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A Study on Image Edge Detection Using the Gradients

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Abstract- A study on image edge detection using gradients is presented in this paper. In image processing and image analysis edge detection is one of the most common operations. Edges form the outline of an object and also it is the boundary between an object and the background. Detecting accurate edges are very important for analyzing the basic properties associated with an image such as area, perimeter, and shape. The software tool that has been used is MATLAB 7.0.

Index Terms: image processing, edge detection, gradients

I. Introduction

Edge detection is a very important field in image processing and image segmentation [1-4]. Edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality. For those reasons edges [5-7] forms the outline of an object and also indicates the boundary between overlapping objects. Identification of accurate edges of image objects helps to analyze and measure some basic properties related with an objects or objects of an image such as area, perimeter, and shape. As discontinuities in intensity values of an image form the edges of objects, so it is essential to detect accurate discontinuities in intensity levels for accurate edge detection. Such discontinuities are detected by using first- and second- order derivatives.

The gradient [8-10] of the image is one of the fundamental building blocks in image processing. The first- order derivative of choice in image processing is the gradient. Mathematically, the gradient of a two-variable function (here the image intensity function) at each image point is a 2D vector [10-11] with the components given by the derivatives in the horizontal and vertical directions. At each image point, the gradient vector points in the direction of largest possible intensity increase, and the length of the gradient vector corresponds to the rate of change in that direction.

Several edge detector operators [12-15] are there for generating gradient images like sobel, prewitt, laplacian and laplacian of Gaussian (LoG). These edge detectors work better under different conditions [13,15]. Comparative analysis between these operators has been presented in this paper. Performances of such operators are carried out for an image by using MATLAB 7.0 software. In this paper the section 2 presents a brief description of gradients. Section 3 introduces comprehensive theoretical and mathematical background for edge detection and explains different computing approaches to edge detection. Section 4 provides the experimental results and discussion and section 5 contains the conclusion.

II. THE GRADIENTS

Edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality. With the help of first- and second- order derivatives such discontinuities are detected. The first- order derivative of choice in image processing is the gradient. The gradient of a 2-D function, $f(x,y)$, is defined as the vector

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

The magnitude of this vector is

$$\nabla f = mag(\nabla f = [g_x^2 + g_y^2]^{\frac{1}{2}} = \left[\left({}^{\partial f}/_{\partial x}\right)^2 + \left({}^{\partial f}/_{\partial y}\right)^2\right]^{\frac{1}{2}}$$

This quantity is approximated sometimes by omitting the square root operation,

$$\nabla f \approx g_x^2 + g_y^2$$

Or by using absolute values,

$$\nabla f \approx |g_x^2| + |g_y^2|$$

These approximations still behave as derivatives; that is, they are zero in areas is contrast intensity and their values are related to the degree of intensity change in areas of variable intensity. It is common practice to refer the magnitude of the gradient or its approximations simply as “gradients”.

III. GENERATING GRADIENT IMAGES USING TRADITIONAL FILTERS

An image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images. An example of small image neighborhood is shown below.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

3.1 Sobel: The sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The sobel operator is based on convolving the image with a small, separable, and integer valued filter. In below a sobel edge detection mask is given which is used to compute the gradient in the x (vertical) and y (horizontal) directions.

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

G_x

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

G_y

3.2. Prewitt: Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images The Prewitt edge detector uses the following mask to approximate digitally the first derivatives G_x and G_y. The following is a prewitt mask used to compute the gradient in the x (vertical) and y (horizontal) directions.

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

G_x

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

G_y

3.3. Laplacian: In mathematics the Laplacian is a differential operator given by the divergence of the gradient of a function on Euclidean space. The Laplacian of an image *f(x,y)*, denoted $\nabla^2 f(x,y)$, is defined as

$$\nabla^2 f(x,y) = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$$

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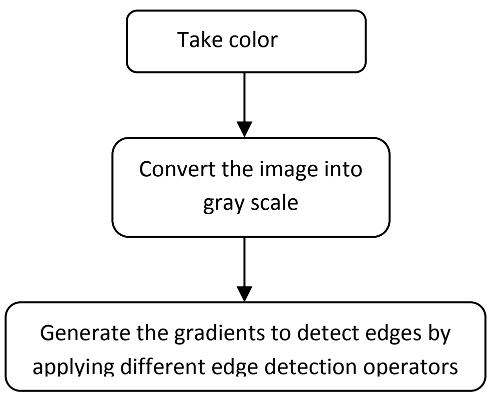
3.4. Laplacian of Gaussian (LOG): This detector finds edges by looking for zero crossings after filtering *f(x, y)* with a Laplacian of Gaussian filter. In this method, the Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It finds the correct place of edges and testing wider area around the pixel. In below a 5x5 standard Laplacian of Gaussian edge detection mask is given.

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

IV. APPROACH

The flowchart of the approach of generating gradient images is given below. At very beginning a colored image is chosen and inserted into the Mat Lab software for processing. The image is converted into gray scale in the immediate step. A gray scale image is mainly combination of two colors, black and white. It carries the intensity information where, black have the low or weakest intensity and white have the high or strongest intensity. Variation of this intensity levels forms the edges of object or objects. In final step different edge detection operators are applied to detect the object boundaries and gradients.



V. RESULTS AND DISCUSSIONS

We ran one real life image through our edge detectors. The resultant images are shown in the figures from figure 1 to figure 5 and statistical analyses are given below in table 1. The first thing to notice about the gradient images obtained using laplacian and Laplacian of gaussian edge detectors is that the edges are often spotty and disconnected. Though LoG gives better visual assessment then laplacian still the edges are spotty and thick. On the other hand the edges in gradient images obtained by sobel and prewitt operator produces much satisfactory results in terms of clearer edges where both produces much accurate results then laplacian and LoG. In statistical analysis the gradient image obtained by laplacian operator produces highest MSE and lowest entropy and PSNR. Gradient image obtained by prewitt operator produces highest PSNR.

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

VI. CONCLUSION

In this paper the study and comparative analysis of various gradient based image edge detection techniques is presented. Identification of accurate edges of image objects are very important for analyzing and measuring some basic properties related with an objects or objects of an image such as area, perimeter, and shape the software is developed using MATLAB 7.0. It has been shown that the sobel edge detection algorithm performs better than prewitt, laplacian and LoG under almost all scenarios.

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