusions

In this research work, attention was drawn towards the current trend of the use of multi-resolution image fusion techniques, especially approaches based on cross bilateral filter. Due to cross bilateral filter, final results of fused images are very impressive in terms of sharp and smooth images. It helps to get more accurate results. PSNR and MSE also get good results for proposed methodology.

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