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Color Edge Detection in RGB Color Space using Automatic Threshold Detection

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Abstract*— Edge detection is one of the most commonly used operations in image processing and pattern recognition, the reason for this is that edges form the outline of an object. An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. Edge detection reduces the amount of data needed to process by removing unnecessary features. Edge detection in color images is more challenging than edge detection in gray-level images. Compared with gray image, color image provides more edge information of objects. However, the current color edge detection algorithms acquired so much time to compute and they are hardly used in real-time system. In order to improve the efficiency and the performance of the color edge detection. This paper proposes a method for edge detection of color images with automatic threshold detection. The proposed algorithm extracts the edge information of color images in RGB color space with fixed threshold value. The algorithm works on three channels individually and the output is fused to produce one edge map. The algorithm uses the improved Kuwahara filter to smoothen the image, sobel operator is used for detecting the edge. A new automatic threshold detection method based on histogram data is used for estimating the threshold value. The method is applied for large number of images and the result shows that the algorithm produces effective results when compared to some of the existing edge detection methods.

***Index Terms*—RGB color space Kuwahara filter, Sobel Operator, Histogram, Edge Thinning, Threshold**.

I. INTRODUCTION

An edge is the variation in the intensity and further it is an essential feature of the image processing. Efficient and accurate edge detection will directly work on the understanding of machine vision system [1]. Edge detection in gray-level images is a well-established area, while edge detection in color images has not received the same attention. The fundamental difference between color images and gray-level images is that, in a color image, a color vector (which generally consists of three components) is assigned to a pixel, while a scalar gray-level is assigned to a pixel of a gray-level image.

Thus, in color image processing, vector-valued image functions are treated instead of scalar image functions (as in gray-level image processing). Thus, additional features can be obtained in color images that may not be detected in gray-level images. In this paper, edge detection plays a very relevant role in the realization of a complete image understanding system.

In typical images, edges characterize object boundaries and are therefore useful for segmentation, registration and identification of objects in a scene. The research has shown that 90% of the edges are about the same in gray-value and color images. Consequently, there are still 10% of edges have been left and may not be detected in intensity images due to change in color. Xin et al. [1] proposed a method for edge detection of color images which uses an improved Kuwahara filter to smoothen the images and uses adaptive threshold method. Lianaiang et al. [2] proposed a method for color edge detection based on direction information measure used in HSV color space. The algorithm concentrates on directional property of the edges and filter scale's effect on edge detection but it needs to convert the widely used RGB color space to HSV color space. Jin et al. [3] proposed the fuzzy edge detection method based on the morphology. Salish et al. [4] proposed a color edge detection method using principle component analysis, but it doesn't deal with any threshold detection mechanism. Li Xue-wei et al. [5] proposed a perceptual color edge detection algorithm, based on eye blurring technique by using 2-D Gaussian filter and it considers a constant threshold value for all kind of the images. Eswaran et al. [6] proposed a fuzzy multiscalar color edge detection method it uses pixel enhancement before applying a constant threshold value. Jian et al. [7] proposed edge detection method using quaternion convolution masks, by neglecting the threshold detection part. Soumya et al. [8] proposed a method for detecting the edges of color images in RGB color space which uses average maximum color difference for predicting the optimum threshold value.

In this paper, a synthetic method to detect the edges of the images in RGB color space is defined using Kuwahara filter to smoothen the image and uses Sobel operator to detect the edge. A new automatic threshold detection mechanism based on histogram data is used. New set of edge thinning masks are introduced which works in four different directions used to get thin edges from thick edges.

II. THE PROPOSED APPROACH

The proposed method involves four steps. At first, the image is smoothed by improved Kuwahara filter to suppress unwanted noise in the image. Secondly, Sobel operator is used for edge detection. In the third step, A new automatic fixed threshold detection method from histogram data is used and finally the detected edges are thinned to get the proper edge map.

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A. Smoothing by Improved Kuwahara Filter

The Kuwahara filter is a noise reduction filter that preserves edges. It works by calculating the mean and variance for four sub quadrants and chooses the mean of the region with smallest variance. Traditional Kuwahara filter uses a square shaped window, however window size varies. Computational complexity of the algorithm for each channel is high which involves 16 additions, 16 subtractions, 2 divisions and 9 multiplications at least and in order to reduce computational complexities the shape of the traditional Kuwahara filter is reduced into triangular regions [1] which is as shown in the Fig.1.In each of the triangular regions (R1, R2, R3, R4) the mean (μ) and variance (σ) is calculated according to (1) and (2) respectively.

$$\mu=1/n\ \Sigma(x,y)\ p(x,y)\ . \qquad (1)$$

$$\sigma^2=(1/\ n-\Sigma(x,y)\ [p(x,y)-\mu]^{1/2} \qquad (2)$$

Where n is the number of pixels belonging to one region(n=6) and p(x,y) is the pixel value corresponding to the position (x,y). The improved Kuwahara filter has only 6 pixels in each regions ,that means only 12 additions ,12 subtractions 2 divisions and 2 multiplications when we deal with each pixel of signal channel image thus the computational complexity has been reduced.

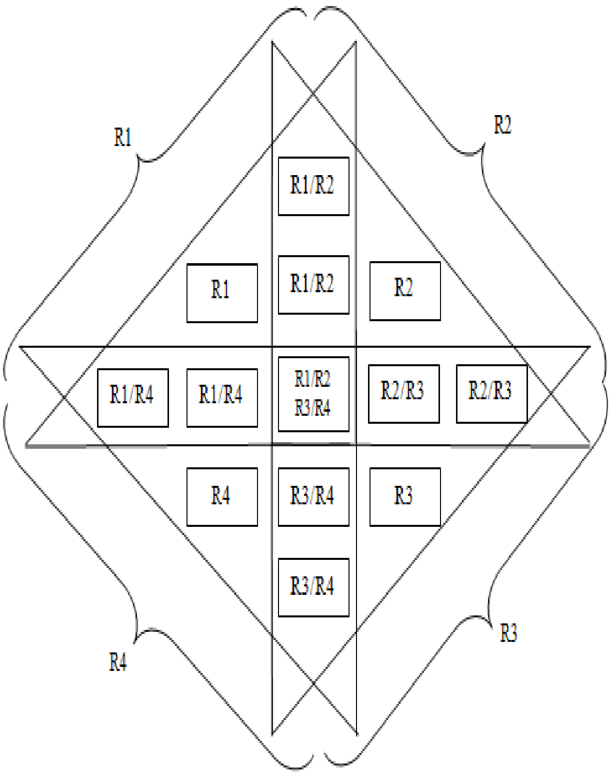

Fig. 1. Four triangular regions of improved Kuwahara filter

B. Color Edge Detection by Improved Sobel Operator

The proposed color edge detection method in this paper is a synthetic method. This method separate red, green and blue channel from image first. Then improved Sobel operator is applied to each single channel image to generate edge map[9]. The convolution matrix of traditional sobel operator is defined by two kernels which work in two different directions one in horizontal and one in vertical. The edge information usually present in four different directions ($0^0,45^0,90^0,135^0$) . The improved Sobel edge detector has four masks which operate in four directions as shown in the Fig 2.

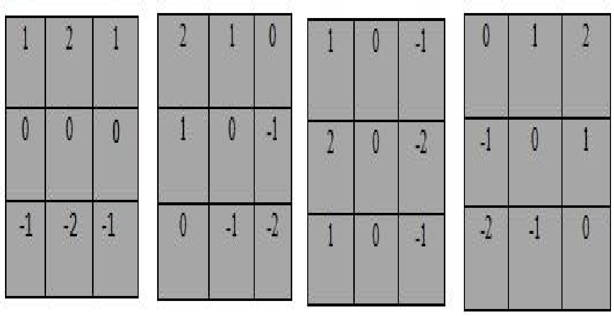

Fig. 2. Directional masks ($0^0,45^0,90^0,135^0$) defined in improved Sobel operator

The directional masks of improved Sobel operator works in $0^0,45^0,90^0,135^0$ directions respectively and the mathematical model for it is defined below.

$$\Delta1=\{\Phi(i-1,j+1)+2\Phi(i,j+1)+\Phi(i+1,j+1)\}-\{\Phi(i+1,j+1)+2\Phi(i+1,j)+\Phi(i+1,j-1)\} \qquad (3)$$

$$\Delta2=\{\Phi(i-1,j+1)+2\Phi(i,j+1)+\Phi(i+1,j+1)\}-\{\Phi(i-1,j-1)+2\Phi(i,j-1)+\Phi(i+1,j-1)\} \qquad (4)$$

$$\Delta3=\{\Phi(i,j-1)+2\Phi(i-1,j-1)+\Phi(i1,j)\}\Phi(i+1,j)+2\Phi(i+1,j+1)+\Phi(i,j+1)\} \qquad (5)$$

$$\Delta4=\{\Phi(i-1,j)+2(i-1,j+1)+\Phi(i,j+1)\}-\{\Phi(i,j-1)+2\Phi(i+1,j-1)+\Phi(i+1,j)\} \qquad (6)$$

Where Φ (i, j) is the value of the pixel at position (i,j). The magnitude (g) of the gradient is given in (7).

$$g(x,y)=(\Delta1^2+\Delta2^2+\Delta3^2+\Delta4^2)^{1/2} \qquad (7)$$

C. Thresholding

Threshold technique is very important task in edge detection algorithms. The accuracy of an algorithm is dependent on the choice of threshold parameters. One of the foremost criteria of thresholding is that the program should be efficient enough to automatically compute the optimum threshold parameter. The criteria of selection of a parameter for a given image are that the resultant edge map should satisfy the following:

1. It should contain most of the prominent edges;
2. It should not contain too much spurious edges;
3. It should be meaningful and visibly pleasing;

Due to the existence of the weak edge information, the outline of objects in the final edge image is not so evidence. Threshold detection technique is very important task in edge detection [8]. It is important in picture processing to select an adequate threshold of gray level for extracting objects from the background [10]. The proposed method uses a fixed or global threshold value from the histogram data which carries image information, the value of the threshold remains constant throughout the image. Fixed threshold is of the form is given by (8).

$$g(x,y)=\begin{cases}0 & f(x,y)<T\\ 1 & f(x,y)\geq T\end{cases} \qquad (8)$$

Assuming high intensity pixels are of interest and low intensity pixels are not of interest.

Consider the gray level histogram $h_i\{i=0,1,2,3..........N_{g-1}\}$ where N_g is the number of distinct gray levels, if n is the total number of pixels in the region then the normalized histogram is given by H_i $\{i=0,1,2,3.......N_{g-1}\}$ where $H_i=h_i/n$. The proposed method selects the region having highest H_i value. The threshold (T) is calculated using (9) and (10).The obtained threshold value is obtained over the image to get the binary image.

$$Sum = \sum_{i=1}^{N_g} h_i \quad (9)$$

$$T = Sum/N_g \quad (10)$$

D. Edge Thinning

Inorder to remove superior and unwanted edge information a thinning technique is applied to create thinner edges which will be more accurate and visibly soothing. Edge thinning masks which works on binary images in four different directions (0^0,45^0,90^0,135^0) are shown in Fig 3.

$$\begin{bmatrix} 0 & 0 & 0 \\ -2 & 2 & -2 \\ 0 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & -2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 & -2 & 0 \\ 0 & 2 & 0 \\ 0 & -2 & 0 \end{bmatrix} \quad \begin{bmatrix} 0 & 0 & -2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix}$$

Fig. 3. Four edge thinning masks (0^0,45^0, 90^0, 135^0)

III. EXPERIMENTS

Here we have demonstrated our color edge detection algorithm in comparison with some of the existing edge detection techniques and the result is shown in the Fig 4. The experimental results show that the proposed method is better than the existing methods in some cases with much thin edges. The algorithm is implemented for a 250x250 image in RGB color space. Though zerocross operator is giving better results, some of the facial features which are not detected by zerocross operator has detected by proposed method. One of the major disadvantage of canny operator is threshold value must be given manually which consumes lots of time. Proposed method detects threshold value automatically by concentrating the object which occupies major portion of the image, so that the algorithm can be used in real time applications such as lane detection system which is as shown in the Fig 5.

IV. CONCLUSIONS & FUTURE WORK

In this paper we demonstrated a color edge detection method for images in RGB color space. The performance of the proposed method is compared with some of the existing edge detection techniques and shown in Table1. Since the threshold value is based on histogram data the edge of the object which occupies major portion of the image will be detected which will be helpful in applications where background will remain same and foreground changes such as video processing.

Table I- Performance of the existing edge detection methods and proposed method

Techniques	Time Taken(s)
Laplacian	0.27
Prewitt	0.19
Zerocross	0.11
Canny	0.11
Robert	0.10
Proposed Method	0.50

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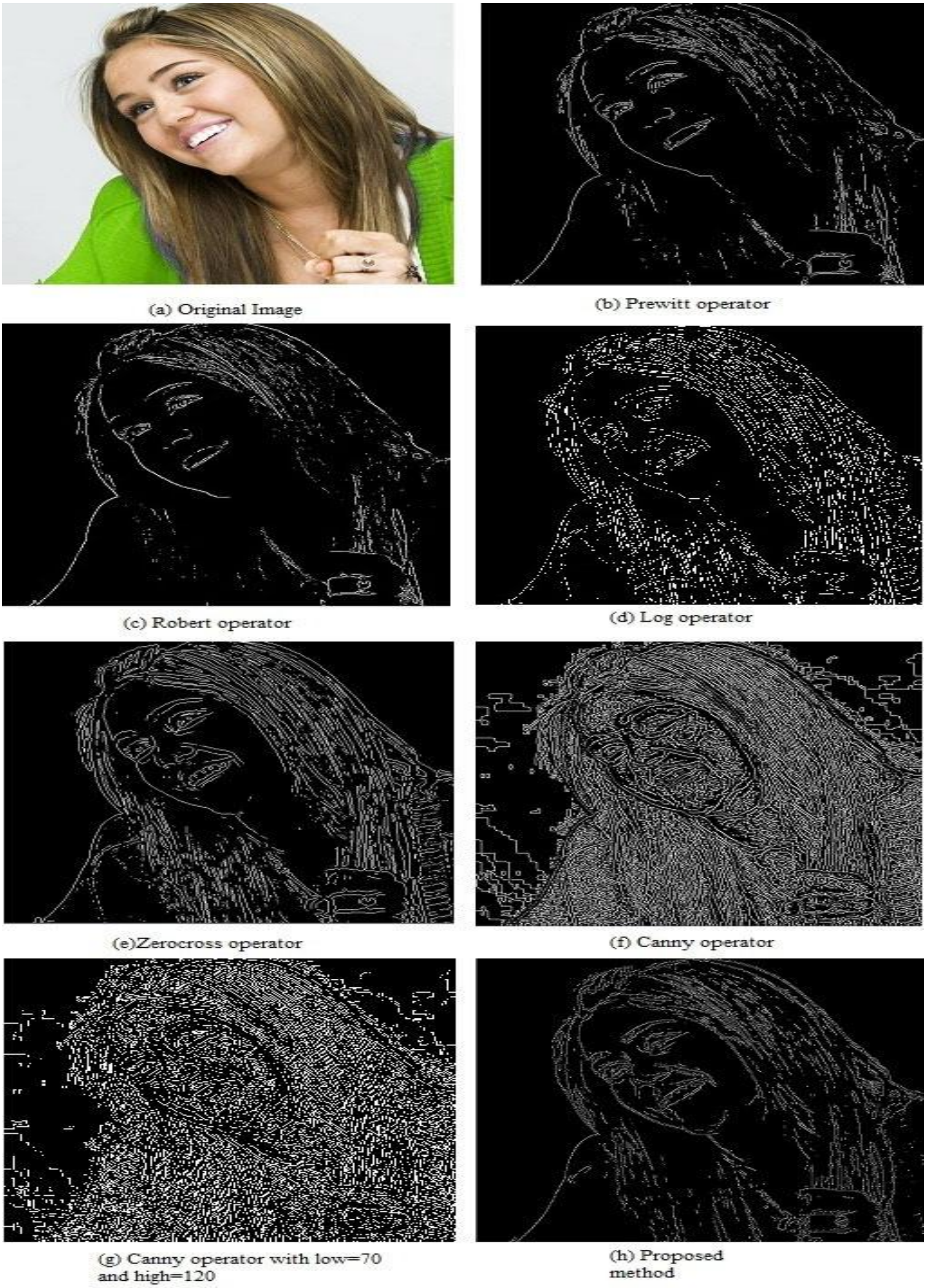
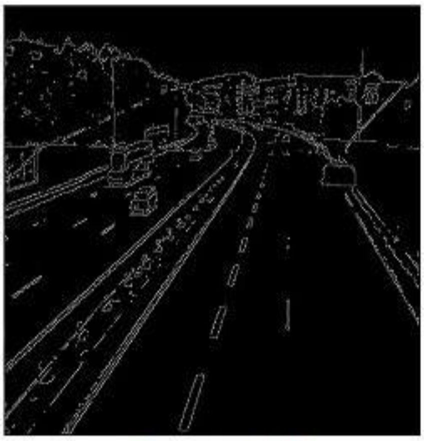
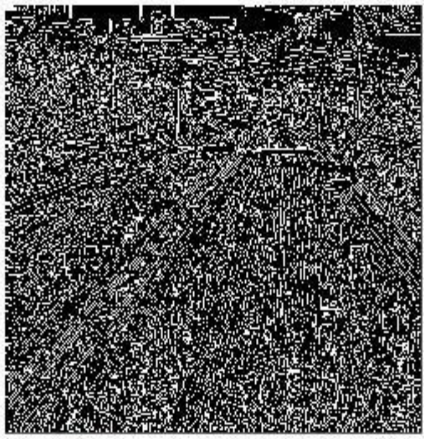


Fig. 4. Comparison of proposed method with existing edge detection techniques

Original image



Proposed method



Canny edge detector with low=70 and high=120

Fig. 5. Results of proposed method and the Canny operator applied to a lane image