Comparison of Edge Detection Techniques

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Comparison of Edge Detection Techniques

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***Abstract*- Image segmentation is the first pre-processing step for feature extraction in images. Edge Detection as an image segmentation technique has been widely used for a variety of applications such as Object detection and Recognition, Video Retrieval, Image Enhancement. This paper reviews the Canny edge detection algorithm and Sobel edge detection algorithm which are popularly used for image segmentation. Both of these proposed algorithms detect edges in image from video sequences. This paper demonstrates the experimental result of Canny edge detection and Sobel edge detection algorithm, compares both of them and shows how the Canny edge detection overcomes the drawbacks of Sobel operator. With the base of Canny, Sobel operator and the improvement, this paper discusses various aspects of edge detection for real-time application.**

***Keywords*- Image Segmentation, Object Detection and Recognition, Video Retrieval, Image Enhancement, Edge Detection, Canny operator, Sobel operator.**

I. INTRODUCTION

Image Processing has been evolved basically for two purposes. The first is for better interpretation of images by human and second is for data storage, analysis and transfer. There have been significant advances in the field of Image Processing. The applications of image processing have emerged in different fields like medical, security and surveillance, retrieval and much more. Various applications such as Feature extraction, Object detection and recognition, Image Analysis (X-ray scanning) have Image Segmentation as a pre-processing step [6] [10].

Image segmentation is the process of dividing the image into regions or segments which are dissimilar in certain aspects or features such as colour, texture or gray level [8]. Each region is a collection of pixels.

Image Segmentation can be done in many ways. Some of them are using region based segmentation (similarity detection), histogram based method and the edge detection algorithm (dissimilarity detection) [8] [10]. This paper discusses the edge based image segmentation.

II. EDGE DETECTION

Edge detection is a type of image segmentation technique where edges are detected in the image. Edges are introduced as a set of connected points lie on the boundary between two regions. The edges represent object boundaries and therefore can be used in image segmentation to subdivide an image into its basic regions or objects.

The image is simply a combination of different intensities, noise, etc. The local change of intensity in an image is edge. Edges divide the image in different segments or regions. Edges are boundary between segments or regions. Edge detection means extraction of information about the image. Examples are location, shape, size of object in image, image sharpening and enhancement.

As described by Y. Ramadevi in [8] the main steps in edge detection are Filtering, Enhancement and Detection. Edge detection produces a line drawing scene from image. Various important features like corners, lines, curves can be extracted from these lines. Extracted features can be used for recognition as a higher-level computer vision algorithm.

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 for the application.

There are many edge detection algorithms such as Canny edge detection, Robert, Prewitt, Sobel, Frie Chen edge detection algorithms[1][8]. Out of these algorithms, efficiency of Canny and Sobel edge detection algorithms is higher than other algorithms. This paper will discuss the Sobel and Canny operators in detail.

III. SOBEL EDGE DETECTION

The Sobel operator measures a 2-Dimensioanal spatial gradient on an image and gives more attention on regions of high spatial gradient corresponding to edges [1]. It is used for finding gradient magnitude at each point in a gray scale image.

One way to keep away from having the gradient computed about an interpolated point between the pixels is to use 3 x 3 neighbourhood for the gradient computation [5]. There are various pairs of Sobel operator such as 3×3, 5x5 convolution kernels.

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

G_x

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

G_y

Fig.1 3x3 Sobel mask

We can say,

G_y=Anticlockwise rotation (G_x)

We will get other kernel, i.e., G_y by rotating G_x in anticlockwise direction by 90°. These kernels work mostly on vertical and horizontal edges with reference to the pixel grid. The G_x kernel will work in the horizontal direction and the G_y is for vertical direction [3]. The kernels applied to the input image, produce separate gradient component measurements in each orientation (G_x and G_y). The |magnitude| of the gradient at every pixel and the direction of the gradient are computed by combining G_x and G_y together [3].

The gradient magnitude is given by:

$$|G|=\sqrt{G_x^2 + G_y^2}$$

And the approximate value of the Magnitude is calculated by:

$$| G | = | G_x| + | G_y|$$

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

Where, θ is angle of direction of the edge.

Input to the Sobel is a sample image. The expected output is efficient detection of object boundaries

A. Pseudo code algorithm:

The pseudo code algorithm as discussed in [5] is as follows:

Step1: Accept the sample input image.
Step2: Perform masking on given image.
Step3: Apply algorithm and the gradient.
Step4: On the input image perform mask manipulation in both the directions.
Step5: Find the absolute magnitude of the gradient. The absolute magnitude is the output edge.

B. Advantages:

The advantages as seen in [2] are:

1. Random noise of the image affected by smoothing effect of average factor.
2. Because of X-directional and Y-directional difference of the image improves element edge on both sides, therefore edge looks thick and bright.

IV. CANNY EDGE DETECTION

The canny edge detection algorithm was proposed to enhance the edge detection process. Three important criteria were taken into consideration for this purpose. The first and most important criterion was to detect all the important edges in the source image. This means the goal was to lower the error rate. The second criterion was that the edge points to be detected as close as possible to the true edge, also called as localization. A third criterion was not to have more than one response to a single edge. The first two were not significant enough to remove the possibility of more than one response to an edge due to which the third one was implemented.

The Canny edge detector was thus implemented on these criteria. It first smooths the image to eliminate noise. Then the image gradients are calculated to point out those regions where the gradient difference is maximum, which have high spatial differences. Finally, it then tracks along these regions and discards any pixel that weakly defines an edge (non-maxima suppression) in order to make the edges thinner. To further reduce the gradient array, it performs hysteresis which tracks along the remaining pixels that have minimum gray level values but have not been suppressed.

A. Working of Canny Edge algorithm:

The algorithm runs in 5 separate steps:

1) Smoothing: The input image must be converted into gray scale by adjusting contrast and brightness, so that the image is blurred to remove noise. Thus, the first step is to filter out the noise in the original image to make the location and detection edges efficient. Generally a Gaussian filter is used for noise removal [3].

2) Finding gradients: Edge pixels are those where there is a sharp change in gray level values, these are identified by computing the gradient of the image. The gradient is a unit vector which points in the direction of maximum intensity change. In this step first the vertical and horizontal components of the gradient are computed and then the magnitude and direction of the gradient is computed [6].

3) Non-maxima suppression: In this step the detector converts the thick edges in the image, based on the gradient magnitudes, to approximately thin and sharp edges which can be further used for recognition purpose. Mainly edge thinning is performed in non-maxima suppression. In this process the image is scanned along the edge direction and discards any pixel value that is not considered to be an edge which will result in thin line in the output image.

4) Double Thresholding: The threshold value consists of 2 characters, T1 = High Threshold, T2 = Low Threshold. The pixels having values of gray scale level higher than T1 are strong edge pixels, and the result is edge region. The pixels having values of gray scale level less than T2 are weak edge pixels, and the result is non-edge region. If the pixels have values of gray scale level between T1 and T2, the result is depending on the neighbouring pixels [9].

5) Edge tracking by hysteresis: Edges that do not connect to a very certain (strong) edge are discarded in the final output image. Strong edges are interpreted as “certain edges” and are included in the final edge image. Weak edges that are linked with strong edges are included in the output image.\

V. Comparison of Canny and Sobel Edge detection algorithm

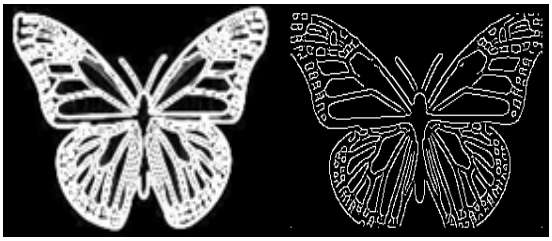
The main advantage of Sobel operator is its simplicity which is because of the approximate gradient calculation. On the other hand Canny edge detection has greater computational complexity and time consumption.

The major disadvantage of Sobel operator was the signal to noise ratio. With the increase in noise the gradient magnitude of the edges also degrades which produces inaccurate results. None of the Sobel, Perwitt, Roberts Cross operator was able to detect the appropriate edges, discarding the noise in the source image [4]. The Canny edge detection on the other hand has good signal to noise ratio. The non-maximal suppression results in thin edges. i.e., Single pixel wide edges in the output. The thresholding method provides good edge detection in Canny.

The gradient based operators detect thick and rough edges which did not give appropriate results in further matching process [4]. Due to this reason the non-maximal suppression was included in Canny for getting thin and smooth edges in the outputs.

The difference between Canny and Sobel becomes clear through the fig. 2 which shows the original image as well as the output image as produced by Canny and Sobel operators. The output of Sobel operator is a blurred image with edges being overlapped on the butterfly‘s texture. On the other hand the Canny operator gives a clear difference in edges that come under the texture.

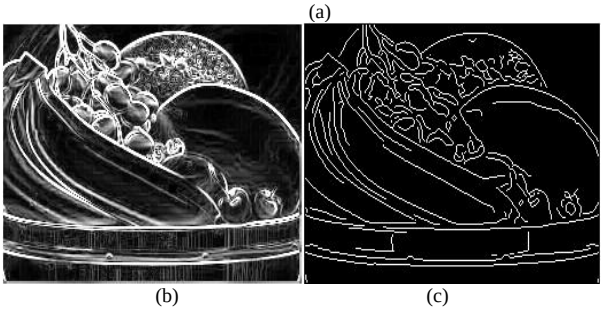
(a)



(b) (c)

Fig 2 Sample image for texture detection (a) Original image (b) Sobel output (c) Canny output

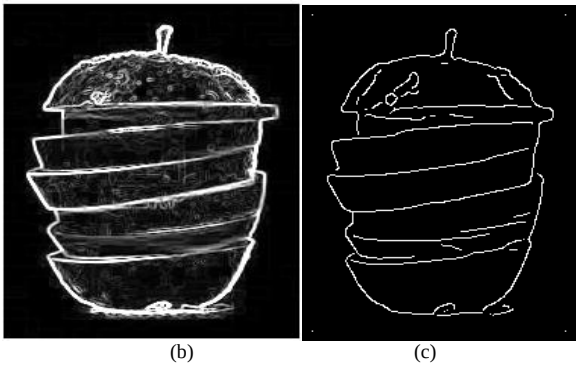
(a)



(b) (c)

Fig. 3 Sample images for complex image containing more objects (a) Original image (b) Sobel output (c) canny output

(a)



(b) (c)

Fig.4 Sample images for image containing minimum objects
(a) Original image (b) Sobel output (c) Canny output

VI. Result Analysis

The table 1 shows the overall summary of the operators and gives a crystal clear idea that each operator has its own advantages and disadvantages. Each is application specific. Thus the use of these operators is justified by the need of the application. Systems requiring fast computation without having to preserve minute details can use Sobel. Whereas, systems requiring accurate results and need to preserve maximum possible features can use Canny operator.

TABLE I

SUMMARY OF COMPARISON

Parameters	**Sobel**	**Canny**
Computation[5]	Simple and time efficient	Complex and time consuming
Signal to Noise ratio	Low	High
Texture based image Fig.2	Less efficient	More efficient
No of objects in image Fig.3, Fig.4	Suitable for simple images	Suitable for simple as well as complex images
Application area /domain [5] [6]	Massive data communication and data transfer	Medical field for X-ray diagnosis and object recognition

VII. Conclusion and Discussion

This paper gives the comparative study of Sobel and Canny edge detection methods. Both are popularly used operators for edge detection. Each is useful in specific domain. Sobel is useful for applications such as heavy data transfer in the form of images and videos. In these applications timely arrival of data is important which can be satisfied as Sobel gives faster performance in terms of computation. On the other hand, Canny is used for object recognition, and pattern matching purposes where it is necessary to retain the features even in case of noisy images. Every application has its own constraints and to meet them appropriate edge detection algorithm must be implemented to get the desired results.

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