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DETECTING EDGES FOR IMAGE REPRESENTATION & DESCRIPTION

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ABSTRACT

This paper deals with the evaluation of edge detection from images which are one of the most important concerns in digital image and video processing. It consists of the implementation and results of various edge based segmentation techniques that employ the usage of gradient methods for efficient detection of edges in order to make it suitable for representation in number of advancing fields. The algorithmic computations in image processing may have high level of time based complexity and therefore it becomes essential to employ techniques that are less complex and at the same time yield high performance. This paper explains and analyzes different techniques for edge detection that follow the stage process of detection of noise and filtering of noisy pixels to achieve better performance than others.

***Keywords**: edge detection, segmentation, gradient methods, noisy pixel, computations, image processing.*

INTRODUCTION

Edge detection refers to the process of identifying and locating sharp discontinuities in image .the discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variable involved in the selection of an edge operator include edge orientation Edge detection, noise environment and edge structure. the geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency. Content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. Edge detection is a problem of fundamental importance in image analysis. In typical images, edges characterize object boundaries and are therefore useful for segmentation, registration, and identification of objects in a scene. Edge detection of an image reduces significantly the amount of data and filters out information that may be Intensity changes, which occur in a natural image over a wide range of scales, are detected separately at different scales. An appropriate filter for this purpose at a given scale is found to be the second derivative of a Gaussian. Intensity changes at a given scale are best detected by finding the zero values of image. The intensity changes discovered in each of the channels are represented by oriented primitives called zero-crossing segments.

A. Problem definition

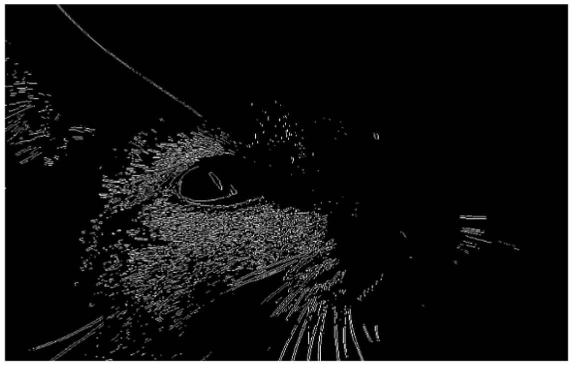
There are problems of false edge detection, missing true edges, producing thin or thick lines and problems due to noise etc. In this paper, we analyzed and did the visual comparison of the most commonly used Gradient and Laplacian based Edge Detection techniques for problems of inaccurate edge detection, missing true edges producing thin or thick lines and problems due to noise etc. The results are obtained using MATLAB 10.

(a) Original Image

B. Edge Detection Techniques

Edge detection techniques transform images to edge images benefiting from the changes of grey tones in the images. Edges are the sign of lack of continuity, and ending. As a result of this transformation, edge image is obtained without encountering any changes in physical qualities of the main image. Edge detection contains three steps namely Filtering, Enhancement and Detection. The most frequently used edge detection methods with details are listed below.

1) The Sobel Detection : The Sobel operator performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial gradient that corresponds to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The Sobel operator is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the opposite of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding opposite of the gradient vector or the norm of this vector. 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 opposite of the gradient approximation that it produces is relatively crude, in particular for high frequency variations in the image. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. In theory at least, the operator consists of a pair of 3x3 convolution kernels. One kernel is simply the other rotated by 90degrees [1] [3].



(c) Sobel method

In simple terms, the operator calculates the opposite of the gradient of the image intensity at each point, giving the direction of the largest possible change from light to dark and the rate of change in that direction. The result therefore shows how "abruptly" or "smoothly" the image changes at that point and therefore how likely it is that that part of the image represents an edge, as well as how that edge is likely to be oriented. In practice, the magnitude (likelihood of an edge) calculation is more reliable and easier to interpret than the direct calculation. Mathematically, the gradient of a two-variable function (here the image intensity function) is at each image point a 2D vector 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. This implies that the result of the Sobel operator at an image point which is in a region of constant image intensity is a zero vector and at a point on an edge is a vector which points across the edge, from brighter to darker values [4]. The Sobel operator represents a rather inaccurate approximation of the opposite of the image gradient, but is still of sufficient quality to be of practical use in many applications. More precisely, it uses intensity values only in a 3×3 region around each image point to approximate the opposite of the corresponding image gradient, and it uses only integer values for the coefficients which weight the image intensities to produce the opposite of the gradient approximation.

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

Gx

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

Gy

Fig.1 Masks used by Sobel Operator

2) Robert's cross operator: The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial gradient which often correspond to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point. The Roberts' Cross operator is used in image processing and computer vision for edge detection. It was one of the first edge detectors and was initially proposed by Lawrence Roberts in 1963. As a differential operator, the idea behind the Robert's Cross operator is to approximate the gradient of an image through discrete differentiation which is achieved by computing the sum of the squares of the differences between diagonally adjacent pixels. The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image [1][2].

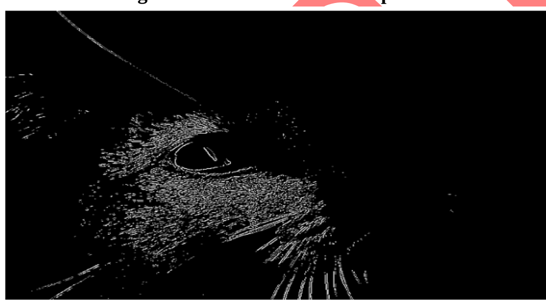
+1	0
0	-1

Gx

0	+1
-1	0

Gy

Fig.1 Masks used for Robert Operator



(e) Roberts method

The operator consists of a pair of 2×2 convolution kernels as shown in Figure 2. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator. These kernels are designed to respond maximally to edges running at 45° to the pixel grid, one kernel for each of the two perpendicular orientations. The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these Gx and Gy).

3) The Prewitt Detection: Prewitt operator is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. The Prewitt operator is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt operator is either the corresponding gradient vector or the norm of this vector. The Prewitt 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. The prewitt operator is limited to 8 possible orientations, however experience shows that most direct orientation estimates are not much more accurate. This gradient based edge detector is estimated in the 3x3 neighborhood for eight directions. All the eight convolution masks are calculated. One convolution mask is then selected, namely that with the largest module [4].

In simple terms, the operator calculates the gradient of the image intensity at each point, giving the direction of the largest possible increase from light to dark and the rate of change in that direction. The result therefore shows how "abruptly" or "smoothly" the image changes at that point, and therefore how likely it is that that part of the image represents an edge, as well as how that edge is likely to be oriented. In practice, the magnitude (likelihood of an edge) calculation is more reliable and easier to interpret than the direction

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calculation.

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

Gx

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

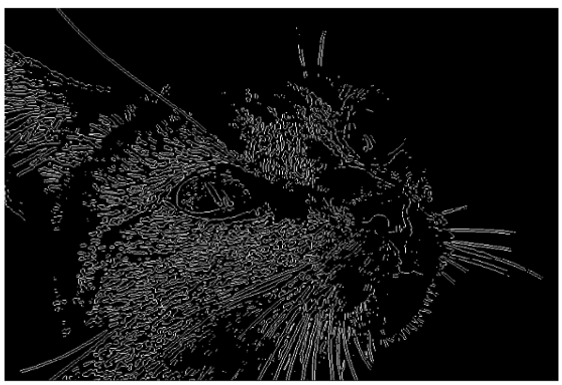
Gy

Fig.3 Masks for the Prewitt gradient edge detector

(b) Perwitt method

Mathematically, the gradient of a two-variable function (here the image intensity function) is at each image point a 2D vector 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. This implies that the result of the Prewitt operator at an image point which is in a region of constant image intensity is a zero vector and at a point on an edge is a vector which points across the edge, from darker to brighter values [2].

4) The Laplacian of Gaussian : The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian smoothing filter in order to reduce its sensitivity to noise, and hence the two variants will be described together here. The operator normally takes a single gray level image as input and produces another gray level image as output. In Laplacian of Gaussian edge detection there are mainly three steps (a) filtering, (b) enhancement and (c) detection. Gaussian filter is used for smoothing and the second derivative of which is used for the enhancement step. The detection criterion is the presence of a zero crossing in the second derivative with the corresponding large peak in the first derivative. In this approach firstly noise is reduced by convoluting the image with a Gaussian filter. Isolated noise points and small structures are filtered out [3] [4] [1].With smoothing; however; edges are spread. Those pixels, that have locally maximum gradient, are considered as edges by the edge detector in which zero crossings of the second derivative are used. To avoid detection of insignificant edges, only the zero crossings, whose corresponding first derivative is above some threshold, are selected as edge point. The edge direction is obtained using the direction in which zero crossing occurs. The Laplacian is therefore a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for



(d) Laplacian method

5) The Canny Technique:

The Canny operator was designed to be an optimal edge detector (according to particular criteria --- there are other detectors around that also claim to be optimal with respect to slightly different criteria). It takes as input a grey scale image, and produces as output an image showing the positions of tracked intensity discontinuities

(f) Canny method

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images. Most importantly, Canny also produced a computational theory of edge detection explaining why the technique works. The Canny edge detection algorithm is known to many as the optimal edge detector. Canny's intentions were to enhance the many edge detectors already out at the time he started his work. He was very successful in achieving his goal and his ideas and methods can be found in his paper, "A Computational Approach to edge Detection". He followed a list of criteria to improve current methods of edge detection.This was implemented because the first two were not substantial enough to completely eliminate the possibility of multiple responses to an edge. Based on these criteria, the canny edge detector first smoothes the image to eliminate and noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (no maximum suppression).The Canny Edge Detection Algorithm has the following steps (a)Smooth the image with a Gaussian filter,(b)Compute the gradient magnitude and orientation using finite-difference approximations for the partial derivatives,(c)Apply nonmaxima suppression to the gradient magnitude,(d)Use the double thresholding algorithm to detect and link edges. Canny edge detector approximates the operator that optimizes the product of signal-to-noise ratio and localization. It is generally the first derivative of a Gaussian. The Canny edge detector uses a filter based on the first derivative of a Gaussian, because it is susceptible to noise present on raw unprocessed image data, so to begin with, the raw image is convolved with a Gaussian filter. The result is a slightly blurred version of the original which is not affected by a single noisy pixel to any significant degree. The Canny algorithm contains a number of adjustable parameters, which can affect the computation time and effectiveness of the algorithm. The size of the Gaussian filter: the smoothing filter used in the first stage directly affects the results of the Canny algorithm. Smaller filters cause less blurring, and allow detection of small, sharp lines. A larger filter causes more blurring, smearing out the value of a given pixel over a larger area of the image. Larger blurring radii are more useful for detecting larger, smoother edges – for instance, the edge of a rainbow [4].

C. **Advantages and Disadvantages of Edge Detectors**

As edge detection is a fundamental step in computer vision, it is necessary to point out the true edges to get the best results from the matching process. That is why it is important to choose edge detectors that fit best to the application [1] [5]. In this respect, we first present some advantages and disadvantages of Edge Detection Techniques within the context of my classification are as below.

1) The Sobel and Prewitt Operators: The advantages and disadvantages are listed as below.

Advantages: These operators are chosen because of their simplicity and detection of edges and their orientations.

Disadvantages: These operators are often inaccurate and sensitive to noise too.

2) Laplacian of Gaussian: It has the following advantages and disadvantages –

Advantages: It finds the correct places of the edges and also tests wider area around the pixel.

Disadvantages: It usually shows malfunctioning at the corners, curves and where the gray level intensity function varies. Along with this it also does not find the orientation of edges because of the use of laplacian filter.

3) Canny Detector: Its advantages and disadvantages are listed below.

Advantages: Its biggest advantage is that it improves signal to noise ratio and detects better especially in noisy conditions. Also it uses probability for finding error rate and localization for response.

Disadvantages: Its computations are complex and show false zero crossing. Also it is very time consuming.

CONCLUSION

This paper clearly highlights that edge detection is an important pre-processing step in image analysis for object recognition and that the edge detection operators can have better edge effect under the circumstances of obvious edge and low noise. There are various edge detection methods in the domain of image edge detection, each having its own advantages and disadvantages. The performance of proposed edge detectors can be improved by applying different filtering technique throughout the image in a recursive way. The paper clearly details each technique for effective edge detection

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