STATISTICAL PERFORMANCE BASED ON DIFFERENT EDGE DETECTION TECHNIQUES

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ABSTRACT

Paper is concerned with the study of various edge detection techniques like Prewitt, Robert and Sobel on various images to detect edges and extract its data statistics. Edge detection is a name for set of mathematical methods which aim at identifying point in digital image at which image brightness changes sharply or more formally has discontinuities. Edge detection refers to the process of identifying and locating stridently discontinuities in an image. Hence edge detection is vital step in image analysis and it is the key of solving many difficult problems. In this paper we show the performance analysis of edge detection techniques.

Keywords: Edge Thinning, Convolution, Gradient

I. INTRODUCTION TO EDGE DETECTION

Edge detection is a decisive step in the computer vision and object recognition, because the most fundamental trait for image recognition is the edges of an image [12]. Detection of edges for an image may help for image segmentation, data compression, and also support for image reconstruction and so on. Edge detection is a vital tool in image processing, machine vision and computer vision, mostly in the areas of feature detection and feature extraction. Edges are major local changes of strength in an image. Edges typically happen on the boundary between two different regions in an image. The purpose of edge detection is significantly reducing the amount of data in an image and preserves the structural properties for further image processing. The edge in a grey level image is a local feature that, within a neighborhood separates regions in each of which the gray level is more or less uniform with in different values on the two sides of the edge. For a noisy image edges detection is difficult as both edge and noise contains high frequency filling which results in blurred and distorted result [4]. Edge detection is one of the most frequently used operations in image analysis. If the edges of images could be recognized exactly, all of the objects can be located efficiently and performance can be measured easily [10]. The quality of image is affected when there is an jump in intensity from one pixels to the another. Thus important objective is to detect an edge while preserving the important structural properties of an image. In order to analyze various edge detection techniques, comparative analysis of these techniques based on certain parameters like type of edge, edge localization, environment, cost, role etc. are discussed.

Edge detection converts a 2D image into a set of curves, Extracts salient features of the scene, more compact than pixels.

1.1 Goals of Edge Detection

- Produce a line drawing of a sight from an image of that scene.
- Important features can be extract from the edges of an image (e.g., corners, lines, curves).
- These features are used by higher-level computer vision algorithms (e.g., recognition).

1.2 Applications of Edge Detection

Edge detection is an important image processing technique with wide range of applications. Several edge detection algorithms have been developed in the past few years, though no single algorithm is appropriate for all application type of applications of edge detection. One of the main use of edge detection techniques is in the process of image segmentation and object detection [5].

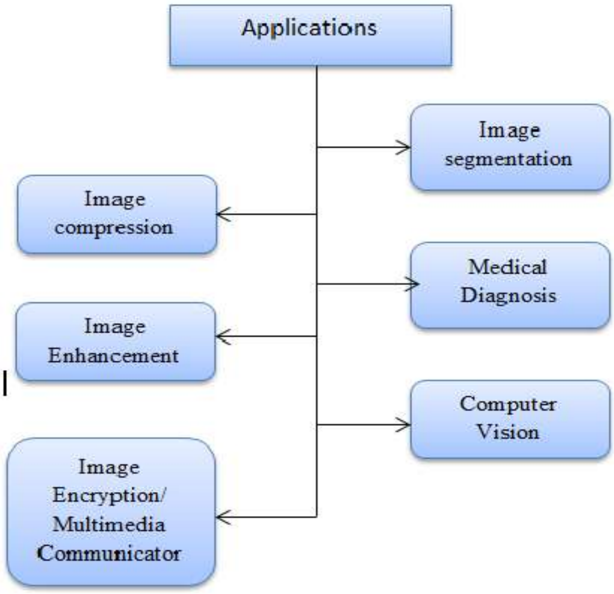


Fig. 1 Applications of Edge Detector

1.3 Edge Detection Methodologies

Edge detection makes use of differential operators to detect changes in the grey levels gradients. It is distributed into two main classes:

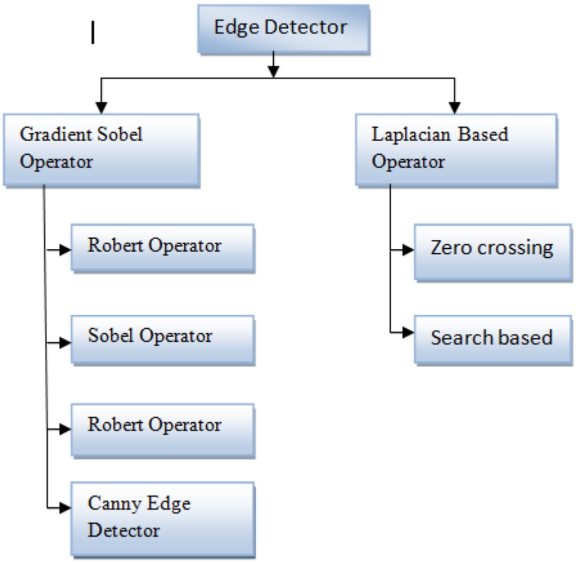


Fig. 2. Edge Detection Methods

The entire paper is organized in the following sequence. Section -1 had the brief introduction of edge detection, which includes goals, applications and methodologies of edge detection. Section -2 explains steps of edge detection; Section -3 states the types of edges. In section -4 Robert, Prewitt and Sobel edge detection techniques are stated. Section -5 shows the result. Lastly, Section -6 ends with conclusion and future work.

II. STEPS OF EDGE DETECTION

Edge detection consists of following four steps.

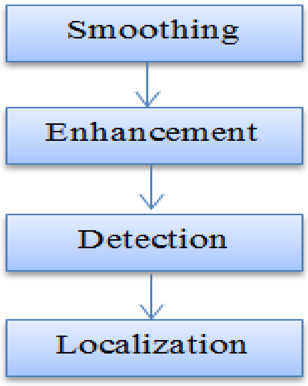


Fig. 3 Applications of Edge Detector

A. Smoothing

Conquer as much noise as possible without terminating the true edges.

A. Enhancement

Apply a filter to enhance quality of images (sharpening).

B. Detection

Determine which edge pixel should be discarded as noise and which should be retained (usually thresh holding provides the criterion used for detection).

C. Localization

Determine the exact location of an edge (Sub pixel resolution might be applicable for some applications,i.e, estimate the edge location to better then the spacing among pixels). Edge thinning and networking are usually required in this step.

III. TYPES OF EDGES

Changes in intensity can occur due to various physical actions like discontinuity in object boundary, surface direction and in geometry changes in intensity [7]. Edges can be shaped according to their amplitude changes as follows:

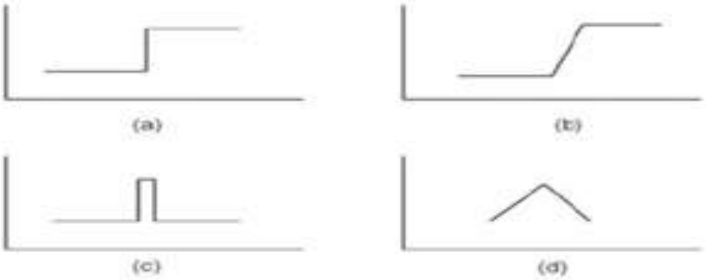


Fig. 4 Different Types of Edges

A. Step Edge

The image intensity suddenly differs from one value to one side of the breakage to a different value on the other side.

B. Ramp Edge

When the intensity change is not natural and seems over a limited distance then step edges become ramp edges.

C. Ridge/Line Edge

The intensity of an image rapidly changes values and then returns to the initial point within short distance.

D. Roof Edge

When the intensity change is not spontaneous and appears over a finite distance usually generated by connectivity of surfaces then line edges become roof edges [7].

IV. TECHNIQUES FOR EDGE DETECTION

4.1 Robert's Cross Edge Detection

Define Roberts edge detection method is one of the oldest methods and is used often in hardware implementations where simplicity and speed are dominant factors. Robert's edge detection operator is based on the principle that difference on any pair of mutually perpendicular direction can be used to calculate the gradient [10].

The Robert's cross operator is used in image processing and computer vision for edge detection. It was one of the first detectors of edge and was initially proposed by Lawrence Roberts in 1963. As a differential operator, the idea behind the Roberts cross operator is to approximate the gradient of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels.

In order to perform edge detection with the Roberts operator we first convolve the original image, with the following two kernels:

$$\begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \; and \; \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix}$$

Let $I(x,y)$ be a point in the original image and $G_x(x,y)$ be a point in an image formed by convolving with the first kernal and $G_y(x,y)$ be a point in an image formed by convolving with the second kernal.

The gradient can then be defined as:

$$\nabla I(x,y) = G(x,y) = \sqrt{G_x^2 + G_y^2}$$

The gradient direction can also be defined as follows:

$$\theta(x,y) = arctan\left(\frac{G_y(x,y)}{G_x(x,y)}\right)$$

4.2 Prewitt Edge Detection

Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images.

The Prewitt operator is used in image processing, mostly within edge detection techniques. Technically, I is a discrete differentiation operator, estimate the gradient of the image intensity function. At all points, the result of the Prewitt operator is either the consistent gradient vector or the custom of this vector. The Prewitt operator is depends upon convolving the image with a small, discrete and integer valued filter in parallel and perpendicular directions and is therefore relatively inexpensive in terms of computations.

The Prewitt edge detector is a suitable way to estimate the magnitude and alignment of an edge. Though differential gradient edge detection needs a rather time consuming calculation to estimate the coordination from the magnitudes in the x- and y-directions, the Prewitt edge detection gain the orientation directly from the kernel with the maximum response [10].

Mathematically, the operator uses two 3x3 kernels which are convolved with the original image to calculate estimates of the derivatives – one for parallel changes, and one for perpendicular. If we define A as the source image, and G_x and G_y are two images which contain the horizontal and vertical derivative estimates, the latters are calculated as:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} * A \text{ and } G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} * A$$

Where * denotes the 2-dimensional convolution operation. Since the Prewitt kernels can be decomposed as the products of an averaging and a differentiation kernel, the compute the gradient with leveling. Therefore it is a separate filter. For example, G_x can be written as:

$$\begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & 1 \end{bmatrix}$$

The x- coordinate is well-defined here as growing in the “right” –direction, and the y-coordinate is well-defined as growing in the “down”- direction. At each point in the image, the resultant gradient approximations can be combined to give the gradient rule, by:

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

Using this information, we can also calculate the gradient's direction:

$$\theta = atan2\left(G_y, G_x\right)$$

Where, for example, Θ is 0 for a perpendicular edge which is obscurer on the right side.

4.3 Sobel Edge Detection

The Sobel operator, sometimes entitled Sobel Filter, that is used in image processing and computer vision, for the most part inside edge detection algorithms, and creates an image which emphasize edges and transitions.

Sobel method is practical to detection an edge. The Sobel edge detector uses two covers with 3x3 sizes, one estimating the gradient in the x-direction and the other estimating the gradient in the y-direction. The cover is slid over the image, using a square of pixels at a time. The algorithm estimates the gradient of the intensity of the image at all point, and then provides the direction to the growth of the image intensity at all point from light to dark. Edges areas represent strong intensity contrasts which are darker or brighter [5].

The maximum value of two convolutions will be referred as output value of the exchanging point. Sobel operator is easy to accomplish in space, has a smoothing effect on the noise, is nearly affected by noise, can provide more accurate edge direction information but it will also detect many false edges with coarse edge width [3].

-1	-2	-1
0	0	0
1	2	1

-2	0	2
-2	0	2
-1	2	1

Fig. 5 Sobel Operator

The operator uses two 3x3 kernels which are convolved with the original image to calculate approximations of the derivatives – one for parallel changes, and one for perpendicular. If we describe A as the source image, and G_x and G_y are two images which at all point contain the parallel and perpendicular derivative estimates, the calculations are as follows:

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * A \text{ and } G_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * A$$

Where $*$ signifies the 2-dimensional convolution operation.

Then the products of an averaging and differentiation Kernel decomposed by Sobel kernels they compute the gradient with leveling.

For example, G_x can be written as

$$\begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \\ 1 \end{bmatrix} \begin{bmatrix} -1 & 0 & +1 \end{bmatrix}$$

The X-coordinate is well-defined here as growing in the “right” –direction, and the Y-coordinate is well-defined as growing in the “down” –direction. At all point in the image, the resultant gradient estimates can be combined to provide the gradient rule, by:

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

Using this information, we can also calculate the gradient’s direction:

$$\theta = atan2(G_y, G_x)$$

Where, for example, **Θ** is 0 for a perpendicular edge which is brighter on the right side.

The edge detection methods that have been published mainly differ in the types of smoothing filters that are applied and the way the measures of edge strength are calculated. As many edge detection methods depend on the calculation of image gradients, they also vary in the types of filters used for calculating gradient estimates in the x- and y-directions.

V. RESULTS

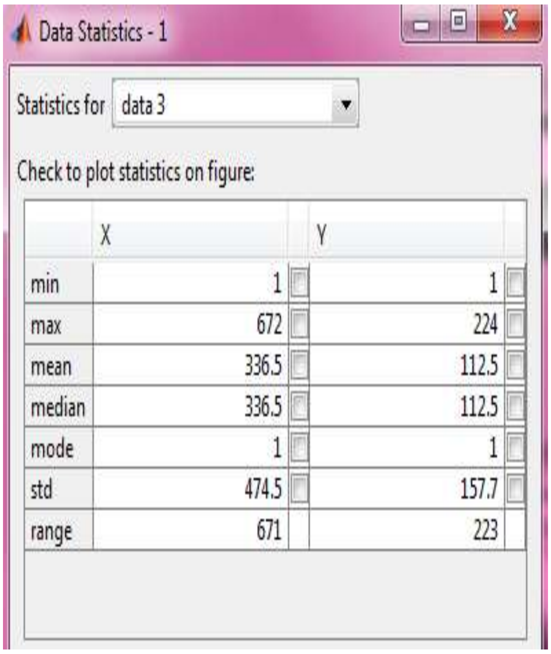
Figure below shows the original image on which different edge detection techniques are applied to detect the edges and find out the discontinuities in the image.

Fig 7 Original Image

5.1 Robert's Cross Edge Detection

Here we show the edge detected and data statistics obtained from Robert's cross Edge Detection method.

Fig 8 Edge Detected by Robert's Method



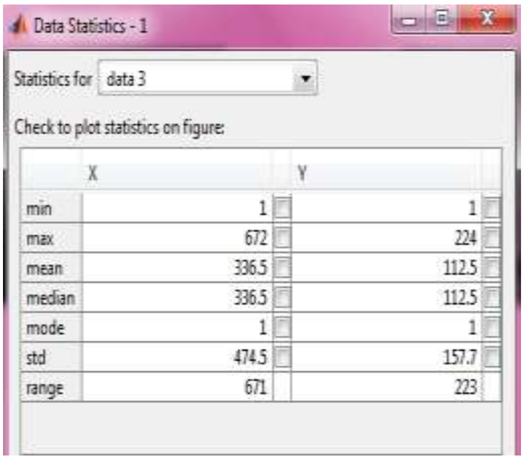
	X	Y
min	1	1
max	672	224
mean	336.5	112.5
median	336.5	112.5
mode	1	1
std	474.5	157.7
range	671	223

Fig 9 Data Statistics Obtained by Robert's Method

5.2 Prewitt Edge Detection

Here we show the edge detected and data statistics obtained from Prewitt Edge Detection method.

Fig 10 Edge Detected By Prewitt Method



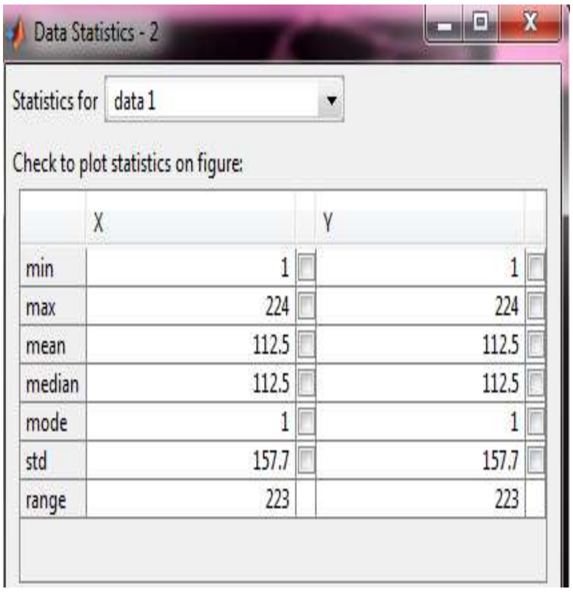
	X	Y
min	1	1
max	672	224
mean	336.5	112.5
median	336.5	112.5
mode	1	1
std	474.5	157.7
range	671	223

Fig. 11. Data Statistics Obtained by Prewitt's Method

5.3 Sobel Edge Detection

Here we show the edge detected and data statistics obtained from Sobel Edge Detection method.

Fig. 12 Edge Detected By Sobel Method



	X	Y
min	1	1
max	224	224
mean	112.5	112.5
median	112.5	112.5
mode	1	1
std	157.7	157.7
range	223	223

Fig. 13. Data Statistics Obtained By Sobel Method

VI. CONCLUSION AND FUTURE WORK

It is important to know the differences between edge detection techniques because edge detection is the very early stage in object recognition. For recalling most of the information of the image, representing an image by its edge has the advantage as it reduces the amount of data required to be stored. In this paper, we show the relative performance of different edge detection techniques is done with an image. These three techniques Robert, prewitt and sobel comes under the gradient edge detection technique. We observe that Sobel edge detection technique produces fewer discontinuities in detection of edges as compared to Robert and Prewitt edge detection techniques as shown in figure 7,9,11 respectively. Its corresponding data statistics obtained through MATLAB shows that data of Robert and Prewitt are almost same and data of Sobel differs from these two. In future, we can use fuzzy edge detection technique to resolve the discontinuities formed in Sobel edge detection algorithm.

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