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EDGE DETECTION TECHNIQUES IN IMAGE PROCESSING WITH ELABORATIVE APPROACH TOWARDS CANNY

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ABSTRACT

Edge is defined as the boundary pixels that connect two separate regions. Edges are local changes in the image intensity. Edges characterize boundaries and are therefore a problem of fundamental importance in image processing.. Edge detection plays a very important role in image processing The edges detected by algorithms are used by advanced computer vision,medical field,Brain Tumor detection,geologic formation extraction,biometrix and many more fields.In this article we are going to survey various edge detection techniques such as sobel, Prewitt, Robert,, Marr Hildrith and Canny operators.Althought each edge detection technique has its own merits and limitations .In this paper we would like to present various edge detection techniques with emphasis on Canny because the performance of canny edge detection technique is judged as the best in the field of image processing.

KEYWORDS:Edge, Edge detection ,pixel, Canny ,image intensity

INTRODUCTION

Edge detection is the concept for a set of mathematical methods whose aim is to identify the points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. Edges typically occur on the boundary between 2 regions[2]. Edge is defined as the boundary pixels that connect two separate regions[3] with changing image amplitude attributes such as different constant luminance and tristimulus values in an image. Edge detection is a well developed field on its own within image processing. The main features can be extracted from the edges of an image which significantly reduce the amount of data to be processed while preserving the important structural properties of an image[1].The example of an original image and image after edge detection are shown in Fig. 1 and Fig. 2 respectively below.

Fig .1 Original Image

Fig. 2 Image AfterEdge Detection

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Edge detection has major feature for image analysis. The process involves applying an edge detection algorithm to an image .The algorithm determines the presence of an edge or line in an image and outlines them in an appropriate way. Now this outline can be used in various i*mage processing applications.There are various edge detection techniques available in the literature such as sobel, Prewitt, Robert,, Marr Hildrith and Canny operators[4]. The Canny edge detector and various improvements in this edge detector since 1886 are considered the best and state-of-the-art edge detectors

LITERATURE SURVEY

As discussed above we know that there are various edge detection[6] techniques available for edge detection[2] but it is not always possible to obtain such ideal edges from real life images. A typical edge might for instance be the border between a block of pink color and a block of black . In contrast a line (a can be a small number of pixels of a different color on an otherwise unchanging background. There are various problems of fake edge detection, edge localization, missing true edges, problems due to noise and high computational time etc.Also it is being noted that the edge that is coming out of the edge detection technique is very much depended on edge density ,presence of noise , the various lighting conditions in which the original image was taken.

With keeping in mind all the above situations many researchers from time to time have investigated the problem of edge detection.The edge detection era is around 50 years old now .Various scientists,mathematicians,engineers and researchers have contributed in this field.Here we are presenting a literature survey of those edge detection techniques that have made a significant effect in edge detection paradigm.
Lets discuss the various Edge detection methods .They are mainly divided into following 2 categories :

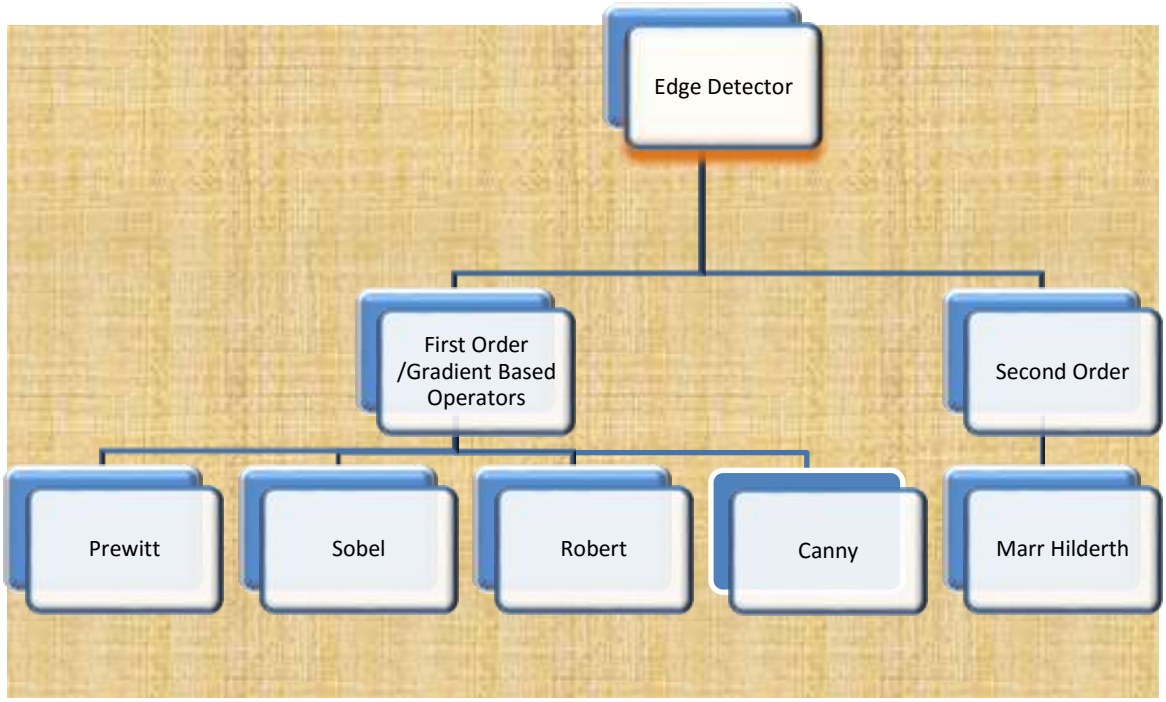

Fig. 3 Some of the Edge Detection Techniques

According to Fig. 3 the major 2 categories are first order and second order .
(1) Edge detection based on gradient operator(first order)
According to this concept the edge is the place where image gray value is changing rapidly, so the method based on the derivation of the gradient operator is most widely used.Example are Prewitt,Sobel,Robert,Canny etc. Here the

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derivatives $G_x$and G_y of the image in the x and y directions respectively are calculated .The Magnitued of the Gradient is calculated as $G= \sqrt{G_x^2 + G_y^2}$

Prewitt Edge Detection

The Prewitt edge detection was proposed by Prewitt in 1970 (Rafael C.Gonzalez [5]. To estimate the magnitude and orientation of an edge Prewitt is a correct way[9].This edge detector is estimated in the 3x3 neighborhood for eight directions. All the eight convolution masks are calculated. One complication mask is then selected, namely with the purpose of the largest module. One kernel is simply the other rotated by 90°. It uses 3 x3 kernels

Dx

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

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

D_y

Prewitt detection is slightly simpler to implement computationally than the Sobel detection, but it tends to produce somewhat noisier results.

Sobel Edge Detection

Sobel edge detection method[6] was introduced by Sobel in 1970 (Rafael C.Gonzalez (2004)). This method precedes the edges at those points where the gradient is maximum.[8] Here also 2 kernels that are of 3 x 3 size are used . One kernel is simply the other rotated by 90o.

D_x

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

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

D_y

Roberts Edge Detection

The Roberts edge detection[6] was introduced by Lawrence Roberts (1965). It performs a simple but yet very quick to compute, 2-D gradient . This method emphasizes regions of high spatial frequency which often correspond to edges. Here 2 kernels are used of size 2x 2

D_x

+1	0
0	-1

0	+1
-1	0

D_y

Canny Edge Detection

In the field of image processing since its evolvment the Canny edge detection technique is one of the standard edge detection techniques. This was first introduced by John Canny[4][5] for his Master's thesis at MIT in 1983, and still a pioneer and beats many of the newer algorithms that have been developed. This edge detection technique provides good detection, clear response and good localization. Canny stated 3 basic criteria[5] desired for any good edge detector(which he later followed in his development):

(a)Good detection: The algorithm should select as many real edges as possible in the original image.

(b)Good localization: The edges that are marked should be as close as possible to the edges in the real image.

(c) Minimal response: This criterion say that given edge in the image should only be marked once and noise should not create any false edges.

Canny proposed[1] a series of steps (5 steps) to implement this algorithms or technique.

Step 1:

This steps says that first filter out or remove any noise that may be present in the original image before applying further processing because if noise is not removed or minimized then the final edge detection output would be not accurate .There is a filter known as Gaussian filter which is used exclusively in the Canny algorithm. The larger the width of the Gaussian mask, the lower is the detector's sensitivity to noise.Mathematically we can say that if the input image is I and Gaussian filter is G then the smooth resultant image is given by

$$F= G * I$$

Step2:

This step says that we have to find out or detect the edges where the change in grayscale intensity is maximum.Here the sobel operator is used . Mathematically we can say that if the smoothed image obtained from step 1 is F then the Gradients in x and y directions respectively are given by

$G_{x=} D_x * F$ $G_{y=} D_y * F$

The magnitude of gradient or edge strength is $G= \sqrt{G_x^2 + G_y^2}$

The direction of gradient or edge direction is $Theta=\tan^{-1}(G_y/G_x)$

Step 3:

This step says that we have to relate this edge direction obtained in step 2 above to a manageable direction in the image so that it can be pointed out.For this purpose canny proposed following 4 rules of thumb

If Theta is between range 0^0 to 22.5^0 OR 157.5^0 to 180^0 it is set to 0^0

If Theta is between range 22.5^0 to 67.5^0 it is set to 45^0

If Theta is between range 67.5^0 to 112.5^0 it is set to 90^0

If Theta is between range 122.5^0 to 157.5^0 it is set to 135^0

Step 4:

This step says that after determining any of the 4 edge directions non-maximum suppression now has to be applied. Non-maximum suppression is used to trace along the edge in the edge direction and suppress any pixel value (sets it equal to 0) that is not considered to be an edge. The "non-maximal surpression" step keeps only those pixels on an edge with the highest gradient magnitude This will produce very thin line in the resultant image. Three pixels in a 3 × 3 around pixel (x, y) are examined such that[5]

If Theta = 0^0, then the pixels (x + 1, y), (x, y), and (x − 1, y) are examined.

If Theta = 45^0, then the pixels (x + 1, y + 1), (x, y), and (x − 1, y − 1) are examined.

If Theta = 90^0, then the pixels (x, y + 1), (x, y), and (x, y − 1) are examined.

If Theta = $135^{0\circ}$, then the pixels (x + 1, y − 1), (x, y), and (x − 1, y + 1) are examined.

If pixel (x, y) has the highest gradient magnitude of the three pixels examined, very importantly saying it is kept as an edge.

If one of the other two pixels has a higher gradient magnitude, then pixel (x, y) should not be kept as an edge .

Step 5:

This step which is the final step in canny says that we must use hysteresis[5],This step says that after step4 yet there are local maxima created by noise.So we make use of thresholds and not one but two thresholds T_{high} and T_{low} .

So for a single pixel which is under consideration and having gradient magnitude G following rules of thumb must be used to finally marke the single pixel as an edge.

If $G < T_{low}$ discard the edge.

If $G > T_{high}$ keep the edge.

If G is between T_{high} and T_{low} and any of its neighbors in a 3 ×3 region around it have gradient magnitudes greater than T_{high} keep the edge.

If none of pixel's neighbors have high gradient magnitudes but at least one falls between T_{high} and T_{low} search the 5 × 5 region to see if any of these pixels have a magnitude greater than T_{high} If so, keep the edge Else, discard the edge.

(2) Edge detection based on the optimum operator (second order)

The gradient of the image edge is the maximum value, that is, the inflection point of the gray image is the edge. From the mathematical point of view, inflection point of the second derivative of the function is 0.Detecting this point, whose second derivative is 0 is a way of edge detection.Examples are Marr Hilderth etc.

Marr-Hildreth Edge Detection

This was a very popular edge detection technique [7] before Canny proposed his algorithm. This technique uses the Laplacian to take the second derivative of an image. It works on zero crossing method. It uses both Gaussian and laplacian operator so that Gaussian operator reduces the noise and laplacian operator detects the sharp edges. The theory of this edge detection is based on two main ideas. First, one simplifies the detection of change of intensity by taking the image separately at different resolutions. The detection process can then be based on finding zero-crossings in a second derivative operator, which, in practice, can be the (non-oriented) Laplacian. The subsequent step, of combining information from different channels into a single description, rests on the second main idea of the theory, which was formulated as the spatial coincidence assumption[7].

The Marr–Hildreth operator, however, suffers from two disadvantages. It generates false edges and the localization error may be severe at curved edges.

RESULTS AND DISCUSSION

Up to this point we have known that edge detection is a fundamental and basic operation in image processing.We have surveyed various techniques so now we present some positive(pros) and negative points(cons) with repect to the surveyed techniques.

Table 1.Comparison table form various edge detection techniques

S.NO.	TECHNIQUE	POSITIVE POINTS	NEGATIVE POINTS
1	Prewitt ,Sobel	• Simplicity, • Detection of edges and their orientations	• Sensitivity to noise • Sometimes Inaccurate
2	Robert	• Simple • Quick to computer 2D gradient	• Sensitivity to noise • Often Inaccurate
3	Canny	• Excellent Edge Detection • GoodLocalization • Minmal response to noise	• Complex Computations • Time consuming
4	*Marr-Hildreth*	• Finds correct places of edges	• Malfunctioning at the corners • Inability to find the orientation of edge

CONCLUSION

In this paper we have discussed various popular and significant methods on edge detection in Image Proceesing field.Early methods like Prewitt,Sobel,Robert and Marr-Hildreth Edge Detection are discussed.Also the Canny Edge Detection method is discussed in great detail using elaborative approach. Amongst all the methods/techniques the Canny technique is superior to all edge detection methods so far. Although it was introduced in 1983 to 1986 but yet today it outperforms all the other methods available in market.Various improvements on no other methods but on canny have been discussed by the researchers from time to time.This alone is sufficient in proving the the canny method is the first choice.

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