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CANNY SCALE EDGE DETECTION

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Abstract—Edge detection is an essential step in digital image processing and image segmentation. Digital image processing is one of the significant tool in image processing and computer vision. Edge is nothing but an abrupt change in the intensity values of the image. Edge is an elementary feature of image, contains rich information which plays a vital role for obtaining the characteristics of image and also useful in object recognition. Edge describes boundaries of actual image and which is a fundamental problem in image segmentation. Detecting an edge in image reduces the amount of data and screens out unwanted information, while keeping the important properties of an image. Canny edge detection algorithm is one of the optimal edge detectors. In this paper, scaled canny edge detector and logical OR operation is used for detection of edges in the image. It has been shown that the scaled canny edge detection performs better than all the other edge detection operators. Canny edge detector gives good edge detection and good edge localization.

Keywords—*Edge, Segmentation, Canny operator, Edge Detection and Localization.*

I. INTRODUCTION

A fundamental task in application of computer vision is the edge detection[1] since from the early 1970's. Edge detection is an important pre-processing step for tasks including segmentation, active contours and object recognition. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The abrupt changes in pixel intensities characterizes the boundaries[2] of objects in an image. Classical edge detection methods[3] uses the convolution on the spatial domain of the image with an operator. An operator (a 2-D filter) is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. Large number of edge detection operators[4] available each operator is designed to be detection of certain type of edges[3]. Edge orientation, noise and edge structure determine the choice of edge detection operator. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be used to look for horizontal, vertical or diagonal edges. In noisy images detection of edge[5] is a difficult task, since both the edges and noise contain high frequency content. Reduction of noise results distorted and blurred images. Edge detectors for noisy images can average enough data to minimize localized noisy pixels. This results in a reduced amount of accurate localization of the detected edges. Due to noise, there are problems of edge localization, high computational time, missing true edges and false edge detection will occur.

Many methods are available for detection of edges[1]. Edge detection operators are grouped into two categories Gradient based and Laplacian based. Differentiation of image [6] is the most common edge detection method. Gradient operators use first-order derivatives of the image by looking for the maximum and minimum. Laplacian operators[7] searches for zero crossings in the second-order derivatives of the image to find edges.

A. Fist-Order Derivative of Edge Detection is computed as follows:

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \qquad (1)$$

Magnitude of the vector is the important quantity in edge detection, denoted with ∇f, Where

$$\nabla f = |\nabla f| = \sqrt{G_x^2 + G_y^2} \qquad (2)$$

Direction of the gradient vector is another important quantity of edge. That is,

$$angle\,of\,\nabla f = \tan^{-1}\left(\frac{G_x}{G_y}\right) \qquad (3)$$

at every pixel location partial derivative of $\partial f/\partial x$ and $\partial f/\partial y$ are computed for calculation of gradient of an image.

B. Second-Order Derivative Edge Detection

The Second-order derivative, the Laplacian of a 2-D function f(*x,y*) is computed as follows.

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (4)$$

Smoothing is usually combined with a Laplacian as a precursor to finding edges via zero crossings. The 2-D Gaussian function

$$h(x, y) = e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (5)$$

Where σ is the standard deviation, which determines the degree of blurring in the image. The Laplacian of h is defined as

$$\nabla^2 h(x, y) = -\left[\frac{x^2+y^2-2\sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}} \qquad (6)$$

The above function is also referred to as the Laplacian of Gaussian (LOG).

$$LOG(x, y) = -\frac{1}{\pi\sigma^4}\left(1 - \frac{x^2+y^2}{2\sigma^2}\right) e^{-\frac{x^2+y^2}{2\sigma^2}} \quad (7)$$
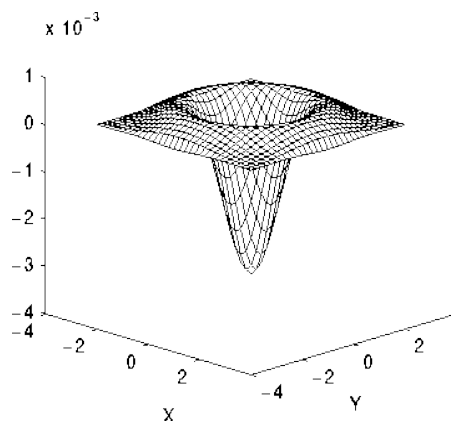

Fig. 1Dimension coordinates of Laplacian of Gaussian (LOG).

After calculating the two-dimensional second-order derivative of an image, we find the value of a point which is greater than a specified threshold and one of its neighbours is less than the negative of the threshold. The property of this point is called zero-crossing and we can denote it as an edge point.

After finding the two-dimensional second-order derivative of an image, next find the value of a point that is greater than a specified threshold and one of its neighbours is less than the negative of the threshold. This point is called the zero-crossing and it is considered an edge point.

II. CANNY EDGE DETECTION ALGORITHM

Edge detection[3], particularly step edge detection is an important technique to extract structural information and considerably reduces the amount of data to be processed. John F. Canny in 1986 developed a Canny Edge detector[8], also known as optimal detector, Canny edge detector aims to satisfy the three general criteria of edge detection[9].

1. Low error rate- which means that it detects only existent edges.
2. Good localization- The difference between real edge pixels and the detected edge pixels have to be minimized.
3. Minimal response- the detected edge should marked only once not many times.

The steps of the Canny edge detection are as follows:
1. Remove any noise using a filter. Gaussian filter[10] is used for removing the noise. An example of Gaussian kernel filter of size 5 is

$$K = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \qquad (8)$$

2. Find the gradient of the image.
 a. Gradient along x, and y directions are calculated using the convolution masks of 3x3 as follows.

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} \qquad (9)$$

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} \qquad (10)$$

 b. Gradient strength and direction of the edges are calculated as follows:

$$G = \sqrt{G_x^2 + G_y^2} \qquad (11)$$

$$\theta = \arctan\left(\frac{G_y}{G_x}\right) \qquad (12)$$

Here G_x and G_y are gradients along x and y directions.
3. Non-maximum suppression is performed. This step removes pixels which are not considered as part of an edge. Only thin lines will remain, these contain pixels which are considered to be part of an edge.
4. Hysteresis- The final step, two thresholds are used named as upper and lower.
 a. If the gradient value of a pixel is higher than the upper threshold, then the pixel is considered as an edge pixel.
 b. If the gradient value of a pixel is less than the lower threshold, then the pixel is rejected.
 c. If the gradient value of the pixel is between the lower and upper thresholds, then the pixel will be accepted only if it is connected to a pixel that is above the upper threshold.

III. CANNY SCALE EDGE DETECTION METHOD

In the proposed Canny scale edge detection approach, image is resized with the help of scaling. Scaling is a insignificant process which involves a trade-off between effectiveness, softness and sharpness. Scaling is of two types standard and automatic. In standard the threshold has been decided manually. Where as in automatic threshold has been decided depending on the factors that are influencing the image. In the proposed method standard threshold has been used as a parameter for effective edge detection with scale down process using Canny edge detection method.

At first, the Canny edge detection and scaling of pixels are used, and then edge linking is performed with the logical operations, consisting the following steps:

1) Read the image.
2) Convert RGB image into gray scale image, if it is a RGB color image.
3) Scale down the pixel values of the image with multiples of 16 starts from 32 to 128.
4) Find the edge image by applying canny edge detector for each scale.

5) Perform logical OR operation for edge linking.

The above approach will detect the edges accurately which are not seen from canny edge detection.
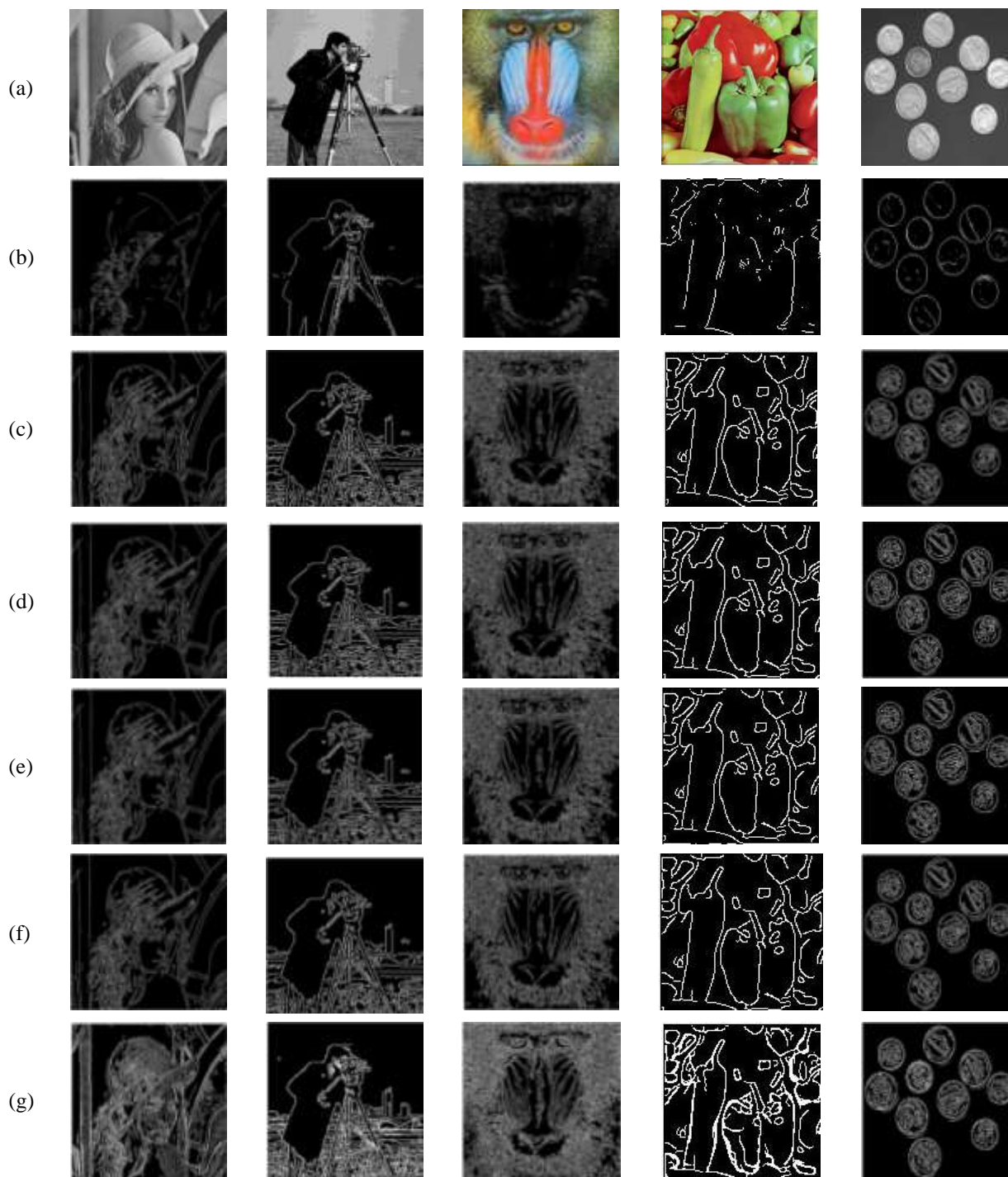

Fig. 2.(a): original image; (b): detected edges using Sobel method; (c): detected edges using Prewitt method; (d): detected edges using Roberts method; (e): detected edges using LOG method; (f): detected edges using Canny method; (g): detected edges using proposed method.

IV. EXPERIMENTAL RESULTS

The proposed method has been simulated using MATLAB. The input images are considered to be of .bmp, .png, and .tif. Other types of images may also be considered. The precision is assumed to be 8 i.e. the number of bits per pixel is 8.Different sizes of image files have been tested using various edge detection methods. Comparison of edge maps, obtained by a various edge detectors is shown in figure 2. The proposed method is giving the better result comparison with Sobel, Roberts, Prewitt, LOG, and Canny edge detection operators.

V. CONCLUSION

Edge detection is an important task in image segmentation for object recognition. Edge contains elementary features of an image and also describe boundary of the image. Canny Edge detector is the optimized edge detector and it aims to satisfy the general criteria of edge detection. Proposed method uses both Canny edge detector and scale down method for edge detection. The results shows that edges are accurately identified in the proposed method and showing more edges which are not seen from Canny edge detection. It can be further extended with automatic scaling for all kinds of images. The thick edges needs to be sharpened to achieve better edge detection.

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