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Edge Detection Techniques on Digital Images - A Review

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Abstract:- Edge is known to be an important changes of intensity in a digital image. It is a sudden changes of discontinuous noticed in an image. The three types of edges are: Horizontal, Vertical and digital images. In this paper, different edge detection methods are reviewed and comparing of different edge detection method, with their advantages and disadvantages. Implementation was done using MATLAB.

Keywords:- *Edge Detection, Prewitt Operator, Sobel Operator, Log Operator, Canny Operator.*

I. INTRODUCTION

Edges are very important in computer images analysis as it is known as change of intensity in a digital image. It is also a sudden change of discontinuities noticed in an image. Edges show the boundaries that exist between regions in a digital image. They are known to also be signs of lack of continuity in a digital image[13]. This helps with segmenting a part of an image and recognition of an object[10]. It shows important variations. Edges are significant information, since it is noted that they correspond to geometric or physical variations in scene object. The physical variations such as illumination and surface reflections notable changes in physical areas show themselves in several ways such as texture, color, and intensity. Edge detection is known as rudimentary of low – level image processing and it is noted that higher level processing requires good edges[7]. It is one of the techniques that are frequently used in digital image processing[3,4].

II. EDGE DETECTION OVERVIEW

Edge detection is known as powerful tool frequently used in image processing. Its applications are seen in many areas such as pattern recognition, motion analysis and objet recognition. Edge detection make use of edged which are present in an image[17]. Based on difference of grey level or intensity of an image, the following are the types of edges as shown in Fig 1a – 1d.

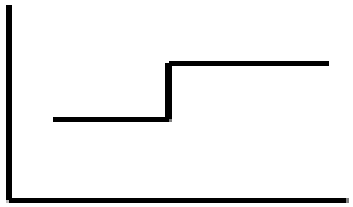

Fig 1a :- Step edge

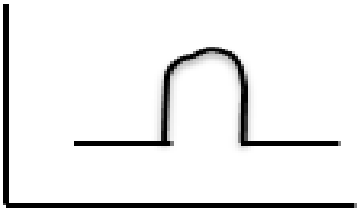

Fig 1b :- Line edge

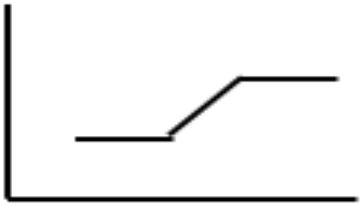

Fig 1c :- Ramp edge

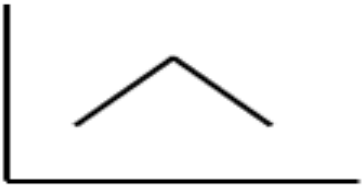

Fig 1d :- Roof edge

To segment the non – trivial images which seems to be sometimes complicated [5]. Some factors needed to be taken into consideration are edge-like features, Noise, image brightness and corners. Image segmentation is based on two major characteristics features of intensity values which are (i) Discontinuity which involves partitioning of an image based on sudden changes in intensity and (ii) Similarity which involves partitioning of an image area that look alike or similar based on some predefined criteria. Digital image has

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three types of discontinuities which are edges, lines and points. Since it is said that edges encapsulate changes in the intensity of an image[6][15]. The causes of this intensity changes are physical events, such as

(a) Illumination discontinuity e.g shadow
(b) Discontinuity of surface orientation
(c) Depth discontinuity which occurs when surface orientation is perpendicular to one's line of sight
(d) Surface reflectance discontinuity which is when there is a change in the degree of light that is incident on the surface that is reflected to the viewer

The following are the descriptors of edge

(a) Edge strength: This works by tracing the local image contrast along the normal
(b) Edge normal: This is when unit vectors is in the direction of maximum intensity change
(c) Edge position: This is the image position in which we can use to locate the edge
(d) Edge direction: This is when unit vector is perpendicular to edge normal as shown in Fig. 2

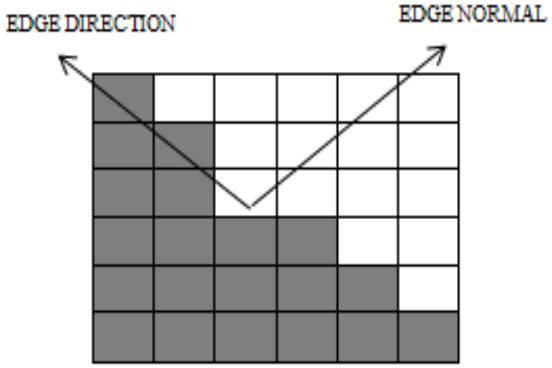

Fig. 2:- Edge direction and edge normal

III. VARIOUS EDGE DETECTION

Edge detection techniques are divided into two main categories which are: (i) Gradient which helps to compute first order derivations in an image and (ii) Gaussian – based which helps to compute second order derivations in an image.[8][14][16], and also shown in Table 1.

Gradient - based	Sobel operator, Prewitt operator, Robert operator
Gaussian - based	Canny edge detector, Laplacian of Gaussian

Table 1:- Edge detection techniques categories

(1) Sobel operator: This is known as a discrete differentiation operator which calculate gradient approximation of image intensity function for image edge detection[1]. Among the pixels of the image, Sobel operator produces either the normal to a vector or gradient vector. It makes use of 3 x 3 two masks or kernels as shown in Fig. 3a and 3b to digitally calculate the first derivative G_x and G_y

G_x

-1	0	1
-1	0	1
-1	0	1

Fig. 3a:- Gx(Vertical mask of sobel operator)

G_y

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

Fig. 3b :- Gy(Horizontal mask of sobel operator)

(2) Prewitt operator: This operator is very much similar to the sobel operator which also detect vertical and horizontal edges of an image[9-12]. This detector is one of the best ways to detect the orientation and magnitiude of an image. It uses the mask in Fig 4a and Fig 4b respectively.

G_x

-1	-1	-1
0	0	0
1	1	1

Fig. 4a :- Gx(Vertical mask of prewitt operator)

G_y

-1	0	1
-1	0	1
-1	0	1

Fig. 4b:- Gy(Horizontal mask of prewitt operator)

(3) Robert operator: This gradient operator calculates the addition of squares of the differences between adjacent pixels at the diagonal in an image via discrete differentiation. Then the gradient approximation is made. It uses 2 x 2 kernels as shown in Fig. 5a and Fig 5b. respectively.

G_x

1	0
0	-1

Fig. 5a :- Gx(Vertical mask of robert operator)

G_y

0	1
-1	0

Fig. 5b :- Gy(Horizontal mask of robert operator)

(4) Canny operator:This is a robust operation which helps in detecting edges unlike sobel and Robert operators, this operator is not susceptible to noise. It can work in different environments. It is one of the best methods because it extracts an image features without affecting or altering the feature. It works based on three criteria which are: (i)Low error rate (ii)

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Edge points must be accurately localized (iii) There should be just one single edge response[4]

(5) Laplacian of Gaussian: Laplacian of Gaussian which was proposed by [2] is also referred to as LoG. This really works well when transition of the grey level seems to be abrupt. In order to have a smooth transition, it is advisable to calculate the second- order derivative. It is important to note when the second order derivative crosses zero, which means that the location corresponds to a maximum level. This location is called edge location. The LoG of a digital image f(x,y) which is a second order derivative is as shown in equation 3

IV. IMPLEMENTATION

Edge detection was implemented on the image as displayed in Fig. (6a -6f) using various techniques. This was performed using Matlab 8.0 (2013a)

Fig 6a :- Original image

Fig 6b :- Sobel Operator

Fig 6c :- Prewitt Operator

Fig 6d :- Roberts Operator

Fig 6e :- Canny Operator

Fig 6f :- Laplacian

Table 3 shows the advantages and disadvantages as observed in fig 6a – 6f and as reviewed by various researchers [2][18][19]

S/No	Techniques	Advantages	Disadvantages
1	Sobel operator	Very easy at searching for smooth edges	Inaccurate
2	Prewitt Operator	There is a good edge detection performance on vertical and horizontal edges	Not too accurate The magnitude of coefficient is fixed and cannot be changed
3	Robert operator	Detection of edges and orientation are very easy	Inaccurate Very sensitive to noise
4	Canny edge Operator	It has good localization It extract image features without altering the features	There is false zero crossing

5	Laplacian of Gaussian	Easy to detect edges and their various orientations There is fixed characteristics in all directions	Very sensitive to noise The operation gets diffracted by some of the existing edges in a noisy image Difficulty in detecting few edges

Table 3 :- Advantages and Disadvantages of Edge detection techniques

V. CONCLUSION

This paper shows studies on different edge detections and are categorized as gradient and Gaussian based edge detection.

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