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Clear Focused Image from Macro and Infinite Images

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Abstract--**In implementation, the time complexity and the performance of image fusion technique influence practicability of the products directly. In this paper, we propose an original image fusion method based on image spatial-domain features.**

I. INTRODUCTION

Recently, digital still camera becomes more widespread. To provide more capability for users and satisfy their different requirements, many techniques have been integrated into digital still camera. Image fusion is the technique to combine information from multiple images of the same scene. The result of image fusion is a single image more suitable for human perception or decision making [1], [2]. Many approaches have been proposed to deal with image fusion. In this paper, we propose an original image fusion method based on spatial-domain features to improve the performance of the technique.

II. REVIEW

Because image fusion has many practical applications, for example: medical imaging, remote sensing [2], quality and defect inspection and so on, many different fusion approaches are proposed to satisfy different requirements. Zhang and Blum proposed a generic image fusion scheme [1] to model a systematic framework for image fusion.

Besides, many fusion approaches based on frequency-domain features were proposed. Recently, the Discrete Wavelet Transform (DWT) and the Discrete Wavelet Frame (DWF) are applied to deal with fusion problem extensively. Wang proposed a multi-focus image fusion method in 2003 [3]. But, frequency-domain approaches are more difficult to implement with inadequate hardware resource.

III. DEVELOPMENT METHOD

The proposed method has three main steps. First, we use edge extraction to extract the edge information from input images. The edge information is the criterion of image fusion. Then, block-based comparison and fusion are applied to generate large-scale rough image. Finally, pixel-based comparison and fusion are put on the rough image generated by block-based fusion to adjust the detail parts of the image.

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The system flowchart is shown in Fig.1.

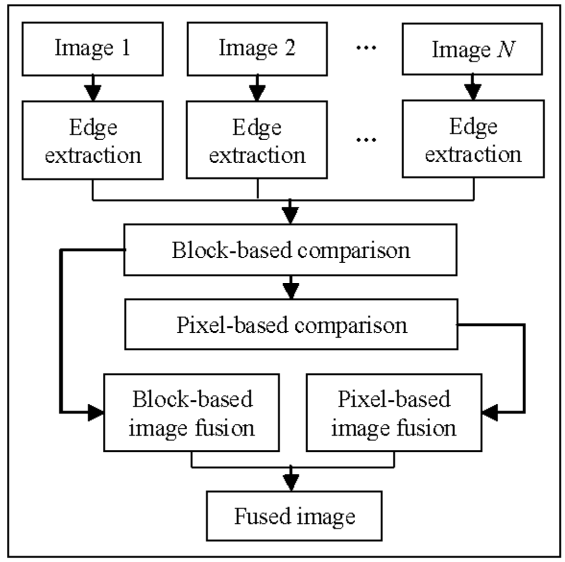

Fig. 1. System framework.

A. Edge Detection

There are many ways to extract edge information from given image. In this paper, we use the Laplacian as edge detector. Assume that, the intensity of the input image I located at spatial coordinate (r,c) is denoted by $I(r,c)$, the Laplacian of a function $I(r,c)$ is defined by

$$\nabla^2 I = \left(\frac{\partial^2}{\partial r^2} + \frac{\partial^2}{\partial c^2} \right) I = \frac{\partial^2 I}{\partial r^2} + \frac{\partial^2 I}{\partial c^2} . \quad (1)$$

In implementation, we can use the convolution of input image and the digital Laplacian mask to simplify the edge extraction.

B. Block-based operation

To increase the fusion efficiency, the block-based approach is applied to deal with mainly global comparison. As mentioned above, the edge information $\{E_1,...,E_N\}$ are extracted from each of the input images $\{I_1,...,I_N\}$ by the Laplacian, where $N \geq 2$.

According to the size of the input image, an adaptive block size is applied to determine the contrast of each input image. The relation between edge information $E_k(x,y)$ and corresponding contrast $C_k(i,j)$ is shown as

$$C_k(i,j) = \sum_{x=i\cdot BW}^{(i+1)BW} \sum_{y=j\cdot BH}^{(j+1)BH} E_k(x,y), \quad (2)$$

$k = 1,...,N$

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where, $C_k(i,j)$ means the contrast value of the kth input images at the index (i,j), and $E_k(x,y)$ means the Laplacian of the kth input images at spatial coordinate (x,y). Moreover, BW and BH mean the width and the height of block. Then, we can use the following criterion to implement block-based fusion.

$F_B(i,j) = I_k(i,j)$,

where $C_k(i,j)$ is the maximum contrast value, and (3)

$k = 1,\ldots,N$.

Because the fusion is base on block-based approach, the zigzag effect of the border between neighboring blocks is difficult to avoid.

C. *Pixel-based operation*

To adjust the perceptual influence, we adopt pixel-based comparison and fusion to refine the border regions between neighboring blocks. An example is shown in Fig. 2, the green blocks represent the borders between in-focus regions and out-of-focus regions.

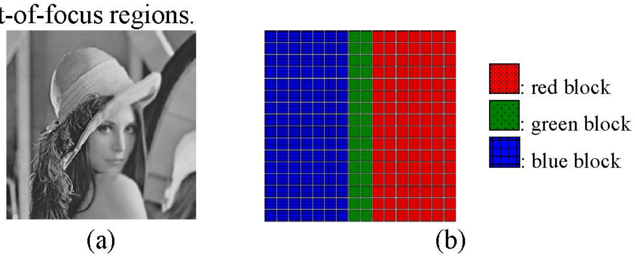

Fig. 2. (a) The right-side blurred image. (b) The block-based diagram, blue blocks mean in-focus parts; red blocks mean out-of-focus parts; and green blocks mean the border between in-focus parts and out-of-focus parts.

First, the pixels $F_P(x,y)$ in border regions are initiated by the edge information $E_k(x,y)$ of the input images. We can use the following criterion to initiate the border regions.

$F_P(x,y) = I_k(x,y)$,

where $E_k(x,y)$ is the maximum contrast value, and (4)

$k = 1,\ldots,N$.

If edge information $E_k(x,y)$ can not provide sufficient discriminative information for above criterion, then we adopt the mean value of corresponding pixels from input images as immediate result. Finally, each pixel in immediate result is modified in accordance with the variance of pixel and its 8-connected neighboring edge information. In other words, pixels with relative maximum variance are applied to refine the immediate result.

IV. EXPERIMENTAL RESULTS

To demonstrate the performance of our proposed method, both mean square error (MSE) [1], [3] and mutual information (MI) [1], [3] are applied. A low MSE value represents a good performance for image fusion, and a high MI value indicates a good performance of image fusion. Table I is the comparison between previous research and our proposed method, and Fig. 3 is a realistic fusion result.

Table I. The experimental result of fusion right-side blurred lena and left-side blurred lena.

	Wang's method		Our Method	
Block Size	16×16	32×32	16×16	32×32
MSE	0.19100	0.39724	0.08202	0.15942
MI	5.00129	4.85514	5.07296	4.99498

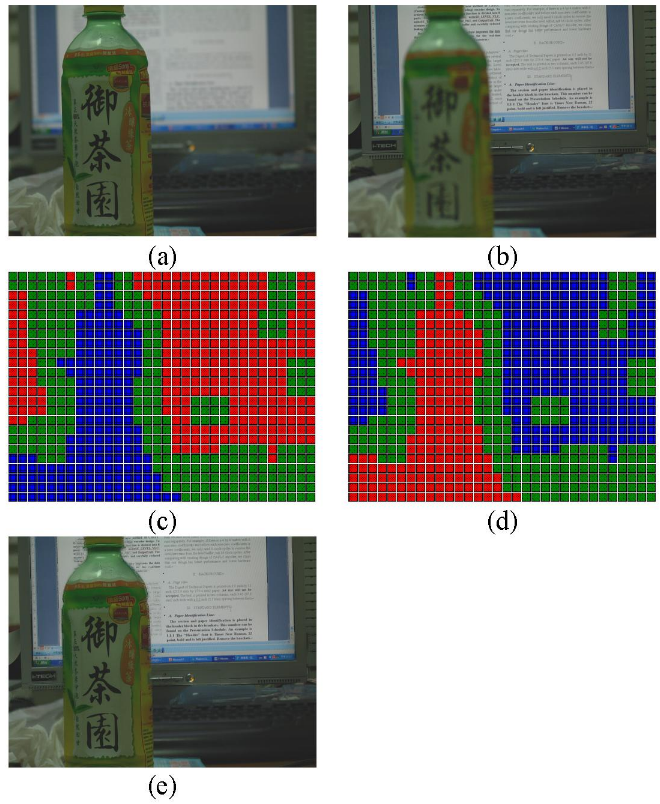

Fig. 3. (a) and (b) The input images. (c) and (d) The block-based diagram of (a) and (b). (e) The fused image.

V. CONCLUSION AND DISCUSSION

Present frameworks of image fusion always assume that the input images have been registered. In fact, due to the different image capture devices or the different images capture settings, the scope of the input images of the same scene will be slightly different. In application, camera magnification effect affects the quality of the fused image indirectly. Therefore, the future work will be adjusting input images by preprocessing and providing an integral framework to improve the performance of the technique.

REFERENCE

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