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Study of Various Edge Detection Algorithms

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Abstract: An image is nothing but the combination of lines and edges filled with colour. Edge of an image is considered the crucial information justifying the data in it. Edge detection technique is a basic and the most important subject in image processing, image analysis and computer vision. The main purpose of edge detection is to produce line and other important features which comprise an image and reduce the other data in the image. Edge detection process uses operators for detecting lines. Edges are identified as the sharp changes of brightness and contrast in the image. This paper comprises the study of various operators such as Sobel, Prewitt, Canny, LOG Roberts which are used for edge detection of the images.

Keywords: Edge; LOG; Sobel; Canny; Prewitt; Robert; Image.

I. INTRODUCTION

Image Processing has gained significant momentum from last few decades with the hike in applications of computer vision in almost every facet of our lives. From cataloguing products in the industry to investigation and observation in the security zones, medical equipment to car bays, military systems to regular house hold systems, everything in this era, requires the aid of automatic visual inspection of images for carrying out the jobs. Image Processing can be described as the analysis and manipulation of a digitized image specifically focusing on the purpose of image enhancement and retrieval of useful information and intricate details. [1], [10], [11]

It finds its application in biometrics, currency uthentication, entailing of vehicles via CCTV footages, security camera details etc.

Methodology of Image Processing [4], [8]:

Image Acquisition: In this process digital image is acquired either through physical image or by using some device.

Image Pre-Processing: Images comprises of numerous types of noises and distortions. Image pre-processing benefits us in reducing these distortions. This can be done through a lot of ways like Image adjusting, Image smoothing etc.

Edge Detection: Edges in a digital image are classified as the points about which the illumination changes suddenly. It is used for abstraction and feature detection.

Image Segmentation: This method divides the image into sub regions reliant upon their resemblances and cutouts.

Feature Extraction: This process is used to recognize the unique and distinguishing features of an image.

Matching Algorithms: This is the last phase used to bout the output image conferring to the features extracted with the original input image.

II. PRINCIPLE OF EDGE DETECTION

Edge detection algorithm is the one wherein the delineations of the image of an object are identified which provides valuable information about the image, in which unexpected dissimilarity of the image intensity is detected, which helps in analysis of image in a proficient way. Thus, image analysis plays a vital role in pattern matching, extracting of useful information, image enhancement and image detection. The edges of the image give the structure and outline of the image depicting intricate lines and details as edges are the representation of the disjointedness of image intensity function and are characterized by sharp changes in the luminous intensity. An edge detector is essentially a high pass mesh that can be pragmatic to excerpt the edge points in an image [8], [5]. Edge detection algorithm can thus be referred to as a medium for showing the cutoffs in any image and since it is pigeonholed by the changes in the brightness level, its detection in binary or segmented image is relatively straightforward. Therefore, edge detection significantly reduces the quantity of data and sieves out the information that may be of less relevance as to the other preserved structural assets of the image. [3] [6]

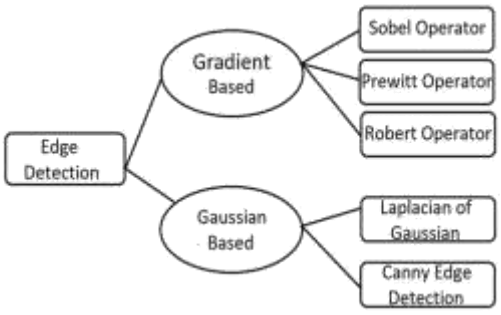

Fig. 1. Classification of Edge Detection Algorithm

With the growing possibilities and soaring of this methodology, many techniques have been developed, formulated and discovered for the purpose of extracting unique features from the digital image using edge detection operators. Though, these can be fragmented into two major partitions namely, derivative approach and pattern fitting approach. Another facet of its major

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classification into two broad categories is based on the type, which is- Gaussian Techniques and Gradient Techniques.

Steps In Edge Detection [11], [1] [9]:

A. Filtration: Every image is allied with some intensity values, random change in these values can result in noise. Some mutual noise is: salt and pepper noise, impulse noise etc. Noise can result in snags in operative edge detection; hence image has to be filtered in order to reduce the noise content that leads to loss of edge strength. It can also be called as Smoothening.

B. Enhancement: Cultivating the quality of image is said to enhance the image, thus the term enhancement. It aims to yield an image which is improved and more suitable than original. A filter is applied in order to augment the quality of edge in image.

C. Detection: Several methods are espoused to govern which points are edge points and which an edge pixel should be cast-off as noise.

III. GRADIENT TECHNIQUES

Edges are areas with high frequency variations in contrast and brightness and these changes from one pixel to the subsequent can create major distortions in picture eminence. These discontinuities can be identified using first and second order derivatives. This first order derivative is known as gradient. The gradient of 2-D function can be written as [12], [7]:

$$\nabla f = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Fig. 2. Formulae for the Gradient

A. Sobel Operator Method:

Sobel method is the rudimentary approach of edge detection which uses two different 3*3 convolution masks (Gx, Gy) for detection in x and y directions respectively. Both of these masks are applied independently to the image and then the output magnitudes are combined together to find the absolute magnitudes of the whole image. The ensuing equation is taken in use for finding the magnitude of the vector values while using Sobel Operator Method [6], [9], [7]:

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

Both of the masks are shown below in fig.:

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

G_x

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

G_y

Fig1. Sobel Masks

B. Prewitt Operator:

Comparable to the Sobel operators, the Prewitt operator method also uses two different 3*3 masks. Edges of high resolution images are effortlessly and proficiently mined using this method [8], [9].

Masks are shown below in fig 2.

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

C. Robert Cross Edge Detection:

This method accomplishes 2-D spatial gradient extent on an image and highlights the high spatial frequency counties in the image. It uses two 2*2 convolution kernels and are designed to respond maximally to the edges at 45° to the grid [7], [8], [9].

Masks used in this technique are represented as depicted below:

-1	0
0	-1

0	1
-1	0

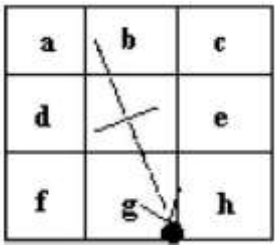
Fig3. Roberts Mask

IV. GAUSSIAN TECHNIQUES

A. Canny Edge Detection:

Canny method works in very robust manner but is not very susceptible to distortions due to noise. It gives optimum solution and even takes less time than Robert

Cross's Method. Also, it is easily adaptable to various environments. It does not disturb or alter the features of the image. Three criteria were set by Canny viz. low error rate, points be well confined, only single reply to each edge [7], [9] [10].



B. Laplacian of Gaussian (LOG):

The Laplacian is a 2-D isotropic ration of the 2nd spatial derivative of a digital picture. The Laplacian helps in highlighting the provinces of swift intensity alteration and is consequently helpful for edge detection. The Laplacian is frequently used on an image that has foremost been levelled with somewhat reminiscent of a Gaussian Smoothing sieve in order to diminish the interference with noise. In this progression, the Gaussian sieving is applied with Laplacian to disrupt the image where the intensity fluctuates to distinguish the edges effectually. It

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discovers the accurate place of edges and for testing of broader expanse around the pixel [2], [10].

It uses filters for the purpose of detection of an edge in the image. Filter used by Laplacian of Gaussian is portrayed as below:

1	1	1
1	-8	1
1	1	1

L_X

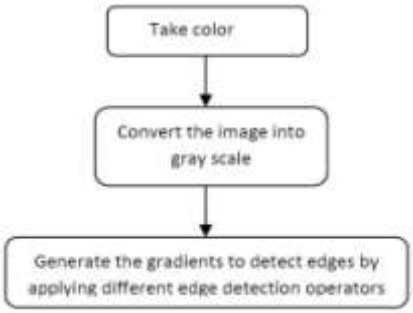
-1	2	-1
2	-4	2
-1	2	-1

L_Y

The widely used and standard LOG edge detection mask is depicted below which expresses about the Laplacian of Gaussian technique:

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

The flowchart of the ploy of engendering gradient images is prearranged beneath. At the instigation leg, a colored image is elected and interleaved into the MATLAB software for dispensation. The same is then rehabilitated into gray scale in the instantaneous phase. A gray scale image is primarily amalgamation of two colors, black and white. It bears the intensity info where, black has the truncated or frailest intensity and white partakes the high or stoutest intensity. Disparity of this intensity echelons formulates the boundaries of entity or things. In the concluding step, dissimilar edge detection operatives are pragmatic to perceive the object margins and inclines.



V. CONCLUSION

This paper shows the study of various edge detection methods on several experimental images in order to depict & formulate the best technique and the most efficient one that needs to be undertaken by a person for getting the most proficient outcomes. According to the experiments, it can be concluded that for inner and outer lines Canny has proven to be the best option as it has better insusceptibility to noise than the gradient detectors. Sobel evidences healthier for the images where only outer lines are painstaking as the boundaries provided are less distorted. But for human faces none of the detectors mentioned fore mostly, deliver the valid and apposite results.

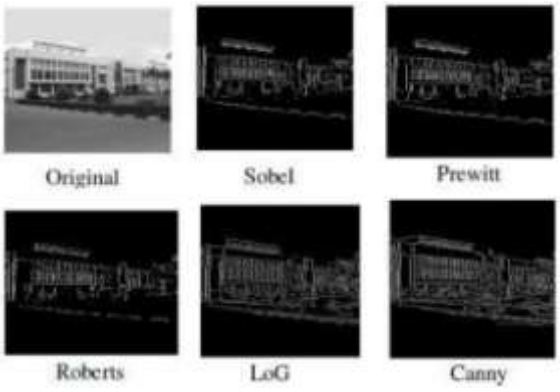


Fig. 1: Original image

Fig.2 Sobel

Fig.3 Prewitt

Fig.4 Laplacian

Fig.5 LoG

Table I- statistical measurement

IMAGE	ENTROPY	PSNR	MSE
Sobel	3.6356	10.9306	5.2483
Prewitt	3.6430	40.7912	5.4195
Laplacian	3.5185	10.7297	5.4969
LoG	3.5516	10.7701	5.4459

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