Edge Detection Based on Bhattacharyya Distance for Color Images Using Adaptive Boundary and Thresholding

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Abstract

Color image edge detection is an important operation in many image processing areas. This paper presents a new method for edge detection based on the Bhattacharyya distance that can handle arbitrary boundaries by exploring several edge patterns. Experiments show promising results compared to some existing methods.

Keywords: color edge detection, edge patterns, Bhattacharyya distance.

1. Introduction

Several algorithms have been proposed for color edge detection, which include the Sobel and Canny methods [1-5]. Recently, a multispectral method based on the Bhattacharyya distance has been proposed [6-7] where the Bhattacharyya distances of four directions were used to detect edges in multi-channel images that include multispectral images and color images. In this paper, we extend the method of [6-7] and considers several possible edge patterns.

2. Methodology

In [7], a color edge detection algorithm based on the Bhattacharyya distance was proposed. The algorithm computes the Bhattacharyya distances of four pairs of blocks: up-down, left-right, diagonal-left-down and diagonal-right-down pairs (Fig. 1). Then, the algorithm uses the maximum value as an edge strength of each pixel.

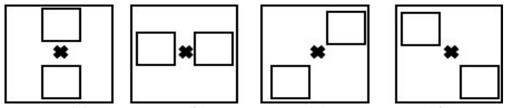
Whereas only four directions were considered in [7], we propose to consider a number of arbitrary edge patterns in this paper. Fig. 2 shows some examples of edge patters considered in this paper.

In other words, we choose a block (e.g., 5 by 5 as shown in Fig. 2) and then divide the block into two regions considering all possible edges that pass the center pixel. Then, we compute the Bhattacharyya distances of the two regions and choose the edge that provides the largest Bhattacharyya distance.

Fig. 3 shows a flowchart of the proposed algorithm. To remove noises, we first applied a pixel-wise adaptive Wiener filter [6,7], which uses the local mean and variance:

$$\mu = \frac{1}{N.M}\sum_{i=1}^{N}\sum_{j=1}^{M} L(i,j) \qquad (1)$$

$$\sigma^2 = \frac{1}{N.M}\sum_{i=1}^{N}\sum_{j=1}^{M} L(i,j)^2 - \mu^2 \qquad (2)$$



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

Fig. 1. Four pairs of neighborhood blocks [7]. (a) Up-down (UD), (b) Left-right (LR), (c) Diagonal-left-down (DLD), (d) Diagonal-right-down (DRD).

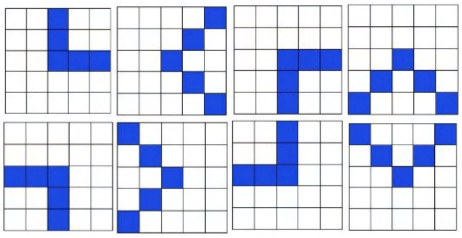


Fig. 2. Some examples of edge patterns.

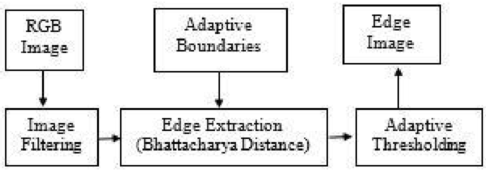


Fig. 3. Flowchart of the proposed method.

Next, we consider a number of edge patterns as shown in Fig. 2. An edge pattern divides the block into two regions (Fig. 4). Then we compute mean vectors and covariance matrices of the two regions. Finally, the Bhattacharyya distance is computed as follows:

$$BD = \frac{1}{8}(\mu_1 - \mu_2)^T \Sigma^{-1}(\mu_1 - \mu_2) + \frac{1}{2}\ln\left(\frac{\det\Sigma}{\sqrt{\det\Sigma_1 \det\Sigma_2}}\right) \quad (3)$$

where, μ_i and Σ_i are the mean vectors and covariance matrices, and $\Sigma = \frac{\Sigma_1 + \Sigma_2}{2}$.

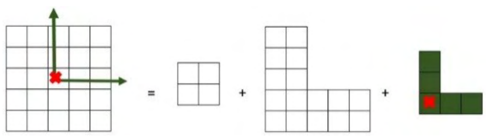


Fig. 4. Edge pattern and two regions

We generated the edge patterns with two constraints: (a) it should pass through the center pixel, (b) each region should include at least four pixels.

Finally, we chose the maximum value as the edge strength of each pixel:

$$Edge = max\{ BD_1, BD_2, \ldots, BD_N\} \quad (4)$$

To determine whether a pixel is an edge or not, we used an adaptive thresholding method based on the Niblack's method where the threshold at each pixel is computed based on local mean and standard deviation:

$$Th(x, y) = M + k.S \quad (5)$$

where M and S are the mean and standard deviation values, respectively.

3. Experimental results

In the experiments, we used a 5x5 blocks and considered 58 edge patterns. When applying the Niblack's method, we considered 15x15 local neighbors. We compared the proposed method with three existing methods: Sobel edge detection, Canny edge detection method, the color edge detection method [7]. Figs. 5-6 shows some output images of the four edge detection methods. As can be seen, the proposed method successfully found edges missed by other methods.

4. Conclusions

In this paper, we propose an edge detection algorithm based on the Bhattacharyya distance that considers several possible edge patterns. By considering many edge patterns, the proposed algorithm can detect more complex edges. Experimental results show favorable results compared to some conventional methods such as the Sobel and Canny edge detection algorithms.

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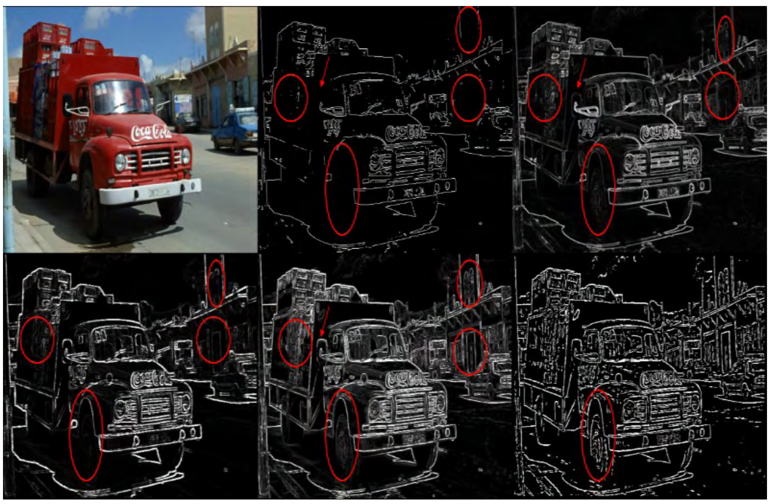

Fig. 5. (up-right) original image, (up-middle) Canny-edge-detector, (up-left) Sobel-edges, (down-left) four-pair direction method, (down-middle) Proposed Method edge image, (down-right) Binary Image proposed method

Fig. 6. (up-right) original image, (up-middle) Canny-edge-detector, (up-left) Sobel-edges, (down-left) four-pair direction method, (down-middle) Proposed Method edge image, (down-right) Binary Image proposed method