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Sobel Edge Detection Algorithm

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Abstract— **Edge detection is in the forefront of image processing for object detection, it is crucial to have a good understanding of edge detection algorithms. Sobel which is a popular edge detection algorithm is considered in this work. There exists a function, edge.m which is in the image toolbox. In the edge function, the Sobel method uses the derivative approximation to find edges. Therefore, it returns edges at those points where the gradient of the considered image is maximum. The Sobel operator performs a *2-D* spatial gradient measurement on images. It uses a pair of horizontal and vertical gradient matrices whose dimensions are 3×3 for edge detection operations. It will also demonstrate how to build a Sobel detector function of 5 ×5 dimension in matlab to find edges.**

Keywords—**Sobel, Edge Operator, Edge Detection, Image Processing, Gradient Matrices, Edge detection.**.

I. Introduction

Using computers to do image processing has two objectives: First, create more suitable images for people to observe and identify. Second, we wish that computers can automatically recognize and understand images. The edge of an image is the most basic features of the image. It contains a wealth of internal information of the image. Therefore, edge detection is one of the key research works in image processing.

- Edges are significant local changes of intensity in an image.
- Edges typically occur on the boundary between two different regions in an image.

• Goal of edge detection

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

There mainly exists several edge detection methods (Sobel [1,2], Prewitt [3], Roberts [4],Canny [5]). These methods have been proposed for detecting transitions in images.

Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Edges in images are areas with strong intensity contrasts – a jump in intensity from one pixel to the next. Edge detecting an image significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. There are many ways to perform edge detection. However, the majority of different methods may be grouped into two categories, gradient and Laplacian. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. The Laplacian method searches for zero crossings in the second derivative of the image to find edges. An edge has the one-dimensional shape of a ramp and calculating the derivative of the image can highlight its location. Suppose we have the following signal, with an edge shown by the jump in intensity below:

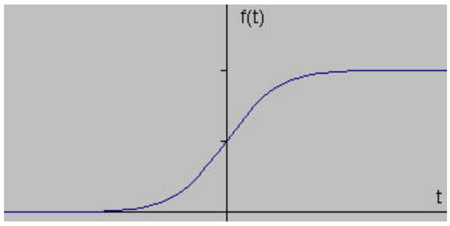


Figure 1 signal with an edge shown by the jump in intensity

If we take the gradient of this signal (which, in one dimension, is just the first derivative with respect to t) we get the following:

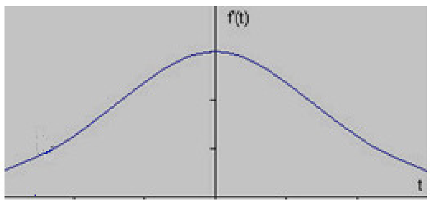


Figure 2 gradient of the above signal

Clearly, the derivative shows a maximum located at the center of the edge in the original signal. This method of locating an edge is characteristic of the "gradient filter" family of edge detection filters and includes the Sobel method.. A pixel location is declared an edge location if the value of the gradient exceeds some threshold. Edges have higher pixel intensity values than those intensity values surrounding it. So once a threshold is set, we can compare the gradient value to the threshold value and detect an edge whenever the threshold is exceeded. Furthermore, when the first derivative is at a maximum, the second derivative is zero. As a result, another alternative to finding the location of an edge is to locate the zeros in the second derivative. This method is known as the Laplacian and the second derivative of the signal is shown below:

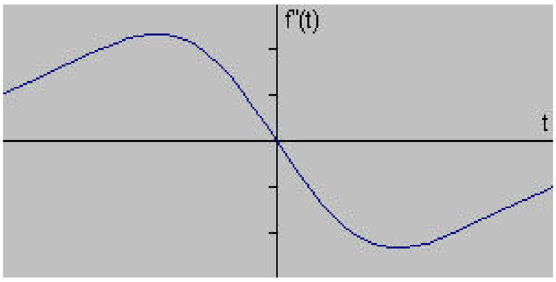


Figure 3 second derivative of the signal

The Sobel operator performs a 2-D spatial gradient measurement on an image and emphasizes regions of high spatial gradient that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input greyscale image. Compared to other edge operator, Sobel has two main advantages:

1. Since the introduction of the average factor,it has some smoothing effect to the random noise of the image.
2. Because it is the differential of two rows or two columns,so the elements of the edge on both sides has been enhanced,so that the edge seems thick and bright.

II. AN EDGE DETECTION MODEL BASED ON SOBEL OPERATOR

Standard Sobel operators, for a 3×3 neighborhood, each simple central gradient estimate is vector sum of a pair of orthogonal vectors [1]. Each orthogonal vector is a directional derivative estimate multiplied by a unit vector specifying the derivative's direction. The vector sum of these simple gradient estimates amounts to a vector sum of the 8 directional derivative vectors. Thus a point on Cartesian grid and its eight neighbouring density values as shown:

a	b	c
d	e	f
g	h	i

Figure 4 a point and its 8 neighbouring values

In [1], the directional derivative estimate vector *G* was defined such as density difference /distance to neighbor. This vector is determined such that the direction of *G* will be given by the unit vector to the approximate neighbor. Note that, the neighbors group into antipodal pairs: (a,i), (b,h), (c,g), (f,d). The vector sum for this gradient estimate:

$$G = \frac{(c-g)}{R}\cdot\frac{[1,1]}{R} + \frac{(a-i)}{R}\cdot\frac{[-1,1]}{R} + (b-h)\cdot[0,1]$$
$$+(f-d)\cdot[1,0\,]$$

where, $R = \sqrt{2}$. This vector is obtained as

$$G = \frac{(c-g-a+i)}{2} + f - d, \frac{(c-g+a-i)}{2} + b - h$$

Here, this vector is multiplied by 2 because of replacing the divide by 2. The resultant formula is given as follows (see, for detail [1]):

$$G' = 2G = [(c-g-a+i) + 2(f-d), (c-g+a-i) + 2(b-h)]$$

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

Gx

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

Gy

Figure1 5 Sobel masks of 3X3 dimension

the operator consists of a pair of 3×3 convolution masks as shown in Figure 1. One mask is simply the other rotated by 90°. These masks are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one mask for each of the two perpendicular orientations.

Now, we explain that the dimension of the matrices are extended by using [1]. The definition of the gradient can be used for 5×5 neighborhood [8]. In this case, twelve directional gradient must be determined instead of four gradient. The following figure has 5×5 neigborhood.

a	b	c	d	e
f	g	h	i	j
k	l	m	n	o
p	r	s	t	u
v	w	x	y	z

Figure 6 structure of a 5X5 mask

The resultant vector *G'* (similar to the determination of Sobel 3×3 method) for 5×5 is given as follows:

$$\begin{aligned} G' = {} & [20(n-l) + 10(i-r-g+t+o-k)] \\ & +5(e-v-a+z) + 4(d-w-b+y) \\ & +8(j-p-f+u), 20(h-s) + 10(i-r+g-t) \\ & +5(e-v+a-z) + 4(j-p+f-u) \\ & +(d-w+b-y)] \end{aligned}$$

The horizantal and vertical masks are obtained by using the coefficents in this equation [8].

-5	-4	0	4	5
-8	-10	0	10	8
-10	-20	0	20	10
-8	-10	0	10	8
-5	-4	0	4	5

5	8	10	8	5
4	10	20	10	4
0	0	0	0	0
-4	-10	-20	-10	-4
-5	-8	-10	-8	-5

Figure 7 sobel masks with 5X5 dimensios

III. SOBEL EXPLANATION

A convolution mask is used is usually much smaller than the actual image. As a result, the mask is slid over an area of the input image, changes that pixel's value and then shifts one pixel to the right and continues to the right until it reaches the end of a row. It then starts at the beginning of the next row. The example below shows the mask being slid over the top left portion of the input image represented by the green outline. The formula shows how a particular pixel in the output image would be calculated. The center of the mask is placed over the pixel you are manipulating in the image. And the I & J values are used to move the file pointer so you can mulitply, for example, pixel (A_{22}) by the corresponding mask value (M_{22}). It is important to notice that pixels in the first and last rows, as well as the first and last columns cannot be manipulated by a 3x3 mask. This is because when placing the center of the mask over a pixel in the first row (for example), the mask will be outside the image boundaries.

Input Image

A_{11}	A_{12}	A_{13}	....	A_{1k}
A_{21}	A_{22}	A_{23}	....	A_{2k}
A_{31}	A_{32}	A_{33}	....	A_{3k}
⋮	⋮	⋮	⋮	⋮

+

Pseudo-convolution mask

M_{11}	M_{12}	M_{13}
M_{21}	M_{22}	M_{23}
M_{31}	M_{32}	M_{33}

=

Output Image

B_{11}	B_{12}	B_{13}	....	B_{1k}
B_{21}	$\boxed{B_{22}}$	B_{23}	....	B_{2k}
B_{31}	B_{32}	B_{33}	....	B_{3k}
⋮	⋮	⋮	⋮	⋮

Figure 8 sobel pseudo convolution mask applied to the image

The above figure illustrates the working of sobel pseudo convolution masks when it is applied to the input given input image.the sobel pseudo mask performs the following operation to calculate the point B_{22} of the image:

$$B_{22} = (A_{11}*M_{11}) + (A_{12}*M_{12}) + (A_{13}*M_{13}) + (A_{21}*M_{21}) + (A_{22}*M_{22}) + (A_{23}*M_{23}) + (A_{31}*M_{31}) + (A_{32}*M_{32}) + (A_{33}*M_{33})$$

The masks can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Although typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan\left(\frac{Gy}{Gx}\right) - \frac{3\pi}{4}$$

In this case, orientation θ is taken to mean that the direction of maximum contrast from black to white runs from left to right on the image, and other angles are measured anti-clockwise from this. Often, this absolute magnitude is the only output the user sees --- the two components of the gradient are conveniently computed and added in a single pass over the input image using the pseudo-convolution operator as shown in Figure 8.

IV. PSEUDO-CODES FOR SOBEL EDGE DETECTION

Input: A Sample Image.

Output**:** Detected Edges.

Step 1: Accept the input image.

Step 2: Apply mask Gx,Gy to the input image.

Step 3: Apply Sobel edge detection algorithm and the gradient.

Step 4: Masks manipulation of Gx,Gy separately on the input image.

Step 5: Results combined to find the absolute magnitude of the gradient.

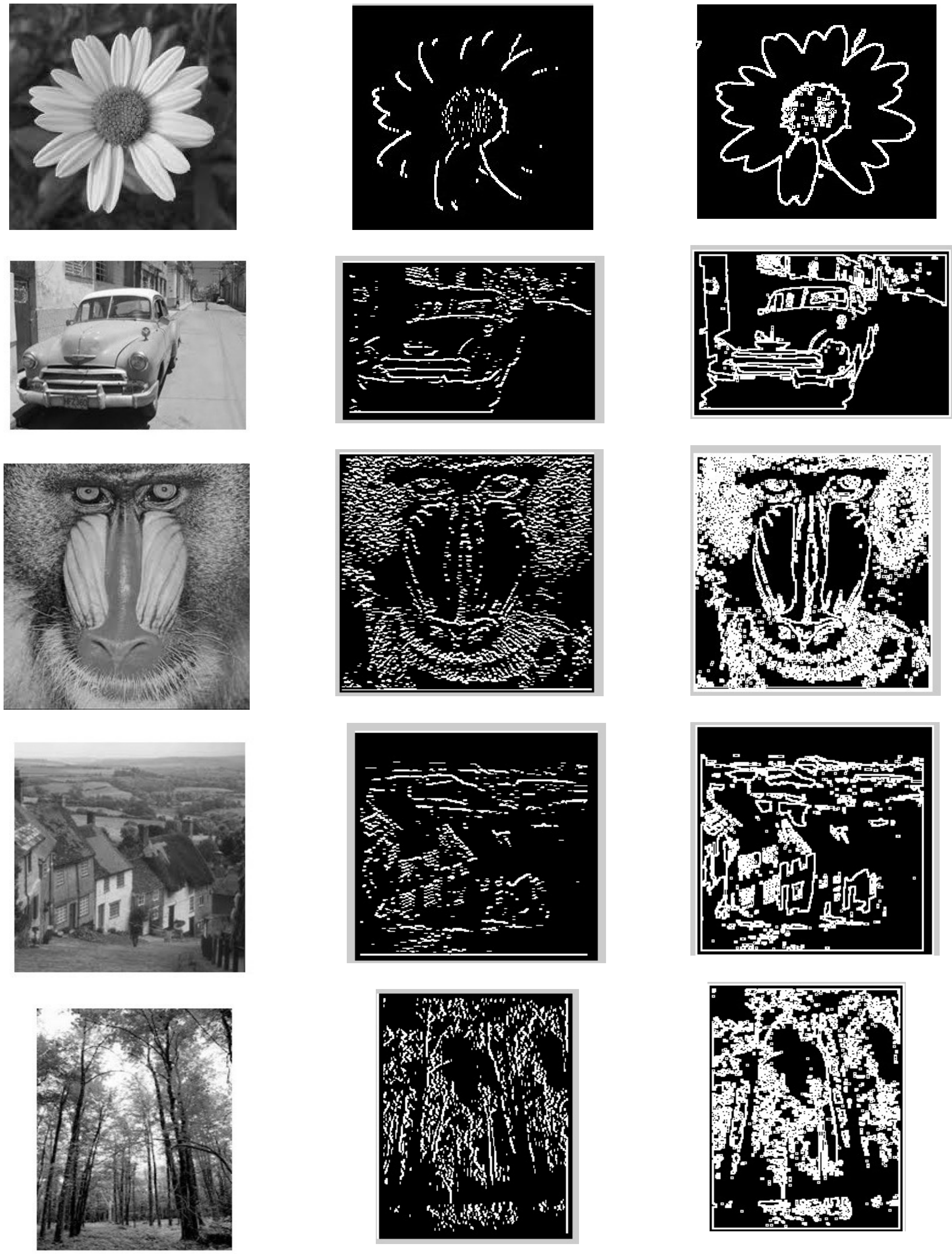
Step 6: The absolute magnitude is the output edges.

V. CONCLUSIONS

The Sobel edge detector uses a pair of 3X3 convolution masks, one estimating gradient in the *x* direction and the other estimating gradient in *y*–direction. It is easy to implement than the other operators. Transferring a *2-D* pixel array into statistically uncorrelated data set enhances the removal of redundant data, as a result, reduction of the amount of data required to represent a digital image. Considering data communication especially the internet, massive data transfer causes serious problems for interactive network users.Edge detection helps in optimizing network bandwidth and it is needed to keep track of data flowing in and out of the network. It helps to extract useful features for pattern recognition. Although the Sobel operator is slower to compute, it's larger convolution kernel smoothes the input image to a greater extent and so makes the operator less sensitive to noise. The larger the width of the mask, the lower its sensitivity to noise and the operator also produces considerably higher output values for similar edges. Sobel operator effectively highlights noise found in real world pictures as edges though, the detected edges could be thick. The Canny edge detector and similar algorithm solved these problems by first blurring the image slightly then applying an algorithm that effectively thins the edges to one-pixel. This may constitute a much slower process, hence, Sobel operator is highly recommended in massive data communication found in image data transfer.The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image.

VI. APPENDIX

In this section, the set of images which are gray scale is considered to use the developed matlab function and edge function. There exist 5 images and resultant image is obtained from Sobel edge operators applied on original images. The original images are in the first column, the resultant images for the edge function (using Sobel's mask 3×3) and the the developed matlab function, Sobel5×5, are respectively in the second and third columns.



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REFERENCES

[1] SOBEL, I., An Isotropic 3×3 Gradient Operator, Machine Vision for Three – Dimensional Scenes, Freeman, H., Academic Pres, NY, 376-379, 1990.

[2] Prewitt, Sobel and Scharr gradient 5x5 convolution matrices Guennadi (Henry) Levkine Email: hlevkin at yahoo.com Vancouver, Canada. First draft,February 2011 Second Draft, June 2012.

[3] A Descriptive Algorithm for Sobel Image Edge Detection, O. R. Vincent, O. Folorunso Proceedings of Informing Science & IT Education Conference (InSITE) 2009

[4] Sobel Edge Detection Method For Matlab, Elif AYBAR Anadolu University, Porsuk Vocational School,26410 Eskisehir .

[5] An Improved Sobel Edge Detection, Wenshuo Gao,Lei Yang ,978-14244-5540-9/10/$26.00 ©2010 IEEE

[6] Study and Comparison of Various Image Edge Detection Techniques, Raman Maini Dr. Himanshu Aggarwal, International Journal of Image Processing (IJIP), Volume (3) Issue.