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Color Edge Detection Based on Data Fusion Technology in Presence of Gaussian Noise

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Abstract

A color edge detection method was developed to correctly reproduce distinct, continuous edges based on the multichannel data fusion technique and the gradient direction information contained in the image. Since the proposed techniques for edge detection are very sensitive to noise, subprefiltering or prefiltering algorithms are generally adopted and very critical. A new nonlinear prefilter is used to reduce noise in the R, G, and, B components of the image. The method preserves edges, corners and fine image details, smoothes Gaussian noise and does not require any a priori knowledge.

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Keywords: color edge detection, data fusion, Gaussian Noise, thinning of edge, Kirsch gradient template;

1. Introduction

Visual information processing is increasingly becoming widespread as multimedia becomes common in everyday life. With the expanding use of color images in multimedia applications and the proliferation of color capturing and display units, the interest in color imaging is rapidly growing[1]. During image formation, acquisition, storage and transmission many types of distortions limit the quality of digital

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images. Transmission errors, periodic or random motion of the camera system during exposure, electronic instability of the image signal, electromagnetic interferences, sensor malfunctions, optic imperfections or aging of the storage material, all disturb the image quality. With respect to gray-scale pictures, color images generally include much more measurement information that can be successfully exploited in order to improve the performance of image-based instrumentation and/or extend its application range.

Edge detection plays a very important role in the realization of a complete image understanding system. Indeed, high-level processing tasks such as image segmentation and object recognition directly depend on the quality of the edge detection procedure. It is well known, however, that the generation of an accurate edge map becomes a very critical issue when the images are corrupted by noise. In this respect, noises having Gaussian-like distribution are very often encountered during image acquisition[2].

Different methods to color edge detection in presence of this kind of noise have been proposed in the scientific literature[2],[3]. Methods that represent extensions of monochrome edge detector typically process the three-color channels independently and combine the resulting edge maps. As an example, the application of the well-known Sobel technique to the three image channels can be considered at a great aspect. An edge point in the color image could be estimated by evaluating the maximum of the gradient components or their vector sum. Many approaches have been proposed in the aspect of color edge detection, vector space approaches take into account this issue by modeling each image pixels as a three-dimensional vector in the assigned color coordinate system. An interesting example is represented by the family of directional operators that aim at detecting the location and orientation of edges in color images. Since gradient-based methods are very sensitive to noise, prefiltering algorithms are generally adopted.

In this paper a new method for color edge detection in presence of Gaussian noises are presented. The proposed approach adopts a multipass processing architecture that aims at reducing noise before detecting the image edges. In order to preserve the details of image and reduce the false edges caused by noise, the proposed approach, we developed a nonlinear prefiltering scheme, which considers the effect of different classed of noise pixels on the subsequent edge detection procedure. Nonlinear approaches generally provide more satisfactory results than linear techniques[4].

2. The proposed prefilter

The input images are the digitized multichannel R, G, and, B images. The proposed method of filtering is based on multipass processing and processes the three-color channels independently. Let $x^{(p)}$ denote the multichannel image at the pass p , where $p=0$ denotes the input noisy image. Let $x_k^{(p)}(i,j)$ be the pixel value $(0 \le x_x^{(p)} \le L-1)$ at the location $[i,j]$ in the k th channel $x_k^{(p)}$ where the R, G, and B channels are, respectively, denoted by k=1, k=2 and k=3. For a 24-bit color image, we have L=256.

The first prefiltering takes into account the differences between the pixel to be processed and its neighbors as follows small differences are considered noise to be reduced; large differences are considered edges to be preserved. Let $x_k^0(i+m,j+n), m=-1,0,1; n=-1,0,1; (m,n)\neq(0,0)$ be the group of N=8 neighboring pixels that belong to 3×3 window around $x_k^0(i,j)$ (Fig.1).

$$\begin{bmatrix} x_k^0(i-1,j-1) & x_k^0(i,j-1) & x_k^0(i+1,j-1) \\ x_k^0(i-1,j) & x_k^0(i,j) & x_k^0(i+1,j) \\ x_k^0(i-1,j+1) & x_k^0(i,j+1) & x_k^0(i+1,j+1) \end{bmatrix}$$

Fig.1 3×3 window

$$x_x^{(1)}(i,j) = x_x^{(0)}(i,j) + \frac{1}{8}\sum_{m=-1}^{m=1}\sum_{\substack{n=-1\\(m,n)\neq(0,0)}}^{n=1}\zeta_k(x_k^{(0)}(i+m,j+n), x_k^{(0)}(i,j)) \tag{1}$$

Where ζ_k is a parameterized nonlinear function. a_k is an integer $0 < a_k$ <L(k= 1,2,3).

$$\zeta_k(u,v) = \begin{cases} u-v & |u-v| \le a_k \\ (\dfrac{3a_k - |u-v|}{2}) sgm(u-v) & a_k < |u-v| \le 3a_k \\ 0 & |u-v| > 3a_k \end{cases} \tag{2}$$

According to (2), this formula aims at gradually excluding pixel values that are very different from the central element, in order to avoid blurring the image details during noise removal. In particular, two opposite effects can be considered. From the formula (2):

A. When all the grey level of the neighbors are very close to the value of the central pixel[4]:

$$|x_k^{(0)}(i+m, j+n) - x_k^{(0)}(i,j)| \le a_k, m = -1,0,1; n = -1,0,1; (m,n) \ne (0,0) \tag{3}$$

In this case, a strong smoothing is performed and the result is the arithmetic mean of the pixel values in the neighborhood, thus realizing the maximum smoothing action.

B. On the contrary, when all the values be very different from the central element, according to the following the relationship:

$$|x_k^{(0)}(i+m, j+n) - x_k^{(0)}(i,j)| > 3a_k, m = -1,0,1; n = -1,0,1; (m,n) \ne (0,0) \tag{4}$$

In this case, $x_x^{(1)}(i,j) = x_x^{(0)}(i,j)$ (5)

The filter behaves as the identity filter, thus performing the maximum detail preservation.

C. Intermediate situations (absolute differences larger than a_k and smaller than 3 a_k) are processed as a compromise between these opposite effects.

D. According to the formulate (2), it should be observed that the filter behaviour depends on the value of parameter a_k only. The optimal choice of a_k depends on the value that could get the minimum MSE between the filtered image and the original noise-free image.

E. The proposed method combines a nonlinear algorithm for detail preserving smoothing of noisy data and a technique for automatic parameter tuning based no noise estimation. And the method does not require any a priori knowledge about the amount of noise corruption.

3. Color edge detection based on the multichannel data fusion technology.

3.1. The select of the gradient operator

The multi-directional differential operator is one of the most effective methods to detect the edge. Because the multipass processing requires accurate location and simple algorithm, Kirsch gradient template is selected. Kirsch operator is made up of eight 3×3 templates. Every template represents one direction. Fig.2 denotes the Kirsch gradient template and direction.

$$\begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix} \begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix} \begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{bmatrix} \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix} \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix} \begin{bmatrix} -3 & -3 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix} \begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}$$

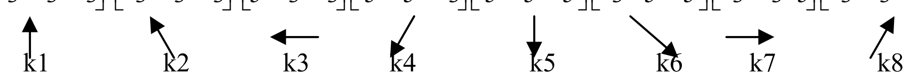


Fig 2 Kirsch gradient template and relevant direction

$p(x,y)$ denotes random pixel in the image, $b_i(i = 1,2,...,8)$ denotes edge intensity using the i th template. Then in the location $p(x,y)$, the edge intensity $S(x,y)$ =max $\{b_i\}$ (i=1, 2…8),and the relevant edge direction D(x,y)={i| b_i is maximal, i=1,2…,8 }.By computing the Kirsch gradient template, the intensity and direction of the every edge pixel could be determinated.

3.2. Thinning of edge (non-maxima suppression)

The width of edge generally is not single pixel during the computing the Kirsch gradient template, so it is not suited to segmentation processing of images and it could make the edges of images blurring. In this paper, a method using Kirsch gradient template, which makes the most of the information of, edges' intensity and direction make the edge thinning. With the view to characteristic of digital image, only horizontal direction and vertical direction are considered. If pixel p(x,y) dissatisfy the formula (6) and (7) , the p(x,y) is not location of edge and the point should be suppressed.

$$(\max(b_1(x,y),b_5(x,y)) \geq \max(b_3(x,y),b_7(x,))) \,\&\, (S(x,y-1) < S(x,y)) \,\&\, (S(x,y) > S(x,y+1)) \quad (6)$$

$$(\max(b_3(x,y),b_7(x,y)) \geq \max(b_1(x,y),b_5(x,))) \,\&\, (S(x-1,y) < S(x,y)) \,\&\, (S(x,y) > S(x+1,y)) \quad (7)$$

3.3. Mutilchannel data fusion

Data fusion technology is a new kind of information technology. A process dealing with the association, correlation and combination of data and information from single and multiple sources to achieve refined position and identify estimates and complete and timely assessment of situations and threats and their significance. In the color edge detection, multichannel data fusion technology could enhance the validity of the algorithm. Data fusion method could integrate R, G and B three gradient image's edge information into a uniform and correct color edge. The method is showed by the following relationship.

A. Integrate R, G and B three image's edge information

$\forall x, y\{x \in [1,m]\, y \in [1,n],\}$ Where the size of image Ω is m×n;

$$F_{E1}(x,y) = E_R(x,y) \mid E_G(x,y) \mid E_B(x,y); \quad (8)$$

$$F_E(x,y) = (E_R(x,y) \,\&\, E_G(x,y)) \mid (E_G(x,y) \,\&\, E_B(x,y)) \mid (E_R(x,y) \,\&\, E_B(x,y)); \quad (9)$$

$$F_D(x,y) = \begin{cases} D_k(x,y), S_k(x,y) = \max(\; S_R(x,y), S_G(x,y), S_B(x,y)), k \in \{R,G,B\} \\ \text{nondirecti on} \quad , \quad \text{if two or more than two max.} \end{cases}$$

B. Using the information in the (1), to modify the rude color image edge $F_E(x,y)$ using a 3×3 window.

$\forall x, y\{x \in [2,m-1], y \in [2,n-1]\}$

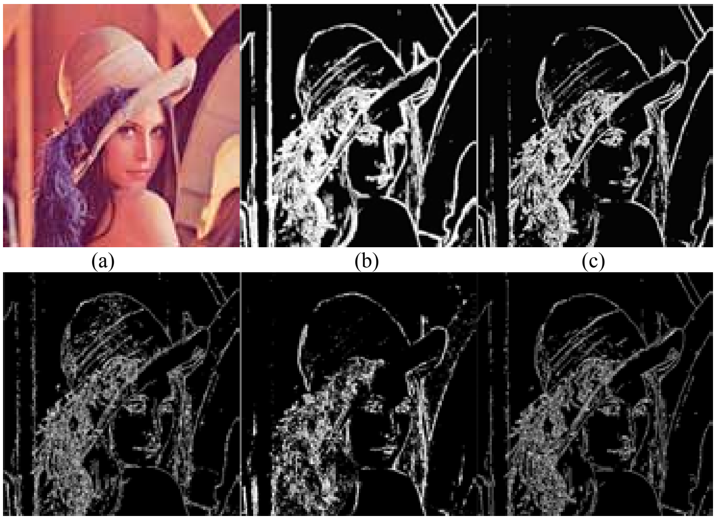
If $\left((F_E(x,y)=1) \,\&\, (\sum_{i=x-1}^{i=x+1}\sum_{j=y-1}^{j=y+1} F_E(i,j) \leq 3) \right)$, then modifying the $F_E(x,y)$ by judging the value of $F_D(x,y)$ defined by the following relationship:

If $F_D(x,y) = 1$,then $F_E(x-1,y) = F_{E1}(x-1,y)$;
If $F_D(x,y) = 2$,then $F_E(x+1,y+1) = F_{E1}(x+1,y+1)$;
If $F_D(x,y) = 3$,then $F_E(x,y+1) = F_{E1}(x,y+1)$;
If $F_D(x,y) = 4$,then $F_E(x-1,y+1) = F_{E1}(x-1,y+1)$;
If $F_D(x,y) = 5$,then $F_E(x+1,y) = F_{E1}(x+1,y)$;
If $F_D(x,y) = 6$,then $F_E(x-1,y-1) = F_{E1}(x-1,y-1)$;
If $F_D(x,y) = 7$,then $F_E(x,y-1) = F_{E1}(x,y-1)$;

If $F_D(x, y) = 8$,then $F_E(x+1, y-1) = F_{E1}(x+1, y-1)$;

4. Experimental results

We present experimental results from the following images[1,2,3]. The images from (a) to (f) show the experimental results. For a comparison, it is obvious that the proposed method is more available to the literature method.



(a) (b) (c)

(d) (e) (f)

Fig. 3 (a) Original color image; (b) Without thinning of edge;(c) Sobel operator;(d) edge detection without using the nonlinear filtering ;(e) Vector order statistics operators ;(f) the proposed edge detection using the nonlinear prefiltering

5. Conclusion

Before edge detection, the paper presents a nonlinear filtering to reduce Gaussian noise. This method could smooth noise and preserve the details of edge without any a priori knowledge about the distribution of noise. During the edge detection, a new color edge detection approach based on data fusion could availably make use of information of R, G, and B three colors and gradient and assure precision of edge. The method also could preserve the edges that are very slender. Since the complexity of algorithm is lower than VA (vector angles) and VSG (vector sum of gradients)[4], it is more suited to practical application.

References

[1]Nonlinear Techniques of Noise Reduction in Digital Images, published 2004 by the Silesian University Press

[2]S.-Y.Zhu,K.N.Plataniotis, A.N.Venetsanopoulos.Comprehensive analysis of edge detection in color image processing.Opt.Eng,vol.38,no.4,pp.612-625,Apr.1999.

[3]F.Russo.A method for estimation and filtering of Gaussian noise in images.IEEE Trans,Instrum.Meas, vol.52, pp.1148-1154.Aug.2003.

[4] Harro Stokman, Theo Gevers.Selection and Fusion of Color Models for Image Feature Detection, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 29, no. 3, pp. 371-381, Mar. 2007.