Operators Use in Edge Detection of Image and Determination of Actual Threshold Values

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Abstract – **Now a days digital image processing is rapid emerging field with fast growing applications in sciences and engineering technologies. Digital image processing has broad spectrum of applications such as remote sensing, medical processing, radar, sonar, robotics, sport field and automated processes [1-2]. Edge detection techniques are employed for the detecting the edges of the primitive picture. Earlier some primitive methods were used for the image processing. H. C. Andrew et.al. gave the method of digital image restoration [3-5], A. K. Jain and et.al put forwarded the partial difference equations and finite differences in image processing [6]. Image process, image models and estimation regarding the edge detection has been flourished during last decade [7-9]. Most modules in practical vision system depend, directly or indirectly, on the performance of an edge detector and digital image processing. The edge detection process tends to simplify the analysis of the image by drastically reducing the amount of data to be processed and at the same time preserving the useful structural information about object boundaries. An edge-detector is employed to detect edges, in particular boundaries of objects in images which is very important in image processing. Since edges are regarded as primitives of pictures. An edge is said to be occur at a point in an image, if some image attributes changes discontinuously. Edge detection techniques are employed by many researchers with the help of different operators.**

In the present investigation edge detection process is employed for different operators and threshold values and its images for 128 x 128 image was obtained by trial and error method i.e. comparing the results below and above the threshold by using higher level 'C' language, which is a user friendly. The comparison of the obtained and the original values of the threshold values is also studied with the percentage of errors occurred in the processing present detection.

Key words - **digital image processing, edge detection, operators, piexel process, operator comparison**

I. EDGE - DETECTION OPERATORS

The idea underlining most edge detection techniques is the computation of local derivative operator. The first derivative of an edge modeled in this manner is 0 in all reasons of constant gray level. and assumes a constant value during the gray level transition. The second derivative on the other hand is 0 in all locations, except at the onset and termination of the gray level transition.

So it is exigent that the magnitude of the first derivative can be used to detect the presence of the edge, while the sign of the second derivative can be used to determined whether an edge pixel lies on the dark (background) or light (object) side of an edge.

1) GRADIENT OPERATORS :

The gradient of an image f (x , y) at location (x , y) is defined as the two dimensional vector

$G [F (x , y)] = \{ GX / GY \} = (df / dx) / (df / dy)$

For edge detection magnitude of this vector is generally refereed to simply as the gradient and also denoted by

$G [f (x , y)] = [Gx^2 + Gy^2]^{1/2}$

equals the detection, we are interested in the magnitude of this vector, generally refereed to simply as the gradient and also denoted by

$$G [f (x , y)] = |Gx| + |Gy|$$

The direction of gradient vector is also important quantity.

i.e. $\alpha (x , y) = \tan^{-1} (Gy / Gx)$

Angle is measured with respect to x axis , it is a useful tool for linking edge points that have been detected by using the gradient.

2) SOBEL OPERATOR

Consider the window shown below

X1	X2	X3	-1	-2	-1		-1	0	1
X4	X5	X6	0	0	0		-2	0	2
X7	X8	X9	1	2	1		-1	0	1
				(a)				(b)	

(a) and (b) are masks available for Sobel operator. Component of gradient vector in the x and y direction are

$$Gx = (X_7 + 2X_8 + X_9) - (X_1 + 2X_2 + X_3)$$
$$Gx = (X_3 + 2X_6 + X_9) - (X_1 + 2X_4 + X_7)$$
$$Gx [(x , y) = | Gx | + | Gy | \text{ or } G [f (x , y)] = [Gx^2 + Gy^2]^{1/2}$$

In any window, we determine the gradient and compare this with a appropriate threshold. The center of the window is detected as edge only if the gradient in the window exceeds the threshold.

g (x , y) = | 255 if G [f (x , y)] ≥ T |
| 0 otherwise |

Using the 3 x 3 area in the computation of the gradient has an advantage over 2 x 2 area. Since it tends to make derivative operation less sensitive to noise. Convolving these masks with an image f (x,y) yields the gradient at all points in the image, the result often. The Sobel mask operation is omnidirectional which means that all black-to-white and white-to-black edge transition are highlighted, regardless of their direction in an image. Sobel operation is more immune to image noise than laplacian operation and it provides stronger edge discrimination.

3) *ROBERT'S OPERATOR*

This operator has 2 x 2 mask

-1	0		0	-1
0	1		1	0
(r_1)			(r_2)	

$g = \sqrt{X^2 + X_2}$

Since it operates on small neighborhoods, this operator is very sensitive to noise.

4) PREWITT OPERATOR

-1	-1	-1		-1	0	1
0	0	0		-1	0	1
1	1	1		-1	0	1
(P_1)				(P_2)		

$g = [P_1 + P_2]^{1/2}$

This operator is more immune to image noise provides stronger directional edge discrimination.

5) FREI AND CHEN OPERATOR

-1	$-\sqrt{2}$	-1		-1	0	1
0	0	0		$-\sqrt{2}$	0	$\sqrt{2}$
1	$\sqrt{2}$	1		-1	0	1
(F_1)				(F_2)		

$G = [F_1 + F_2]^{1/2}$

6) KIRSCH COMPASS MASKS:

-3	-3	5		-3	5	5		5	5	5
-3	0	5		-3	0	5		-3	0	-3
-3	-3	5		-3	-3	-3		-3	-3	-3
(K_0)				(K_1)				(K_2)		
5	5	-3		5	-3	-3		-3	-3	-3
5	0	-3		5	0	-3		5	0	-3
-3	-3	-3		5	-3	-3		5	5	-3
(K_3)				(K_4)	(K_5)					
-3	-3	-3		-3	-3	-3				
-3	0	-3		-3	0	5				
5	5	5		-3	5	5				
(K_6)				(K_7)						

7) SHIFT AND DIFFERENCE OPERATORS :

The three common shift and difference masks are

0	0	0		0	-1	0		-1	0	0
-1	1	0		0	1	0		0	1	0
0	0	0		0	0	0		0	0	0
(Vertical)				(Horizontal)				(Diagonal)		

The shift and difference operators extracts the vertical, horizontal and diagonal edges in an image. Each pixel is subtracted from its adjacent neighbouring pixel in the chosen direction. The resulting image appears as a directional outline of the object in the original image. This operation is directional, which means that black to white edge transmission are highlighted only in a single direction of travel across the image. The shift and difference operation is the most computationally efficient of all edge enhancement operations, but it trends to accentuate noise in an image.

The shift and difference operation can produce results that are less than 0. This underflow condition occurs when a bright pixel is subtracted from a dark pixel. In these underflow cases, the resulting value is forced to 0. The net effect is that edges going from black to white are brightly highlighted. Edges going from white to black are not, because the bright value is subtracted from dark value. So the underflow condition yields a black result.

8) ISOTROPIC OPERATOR

-1	0	1		-1	$\sqrt{2}$	-1
$-\sqrt{2}$	0	$\sqrt{2}$		0	0	0
-1	0	1		1	$\sqrt{2}$	1
(I_1)				(I_2)		

$g = [I_1^2 + I_2^2]^{1/2}$

This is the gradient operator. It causes thick edges in output images.

9) STOCHASTIC OPERATOR

SNR = 1				SNR = 9		
0.97	0	0.97		0.776	0	-0.776
1	0	-1		1	0	-1
0.97	0	-0.97		0.776	0	-0.776

These masks are poor in presence of noise average low pass filter least square fitting technique can yield some reduction of detrimental effects.

10) LAPLACIAN OPERATORS

Laplcian is a second order derivative operator defined as

$L [f (x , y)] = d^2f / dx^2 + d^2f / dy^2$

This operation can be implemented by convolving the mask with an image f (x , y). Note that the Laplacian is 0 in constant areas and on the ramp section of an edge, as expected of a second order derivative.

The three common laplacian edge detection mask are

-1 -1 -1	0 -1 0	1 -2 1
-1 8 -1	-1 4 -1	-2 4 -2
-1 -1 -1	0 -1 0	1 -2 1
(Mask 1)	(Mask 2)	(mask 3)

The Laplacian edge detection operation extracts all the edges in an image regardless of direction. The resulting image appears as an omidirectional outline of the objection the original image. Constant brightness regions become black, white changing brightness regions become highlighted.

II. ALGORITHMS AND SOFTWARE

In the present investigation development of algorithms for operation of edge detection mask on 128 × 128 image is done. Applying edge detection mask of size 3 × 3 and gradient magnitude is calculated at each pixel, which is stored in two dimensional array. The gradient magnitude at each pixel is compared with appropriate threshold and the pixel having magnitude greater than threshold is highlighted and other pixels are made off in order to get the edge detected.

PIXEL GROUP PROCESSING

The edge detection masks considered here is implemented through a process called convolution, which is used to calculate what is going on with the pixel brightness around the pixel being processed. It is a mathematical method used in signal processing and analysis.

Each output pixels brightness is dependent on a group of input pixels surrounding the pixel being processed. Weighted average of input pixel and its immediate neighbours are used to calculate the output pixel brightness value called mask and the array of 3 × 3 mask convolution coefficient is given below.

a	b	c
d	e	f
g	h	I

Every pixels in the input image is evaluated with its eight neighbours using this mask to produce an output pixel value which is shown in Fig. 1.

a	b	C
d	e	F
g	h	I

Convolution mask

Fig. 1 The spatial convolution process for the Pixel at location I (x , y) creating output Pixel at O (x , y)

al (x - 1, y - 1)+ bl (x, y - 1)
+ cl (x + 1, y - 1) dl (x - I , y)
+ el (x, y) + fl (x + 1, y) + gl (x - 1, y - 1)
+ hl (x, y + 1) + il (x + 1, y +1)
= Output pixel

The mask is placed over an input pixel and its eight neighbours are multiplied by their respective convolution coefficient and the multiplication’s are summed. The result is placed in the output image at the same centre pixel location. This process occurs pixel by pixel for each pixel in the input image. The equation for the convolution process is

0 (x , y) = al (x - 1, y - 1) + bl (x, y - 1)
+ cl(x + 1, y - 1) + dl (x - I , y)
+ el(x, y) + fl (x + 1, y) + gl (x- , y - 1)
+ hl (x, y + 1) + il (x + 1, y +1)

In the case of a 128 × 128 line image the edge detection mask operation requires the pixel by pixel process to occur 128 × 128 = 16384 times. Each process requires nine multiplication’s and nine. additions per input image pixel

ALGORITHM

Steps required in edge detection mask operation of 128 x 128 image are-

1. Open the image binary coded data file.
2. Read the data from the image file and store it into a two dimensional array for processing.
3. Display the original image on screen.
4. Operate the mask on the input image as stated in previous article pixel group processing operation and calculate value at each pixel.
5. Store value of each pixels in output two dimensional array
6. Display the image pixels stored in output array by appropriate threshold value of get edge detected image

SOFTWARE PACKAGE

Edge detection software is developed in friendly package through C language. In this menu operated package, original image, histogram of the image and results of different edge-detection masks cam be seen. Threshold values for the edge detection are noted by trial and error method for different images

III. RESULTS AND CONCLUSION

In the present work, pixel group processing and algorithms for operation of mask on images of different operators are studied and the threshold results are obtained which are shown in the table 1. Table 2 shows the original and obtained threshold values of SOBEL operator. while fig.1 shows the histograms of original and obtained threshold values. Fig. 2 shows the original image and threshold edge detected images of SOBEL operator carried and also the percentage of error in the observation. From the edge detected images and results obtained, following conclusions are made.

1. Particular threshold value for each operator gives the best result for edge detection of a particular image.
2. The threshold value for the best result using different operators doesn't remain same either for same or different image.
3. The best results are judged on appropriate threshold by using trial and error method.
4. The study of edge detection should be carried out on single / particular image using different operators at different threshold value to obtain the best result.

Edge detection technique is possible for any size of the image by varying the image and the operators by permutation and combination which establish a relation for operators and the type of images. Full image processing software suitable for 128 x 128 image can be developed in used friendly C language. Neural Network approach can be employed for the edge detection to obtain better results over the conventional operators.

TABLE 1 : PERFORMANCE OF OPERATORS

S. No.	Operator	Threshold Value
1	SOBEL	180
2	ROBERTS	100
3	ISOTROPIC	190
4	NORTH	80
5	SOUTH	120
6	LAPLACE-1	120
7	DIAGONAL	48
8	PREWITT	120
9	STOCHASTIC-1	90
10	HORIZONTAL	36
11	VERTICAL	120
12	KIRSCH	250

TABLE 2 : PERFORMANCE OF SOBEL OPERATOR

S. No.	SOBEL original Value	Threshold Value obtained	% of error
1	48	40	16.66
2	64	60	3.12
3	80	78	2.50
4	90	87	3.33
5	100	96	4.00
6	110	108	1.81
7	120	115	4.34
8	140	146	2.85
10	160	155	3.12
11	180	169	6.11
3	190	182	4.21

From the above table it is seen that for Sobel operator at different values the threshold value is slightly less and which is comparable within its range. The percentage of error is also comparable.

Normally the conventional operators are gradient operators. Therefore, when the window lies in a region in which the intensity changes are large the output indicates an edge. This leads to thick edges in regions where there are strong blurred edges in the input. But the neural network is trained as a training set in which the edge patterns always have a one input for centre pixel. Therefore, the edges obtained are much thinner a desirable characteristic for on edge detector . t.

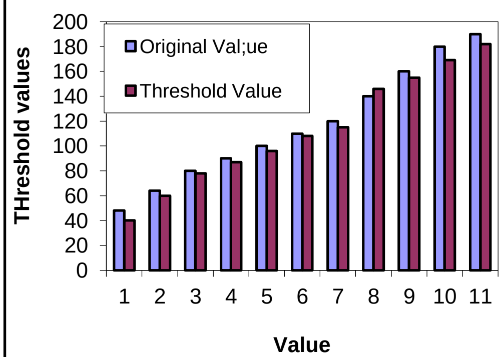

Fig. 1 Histogram of Original and obtained threshold values

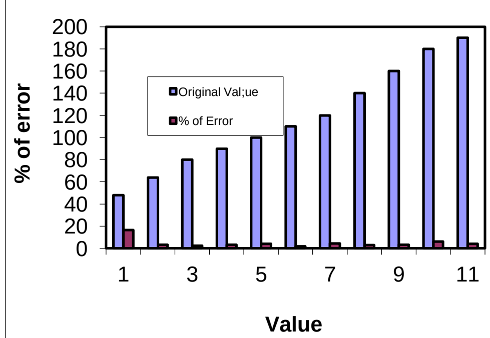

Fig. 2 Original value and % of Error

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