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Quantitative Review Techniques of Edge Detection Operators.

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ABSTRACT
An edge is a boundary between an object and its background. If the edges in an image can be identified accurately, all of the objects can be located and basic properties such as area, perimeter, and shape can be measured. Since computer vision involves the identification and classification of objects in an image. So for this purpose edge detection is an important tool. This technique helps to localize the significant variants of the gray-level images and to identify the physical phenomena. This information is very useful in image registration, compression, enhancement and restoration, reconstruction, understanding, recognition.
Keywords: Canny , Prewit , Roberts , Sobel Edge Detection operator.

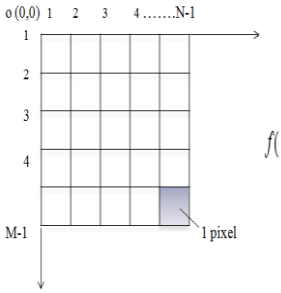
I. INTRODUCTION

1. Image Analysis
2. Segmentation
3. Edge Detection
4. Results
5. Application
6. Conclusion

1. IMAGE ANALYSIS

The basic structure of an Image is an array of matrix.

- Each unit element of a matrix is a pixel in the displayed image.
- The quality of an image is directly proportional to the number of pixels in the image.



$$f(x,y)=\begin{bmatrix} f(0,1)\ f(0,2)\ldots\ldots f(0,N-1) \\ f(1,0)\ f(1,1)\ldots\ldots f(1,N-1) \\ \cdot \quad \cdot \quad \ldots\ldots \quad \cdot \\ \cdot \quad \cdot \quad \ldots\ldots \quad \cdot \\ f(M-1,0). \quad \ldots f(M-1,N-1) \end{bmatrix}$$

2. SEGMENTATION

This means sub-division of an image into its constituent regions or objects.
It is based on one of two basic properties of intensity values:
i) **Discontinuity***:* Abrupt changes in intensity.
Example: Edges (Line, Point, Edge detections are in this category)
ii) **Similarity***:* Regions similar according to some predefined criteria

3. EDGE DETECTION

If edges are identified accurately from an image, all of the objects can be located. We can calculate
i) Area
ii) Perimeter
iii)Shape

Edge Detection Techniques are basically of two types:
a) Gradient,
b) Laplacian.
Gradient: It uses first order derivative

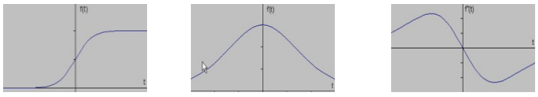
$$\nabla f = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Magnitude of this vector

$$\|\nabla f\| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2}$$

Laplacian: It uses second order derivative

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



Signal Gradient Laplacian

Gradient Based Operators
Sobel Operator: It consists of a pair of 3×3 convolution mask

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

$\frac{\partial f}{\partial x}$

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

$\frac{\partial f}{\partial y}$

$$\frac{\partial f}{\partial x} = (Z_7+2Z_8+Z_9)-(Z_1+2Z_2+Z_3)$$
$$\frac{\partial f}{\partial y} = (Z_3+2Z_6+Z_9)-(Z_1+2Z_4+Z_7)$$

Robert's cross operator: It is simple, quick to compute, 2D spatial gradient measurement of an image. It consists of 2×2convolution mask.

-1	0
0	1

0	-1
1	0

$$\frac{\partial f}{\partial x} = (Z_9-Z_5)$$
$$\frac{\partial f}{\partial y} = (Z_8-Z_6)$$

Here we can see one kernel is simply the other rotated by 90°.

Prewitt's operator: It is similar to Sobel operator and is used for detecting vertical and horizontal edges in images.

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

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

$$\frac{\partial f}{\partial x} = (Z_7+Z_8+Z_9)-(Z_1+Z_2+Z_3)$$
$$\frac{\partial f}{\partial y} = (Z_3+Z_6+Z_9)-(Z_1+Z_4+Z_7)$$

Laplacian Based Operator
Canny's Edge Detection Algorithm **(**Optimal edge detector**)**
The algorithm steps are as follows

1. Convolve the image with a two dimensional Gaussian filter to smooth it.
2. Differentiate the image in two orthogonal directions.
3. Calculate the gradient amplitude and direction.
4. Relate the edge direction to a direction that can be traced.
5. Perform non-maximal suppression. Any gradient value that is not a local peak is set to zero. The gradient direction is used in this process.
6. Threshold these edges to eliminate `insignificant' edges.

II. PERFORMANCE OF DIFFERENT EDGE DETECTION ALGORITHM

Comparison using intensity values

1.Rice

Operator	Root Mean Square Error
Sobel	0.5121
Prewitt	0.5174
Roberts	0.5182
Canny	**0.5025**

2. Pears

Operator	Root Mean Square Error
Sobel	0.8368
Prewitt	0.8368
Roberts	0.8297
Canny	**0.8351**

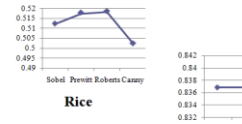
3. Coins

Operator	Root Mean Square Error
Sobel	0.5481
Prewitt	0.5491
Roberts	0.5491
Canny	**0.5472**

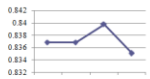
III. GRAPHICAL INTERPRETATION OF THE RESULTS

• Root Mean Square Error

$$e_{RMS} = \sqrt{\frac{1}{MN}\sum_{r=0}^{M-1}\sum_{c=0}^{N-1}[E(r,c)-O(r,c)]^2}$$



Rice



Pears

Coins

IV. APPLICATIONS

- Used to detect Thumb impressions
- Analyze the direction of flow of a river.
- Identify a particular object, its area, shape etc.
- Used in medical sector.
- Identify leakage or cracks in microchips.

V. CONCLUSION

Edge detection techniques are most important factor to identify images in computer vision.This technique helps to localize the significant variants of the gray-level images and to identify the physical phenomena. We are confirmed that out of all the Canny's operator is best to locate the intensity of the edge of an image.

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