영역기반 계단응답 추출 및 디지털자동초점을 위한 점확산함수 추정

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Region-Based Step-Response Extraction and PSF Estimation for Digital Auto-Focusing

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Abstract

Blur identification is the first and the most important step of restoring images. Edge region of the image usually conveys important information of blur parameters. In this paper we propose a region-based edge extraction method for estimating point-spread-function (PSF). As a result, the proposed method can detect the starting and the ending points of a step response, and provides the PSF parameters to the restoration process.

I. Introduction

Edge detection is one of the most commonly used operations in image analysis and computer vision. Edges represent the characteristics of image degradation through the step response of the PSF on the edge. By Finding the starting and the ending points of the step response we can estimation a circularly symmetric point spread function (PSF). The lower and upper cut-offs of the edge response is used in PSF estimation [1].

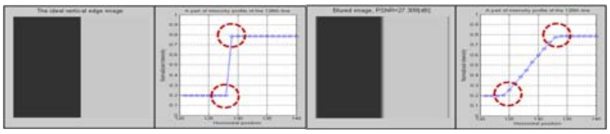
II. Background

An out-of-focused image is made by convolving a PSF and an input image. In most cases a blurring system is modeled as [1]

$$g(x,y) = f(x,y)*h(x,y) + n(x,y) \qquad (1)$$

where f, h, n and g represent the original image, PSF of the imaging system, additive noise, and the observed image, respectively.

Blurred images usually tend to have ramp edges as shown in Figure 1. Lower and upper cut-off limits of the ramp edges can be used for PSF estimation.



(a) (b)

Figure 1:(a) Show edge step-response (128 row, 120~140 column) of edge of ideal image, (b) edge blurred image showing start and end point of blurred edge (128 row, 120~140 column).

Ⅲ. Proposed Edge Region Extraction Algorithm

Most image acquisition processes are subject to noise of a certain type. Noise cannot be accurately predicted because of its random nature [2]. We propose a novel noise removal method called column-mean-filter as

$$\sum_{i=1}^{ce} \frac{g(i,j)}{ce} = M(i,j) \;\Big|\; ce = \text{end of edge},\ j = \text{entire of row}, \qquad (2)$$

which uses sum of column values from the beginning to the end of the edge, and provides suppression of noise using the column-mean-filter. As a result, the noise is removed, remaining the edges.

For finding the starting and the ending points, the noise removal and equalized step-response as

$$\nabla f = \frac{\partial M(i,j)}{\partial i} = M(i,j+1) - M(i,j), \quad \nabla^2 f = \nabla\left(\frac{\partial M(i,j)}{\partial i}\right) \quad (3)$$

We know that the first-order derivative is the slope of edge, and the second derivative is its variation [2].

After column-mean-filter processing, we additionally use thresholding for extracting edge region. At the first point matched with the value over threshold through right direction, we define the first edge point. The end point is matched with the value over threshold through searching in the inverse direction.

$$\nabla^2 f = \nabla\left(\frac{\partial M(i,j)}{\partial i}\right) > Threshold\ Value. \quad (5)$$

The threshold value is inversely proportional to the diameter of the PSF. So the bigger PSF has the slower ramp, where the threshold has a lower value. Threshold values are given in Table 1.

PSF diameter \ SNR	40dB	50dB	60dB
7	0.13	0.136	0.137
11	0.074	0.075	0.075
15	0.036	0.039	0.039
19	0.031	0.031	0.031
23	0.019	0.019	0.019
27	0.016	0.016	0.015

Table 1: threshold values of different PSF diameters.. Because second differentiation value after column-mean-filtering, SNR range consider from 60dB to 40dB.

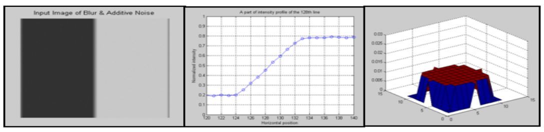
By using equalization as

$$Equalization = \frac{\nabla^2 f - MAX(\nabla^2 f)}{MAX(\nabla^2 f) - MIN(\nabla^2 f)}, \quad (6)$$

we can obtain the normalized edge profile using edge-adaptive thresholding.

Ⅳ. Experimental Result

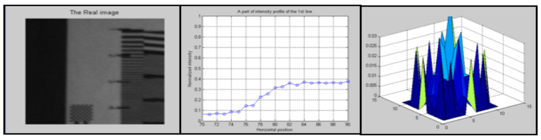
Input image is blurred with an isotropic PSF of diameter 11 as shown in Figure 4. The blurred image also has additive noise of 50dB. We use the column-mean-filtering over 256 lines. As a result, the proposed method detects the correct starting and ending points using adaptive threshold.



(a) (b) (c)

Figure 2: (a) Blurred and noise added input image, (b) step-response of input image, and (c) PSF estimation.

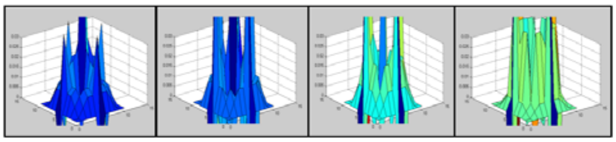
For a real image shown in Figure 5. We apply column-mean-filter over 150 lines and adaptive threshold 0.09. The Proposed method detects edge of the starting point 73 and the ending point 83. This result is approximately equivalent to the diameter of 11 in Table 1.



(a) (b) (c)

Figure 3: (a) Real image, (b) step-response of real image, and (c) PSF estimation.

At several edge of different location, the corresponding PSF are estimated as shows in Figure 6. Similar shapes in all edges proved the feasibility of the proposed method.



(a) (b) (c) (d)

Figure 4: (a) PSF of start point 71 and end point 81, (b) 72 and 82, (c) 74 and 84, and (d) 75 and 85.

Ⅴ. Conclusion

In this paper we proposed edge detection method using adaptive threshold. The proposed algorithm can efficiently remove noise by using the column-mean-filter. The adaptive-threshold-filter adaptively selects the threshold value for feedback. As a result we can detect the starting and ending points of the edge using threshold value based on the diameter of the PSF.

Acknowledge

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Reference

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