

A Review on: Comparison and Analysis of Edge Detection Techniques

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ABSTRACT - The author has tried to compare the different edge detection techniques on real images in the presence of noise and then calculating the signal to noise ratio. Edge detection is a tool which is used in shape, colour, contrast detection, image segmentation and scene analysis etc. Edge detection of Image which provides the information related to the intensity changes at a point of an image. In this paper the comparison of various edge detection techniques and the visual performance analysis of the various techniques in noisy conditions is performed by using the different methods such as, Canny, LoG (Laplacian of Gaussian), Robert, Prewitt, Sobel, Laplacian and wavelet. These methods exhibit the different performance under such conditions respectively.

Keywords—Edge detection, image processing.

INTRODUCTION

The Edges can be defined if there are significant local changes of intensity at a point in an image and these can be formed by connecting the groups of pixels which takes place on the boundary between two different regions in an image. The first derivative is used to consider a local maximum at the point of an edge. The gradient magnitude is used to measure the intensity changes at a particular point of edge. It can be expressed in other two terms such as: the gradient magnitude and the gradient orientation.

In other the objective which is used for the comparison of various edge detection techniques and to analyse the performance of the various techniques in different conditions. There are different methods which are used to perform edge detection. Thus the majority of different methods may be grouped into two categories [1]. The different methods are used for the edge detection but in this paper only 1D and 2D edge detection techniques are used.

EDGE DETECTION TECHNIQUES

Sobel Operator

It was invented by the Sobel Irwin Edward in 1970. It is the operator which consists of pair 3×3 convolution kernels as shown in Figure1. One kernel is simply the other one rotated by 90° . The convolutional kernel provides the way to multiply two array of numbers of different sizes but of the same dimensionality. This can be used to implement the operators in digital image processing where output pixel values are simple linear combinations of certain input pixel values. Thus this kernel is a smallest matrix of numbers that is used in image convolutions. Different sized kernels contain the different patterns of numbers that give rise to different results under convolution. Convolution is done by moving the kernel across the frame one pixel at a time. As each pixel and its neighbours are weighted by the corresponding value in the kernel and summed to produce a new value. The G_x and G_y of the gradient is calculated by subtracting the upper row to lower row and left column to right column. The gradient magnitude is given by:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

Typically, an approximate magnitude is computed using:

| | | |
|----|---|----|
| -1 | 0 | +1 |
| -1 | 0 | +1 |
| -1 | 0 | +1 |

G_x

| | | |
|----|----|----|
| +1 | +1 | +1 |
| 0 | 0 | 0 |
| -1 | -1 | -1 |

G_y

Fig1: Sobel convolution kernels

$$|G| = |G_x| + |G_y|$$

This is much faster to compute. It is used to detect the thicker edges only such as horizontal and vertical gradients. It is not used to detect the diagonal edges of any image. Kernels are designed to respond maximally to running vertical and horizontally relative to the pixel grid. In other 0 is taken to show the maximum contrast from black to white. The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image[1]. The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(G_y/G_x)$$

Robert's cross operator: It was invented by Robert Lawrence Gilman scientist in 1965. This type of detector is very sensitive to the noise. It is based on pixels. The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It highlights the regions of high spatial frequency which often correspond to edges.

| | |
|----|----|
| +1 | 0 |
| 0 | -1 |

G_x

| | |
|----|----|
| 0 | +1 |
| -1 | 0 |

G_y

Fig2: Roberts cross convolution kernels

In its most common usage the input to the operator is a grayscale image. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The operator consists of a pair of 2x2 convolution kernels. In which only addition and subtraction takes place. One kernel is simply the other rotated by 90°. This is

very similar to the Sobel operator. In this detector the parameters are fixed which cannot be changed. Convolution is done by moving the kernel across the frame one pixel at a time. At each pixel and its neighbours are weighted by the corresponding value in the kernel and summed to produce a new value. Thus the G_x and G_y of the gradient is calculated by subtracting the upper row to lower row and left column to right column. The gradient magnitude is given such as:

$$|G| = \sqrt{G_x^2 + G_y^2}$$

The angle of orientation of the edge giving $\theta = \arctan(G_y / G_x) - 3\pi / 4$

Rise to the spatial gradient (relative to the pixel grid orientation) [2].

PREWITT'S OPERATOR:

It was discovered in 1970 by Judith M. S. Prewitt. It is similar to the Sobel edge detector but having different Masks than the Sobel detector. It is proved that Prewitt is less sensitive as compared to the Roberts edge detector. It is used in Image processing for edge detection [3].

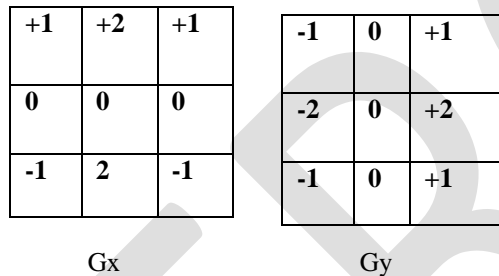


Fig.3:Masks for the Prewitt edge detector

The Prewitt operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and it is inexpensive in terms of computations. Convolution is done by moving the kernel across the frame one pixel at a time. As each pixel and its neighbours are weighted by the corresponding value in the kernel and summed to produce a new value. Thus the G_x and G_y of the gradient is calculated by subtracting the upper row to lower row and left column to right column. It is used to calculate the gradient of the image intensity at each point and giving the direction of the largest possible increase from light to dark and the rate of change in that direction. The obtained results show how abruptly or smoothly the image changes at that point.

LAPLACIAN OF GAUSSIAN:

It was discovered by David Marr and Ellen C.Hildreth. It is the combination of laplacian and Gaussian. The image is smoothed to a greater extent. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection (zero crossing edge detectors). Second order derivative also known to be as Marr-Hildreth edge detector. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise and the two variants will be described together here. The operator normally takes a single grey level image as input and produces another grey level image as output. The Laplacian of an image highlights regions of rapid intensity change and is often used for edge detection [4]. This pre-processing step reduces the high frequency noise components prior to the differentiation step. x is the distance from the origin in the horizontal axis and y represents the distance from the origin in the vertical axis. σ is the spread of

the Gaussian and controls the degree of smoothing. Greater the value of σ broader is the Gaussian filter, more is the smoothing. Two commonly used small kernels are shown in Figure 4.

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

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 8 | 1 |
| 1 | 1 | 1 |

| | | |
|----|----|----|
| -1 | -2 | -1 |
| 2 | -4 | -2 |
| -1 | 2 | -1 |

Fig.4:Three commonly used discrete approximations to the laplacian filter [5-9].

CANNY EDGE DETECTOR

The Canny operator was designed to be an optimal edge detector. It was invented by canny john F.in 1986.In other the input is provided in the form of grey scale image and then it produces the output of an image which is showing the positions of tracked intensity discontinuities. The Canny operator was designed to be an optimal edge detector .It is taking an input as a grey scale image and produces the output of an image showing the positions of tracked intensity discontinuities

WORKING:

It uses the maximum and minimum thresholds and if the magnitude is between the two thresholds then it could be set to zero unless there is a path from this pixel to a pixel with a gradient above T2. Edge strength can be found out by taking the gradient of the image .The mask which is used for the canny edge detector can be a sobel or Robert mask [10-12]. The magnitude or edge strength of the gradient is approximated by using the formula such as:

$$|G| = |G_x| + |G_y|$$

The formula which is used to find the edge direction such as:

$$\text{Theta} = \text{invtan} (G_y / G_x)$$

Convolution is done by moving the kernel across the frame one pixel at a time. At each pixel and its neighbours are weighted by the corresponding value in the kernel and summed to produce a new value.

LAPLACIAN EDGE DETECTION METHOD:

The Laplacian method searches the zero values than those surrounding it. The Laplace operator is named after the French mathematician Pierre-simon de Laplace (1749-1827).In other the Zero crossings in the second derivative of the image which are used to find edges.

$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

To remove the noise [13]. The Laplacian $L(x, y)$ of an image with pixel intensity values $I(x, y)$ is given by:

| | | |
|---|----|---|
| 0 | 1 | 0 |
| 1 | -4 | 1 |
| 0 | 1 | 0 |

Fig. 5:Mask of Laplacian

HAAR WAVELET:

It was invented by Haar Alfred in 1910. Wavelet is the combination of small waves. When it is applied to the image then it provides the approximation and detail coefficient information of the image. Detail a coefficient which contains high frequency information is only used to detect the edges and the approximation coefficients contains the low frequency information. It decomposes the discrete signal into sub-signals of half its length, one signal is running average and the other sub-signal is running difference. There are also other types of waveforms but the Haar wavelet is the origin of other wavelets. It is also used as an edge detection method. Haar wavelet consists the rapid fluctuations between the just non-zero values and with an average value of 0. Reasons for introducing the 1 level Haar wavelet represents the 1 level fluctuations [12].

ADVANTAGES AND DISADVANTAGES OF EDGE DETECTOR:

Edge detection is an important tool which is providing the important information related to the shape, colour, size etc. To find out the true edges to get the better results from the matching process. That's why it is necessary to take the edge detector that fit best to the application [14-21].

TABLE 1: ADVANTAGES AND DISADVANTAGES OF EDGE DETECTORS

| Operator | Advantages | Disadvantages |
|---|--|--|
| Classical(Sobel, Prewitt, Robert...) | Simplicity and easy to implement. Detection of edges and their directions. | These are sensitive to noise, Inaccurate |
| Zero Crossing(Laplacian, Second directional derivative) | These are used to Detect the edges and their directionality. Thus there is a fixed characteristics in all directions | These operators are used to Respond some of the Existing edges. |
| Laplacian of Gaussian (LoG) (Marr-Hildreth) | It is used to find the correct places of edges, Testing broad area around the pixel .Emphasizes the pixels at the place where intensity changes takes place. | Malfunctioning takes place at the corners, curves and where the grey level intensity function varies. Not finding the direction of edge because of using the Laplacian filter. |
| Gaussian(Canny) | It is Using a probability for finding error rate, Localization and response. Improving signal to noise ratio. It is providing a Better detection specially in noisy conditions | Complex to Compute, False zero crossing. It is a Time consuming. |

Comparison of various edge detection techniques

Edge detection of all seven types was performed as in fig. 6.Prewitt provided the better results as compared to the other methods. On the noisy imagescannot provide the better result



Fig. 6: Comparison of edge Detection techniques on the college image

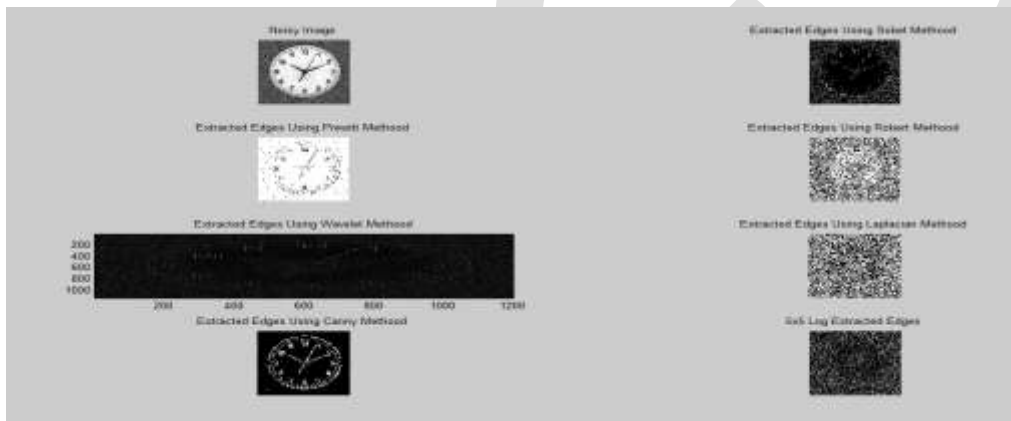


Fig. 8: comparison of edge detection techniques on noisy clock image.

CONCLUSION

1D edge detection method involves the methods such as: Sobel, Prewitt and Roberts edge detectors and the 2D edge detection involves the methods such as: Laplacian, Laplacian of Gaussian, optimal edge detector and wavelets are used to find the optimum edge detector technique. Results on the college image in which the horizontal, vertical and diagonal edges are properly detected by using the Prewitt edge detector. The LOG and Canny also providing the better results even on the low quality images than the other methods. In other the results on the noisy clock images are better obtained by using Canny edge detector than the other methods. Different detectors are useful for different quality of the images. In the future use the hybrid techniques can be used for better results.

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