

Dynamic Thresholding based Adaptive Canny Edge Detection

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ABSTRACT

In this paper, a method for adaptive Canny edge detection algorithm is proposed. Adaptive Canny algorithm is used to increase the accuracy of output objects. In traditional Canny need to set two threshold values manually, so there are some defects to different images but this paper puts forward an adaptive threshold values based on mean and median values. Our proposed adaptive Canny edge detection method can detect edges successfully which is divided into several steps. First, Gaussian filter is used to smooth and remove noise. Second, gradient magnitude is computed. Third, non-maximum suppression is applied in which the algorithm removes pixels that are not part of an edge. Finally, hysteresis thresholding is applied which uses two threshold values, upper and lower. A pixel will be marked as an edge if its gradient lies in between of lower and upper threshold values. A pixel will be discarded if its gradient below the lower or beyond the upper threshold values. Eventually, the pixels gradient is between the two threshold values will be connected as marked edge. The experimental results show the efficacy of the proposed method.

General Terms

Noise Reduction of Images, Compute Gradient Magnitude and Angle, Non-Maximum Suppression, Hysteresis Thresholding, Adaptive Canny Edge Detection Algorithms

Keywords

Adaptive canny; sobel; dynamic threshold; edge detection

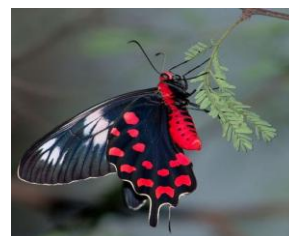
1. INTRODUCTION

Edge detection is a crucial part in object recognition. It is a process of finding sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. In short, the goal of edge detection is to produce a line drawing of the input image. The extracted features are then used by computer vision algorithms, e.g. recognition and tracking [1]. A classical method of edge detection involves the use of operators, a two dimensional filter. An edge in an image occurs when the gradient is greatest. The operator works by identifying these large gradients to find the edges. There are different types of operators designed to detect certain types of edges. The operators can be configured to search for vertical, horizontal, or diagonal edges. Major problem to detect edge is

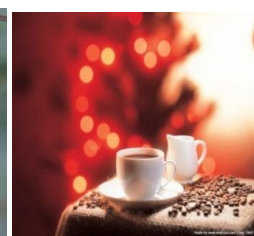
noise. It is not enough to simply reduce the noise, because the image will be either distorted or blurred. Adaptive Canny operator has enough data to discount localized noisy pixels. However, the change in intensity is not always a step change. The intensity change can also be continuous where the operator then has to be modified for proper edge detection. Consequently, there are problems of missing true edges, false edge detection, and high computational time. In this paper, adaptive Canny edge detection algorithm is developed where threshold values are dynamically defined based on mean and median values. Adaptive Canny edge detector performs necessary operation to evaluate adaptive Canny edge detection algorithm to detect edges in X and Y direction. The remainder of the paper is organized as follows. The proposed adaptive Canny edge detection method is described in section II. Evaluation criteria are explained in section III and experimental results are placed in section IV. Finally, mention conclusion in the last section.

2. PROPOSED ADAPTIVE CANNY EDGE DETECTION METHOD

In this paper, a new edge detection method known as adaptive Canny edge detection method is proposed. It is a multi-step process, which can be implemented on the central processing unit (CPU) as a sequence of filters [2]. The proposed edge detection method consists of the following steps. To describe all the steps required to detect edges, the images shown in Fig. 1 are considered.



a) Butterfly



b) Coffee Cup



c) Lena d) Lena-1
Fig. 6. Non-maximum suppressed images

2.4 Hysteresis Thresholding of Adaptive Canny

Some of the edges detected by steps A–C will not actually be valid, but just be noise. We would like to filter this noise out. Eliminating pixels whose gradient magnitude D falls below some threshold removes the worst of this problem, but it introduces a new problem. A simple threshold may actually remove valid parts of a connected edge, leaving a disconnected final edge image. This happens in regions where the edge's gradient magnitude fluctuates between just above and just below the threshold. Hysteresis is one way of solving this problem. Instead of choosing a single threshold, two thresholds t_{high} and t_{low} are used. The adaptive upper and the lower threshold are determined [5, 6, 7, 8,9,10] by using equation (3) and (4):

$$t_{low} = \max(0, (\mu - \sigma)/a) \quad (3)$$

$$t_{high} = \min(A, (\mu + \sigma)/b) \quad (4)$$

Where, μ is the mean value of the normalized probability density function,

σ is the variance of the probability density function,

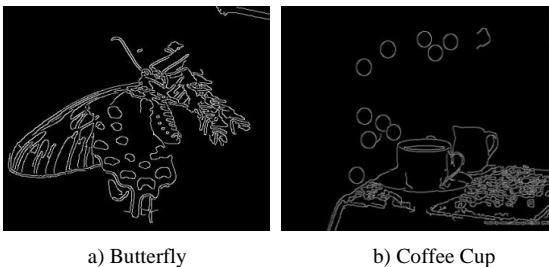
a is a parameter between 5 and 7, preferably 6,

b is a parameter between 2 and 4, preferably 3, and

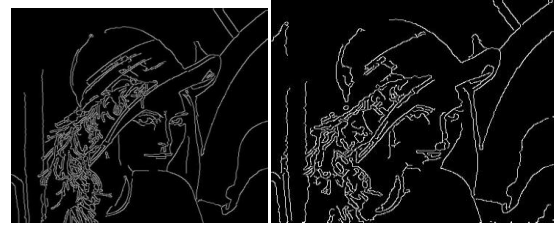
A is the maximum intensity value.

Pixels with a gradient magnitude $D < t_{low}$ or $D > t_{high}$ are discarded immediately. However, pixels with gradient magnitude $D \geq t_{low}$ and $D \leq t_{high}$ are only kept if they form a continuous edge line with pixels with high gradient magnitude (i.e., above t_{high}).

Final edge images after step D is demonstrated in Fig. 7.



a) Butterfly b) Coffee Cup



c) Lena d) Lena-1

Fig. 7. Final result images

Work flow of the proposed adaptive Canny Edge detection method is shown in Fig. 8.

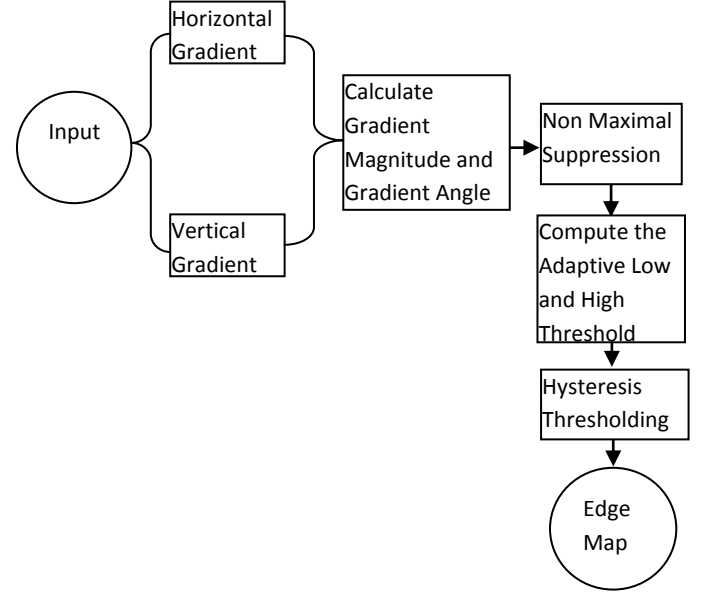


Fig. 8. Basic steps of adaptive Canny algorithm

3. EVALUATION CRITERIA

To evaluate the performance of the proposed adaptive Canny Edge detection method Signal to Noise Ratio (SNR), Mean Square Error (MSE) and Edge Preservation Factor (EPF) parameter are used [11].

Signal to Noise Ratio (SNR):

$$SNR = -10 \log_{10} \left[\frac{\sum_{x=1}^M \sum_{y=1}^N (I_d(x, y) - I(x, y))^2}{\sum_{x=1}^M \sum_{y=1}^N (I_d(x, y))^2} \right] \quad (5)$$

Mean Square Error (MSE):

$$MSE = \left[\frac{1}{M \cdot N} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (I(x, y) - I_d(x, y))^2 \right] \quad (6)$$

Where, the image size is $M \times N$. x means row, y means column, I means original image and I_d means filtered Image.

Edge Preservation Factor (EPF):

$$EPF = \frac{\sum (\Delta I - \overline{\Delta I})(\Delta I_d - \overline{\Delta I_d})}{\sqrt{\sum (\Delta I - \overline{\Delta I})^2 (\Delta I_d - \overline{\Delta I_d})^2}} \quad (7)$$

Where ΔI and ΔI_d are the high pass filtered versions of Images I and I_d obtained with a 3×3 pixel standard approximation of the Laplacian operator. The larger value of EPF means more ability to preserve edges

4. EXPERIMENTAL RESULTS

The proposed algorithm has been applied to 2D image with have been corrupted by noise. The computation is carried out on C#.Net in visual studio 2008 in a Core i5 1.8 GHz and 4GB RAM laptop having a Windows 7 Home Premium operating system. Experiment was done on hundred of images but here four images in 512*512 sizes (e.g. Butterfly, Coffee Cup, Lena, and Lena-1) are mentioned for testing the performance of the proposed algorithm. Moreover, the performance of our proposed method is compared with the Sobel and traditional Canny edge detection method. Table 1 shows SNR, EPF and MSE values of four images (Butterfly, Coffee Cup, Lena, and Lena-1 images) with respect Sobel, traditional Canny and proposed (Adaptive Canny) Methods. Fig. 9 shows comparison graph of SNR with respect of applied methods where it shows that SNR are highest for all four images for the case of proposed method among the all methods.

Table 1. SNR, EPF AND MSE values of experimental images

Operator	Sobel			Canny			Proposed (Adaptive Canny)		
	SNR	EPF	MSE	SNR	EPF	MSE	SNR	EPF	MSE
Image									
Butterfly	17.45 6	0.41 5	6.43 5	18.17 5	0.52 7	6.63 2	19.91 6	0.65 5	5.12 3
Coffee Cup	17.87 3	0.39 1	6.33 2	18.19 2	0.43 9	6.10 8	19.99 8	0.53 2	5.00 8
Lena	22.40 4	0.45 3	5.30 4	22.52 3	0.53 2	4.80 8	23.87 2	0.68 1	4.13 6
Lena-1	22.56 7	0.48 2	5.31 2	22.63 2	0.54 8	4.85 8	23.91 4	0.68 7	4.13 5

Fig. 10 show the larger value of EPF means more ability to preserve edges. Finally, Fig. 11 shows the result of MSE, where MSE are lowest for the case of proposed method.

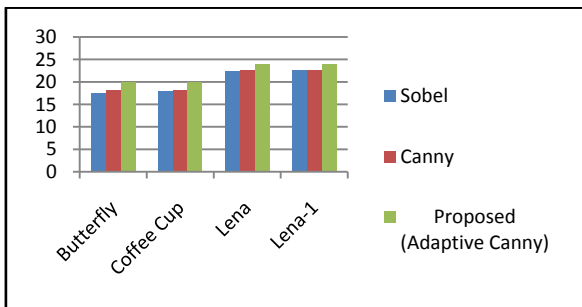


Fig. 9. Comparison of SNR of experimental images.

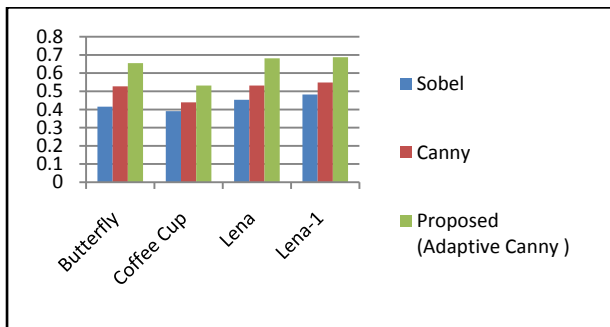


Fig. 10. Comparison of EPF of experimental images.

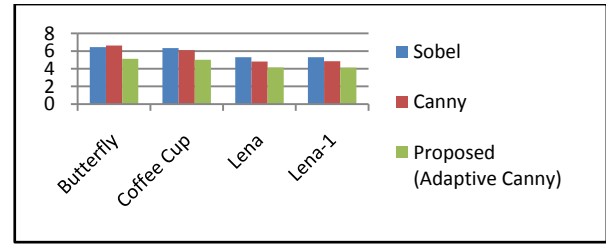


Fig. 11. Comparison of MSE of experimental images.

5. CONCLUSION

In this paper an effective method for edge detection via dynamic thresholds of adaptive Canny algorithms. The edge detection is the primary task in identifying an object from an image, it is vitally important to know the advantages and disadvantages of each edge detection filters. This is a novel edge-detection algorithm is to provide an errorless solution that is adaptable to the different noise levels of these images to help in identifying the valid image contents. This work has been done for the edge detection techniques of the Gradient-based. The edge detection techniques are compared with case study of identifying a different type of image. The software was implemented using C#. Gradient-based algorithms have major drawbacks in sensitive to noise. Adaptive Canny operator can be applied to different situations for detect the edge clearly. In order to improve its performance, we propose the calculation of gradient magnitude and gradient direction based on 8 neighborhoods, and makes the adaptive calculation of the threshold of adaptive Canny operator. The experimental results show that the edge detected by the improved Canny operator has more continuity, and greater signal to noise ratio.

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