Comparative Analysis of Various Edge Detection Techniques and Cancer Cell Detection using Sobel Algorithm

K. J. S Lorraine, K. Bala Teja, G. Durga Devi, K. Harika

Abstract- Image Edge detection significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. Since edge detection is in the forefront of image processing for object detection, it is crucial to have a good understanding of edge detection algorithms. In this paper, the comparative analysis of various Image Edge Detection techniques has been presented. It has been shown that the canny edge detection algorithm performs better than all these algorithms under almost all scenarios. However, it has been observed that under noisy conditions Sobel algorithm detect edges more clearly when compared to Canny. It has been also observed that Canny edge detection algorithm is computationally more expensive compared to Sobel, Prewitt and Robert's algorithms. Cancer is a disease characterized by uncontrolled growth of abnormal cells. Hence, it is necessary to detect the edges of cancer cells so that they can be easily subjected to radiation therapy without affecting the other blood cells. So, in this paper Sobel & Canny algorithms have been used to detect the boundaries of cancer cells. Sobel algorithm has detected the edges of cancer cells more clearly compared to Canny algorithm.

KEYWORDS: Kernels, Gradient, Roberts, Sobel, Prewitt, Canny.

I. 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 algorithms are available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection algorithm include Edge orientation, 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.

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Algorithms used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels. This results in less accurate localization of the detected edges. Not all edges involve a step change in intensity. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual change in intensity. The algorithm needs to be chosen to be responsive to such a gradual change in those cases. So, there are problems of false edge detection, missing true edges, edge localization, high computational time and problems due to noise etc. Therefore, the objective is to do the comparison of various edge detection algorithms and analyze the performance of the various algorithms in different conditions.

1.1 Roberts Algorithm

As a differential operator, the idea behind the Roberts 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. In order to perform edge detection with the Roberts operator we first we convolve the original image, with the following two kernels in horizontal and vertical directions. Gradient size of Roberts operator represents the edge strength of the edge and direction of the gradient and the edge are vertical. The operator edge has higher positioning accuracy, but it is easy to lose a part of the edge.

-1	0
0	1

0	-1
1	0

Fig 1: Roberts Operators

The gradient can then be defined as $I(x,y) = G(x,y) = (G_x^2 + G_y^2)^{1/2}$

The direction of the gradient can also be defined as follows
$\theta(x,y) = \arctan(Gy(x,y)/Gx(x,y))$

1.2 Prewitt Algorithm

The Prewitt algorithm is used in image processing, particularly in edge detection algorithms. Technically, it is a discrete differentiation algorithm, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Prewitt algorithm is either the corresponding gradient vector or the norm of this vector[3]. The Prewitt algorithm is based on convolving the image with a small, separable, and integer

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valued filter in horizontal and vertical directions.

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

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

Fig 2: Prewitts Operators

The gradient can then be defined as $I(x,y) = G(x,y) = (G_x^2+ G_y^2)^{1/2.}$

The direction of the gradient can also be defined as follows θ (x,y)=arctan (Gy(x,y)/Gx(x,y))

1.3 Sobel Edge Detection Algorithm

The Sobel edge detection algorithm performs a 2-D spatial gradient measurement on an image and so emphasizes regions of high spatial frequency that correspond to edges. Typically it is used to find the approximate absolute gradient magnitude at each point in an input gray scale image [5]. It is used to extract the edge. Each point in the image are the two nuclear convolutions. One checks maximum response of the vertical edge, and the other one checks maximum response of the horizontal edge. The maximum value of two convolutions will be referred as output value of the changing point. Sobel operator is easy to achieve in space, has a smoothing effect on the noise, is nearly affected by noise, can provide more accurate edge direction information but it will also detect many false edges.

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

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

Fig 3: Sobel Operators

The gradient can then be defined as $I(x,y) = G(x,y) = (G_x^2+ G_y^2)^{1/2}$

The direction of the gradient can also be defined as follows θ (x,y)=arctan (Gy(x,y)/Gx(x,y))

1.4 Canny Edge Detection Algorithm

Canny Edge Detection algorithm is optimal for a certain class of edges (known as step edges). It depicts a partially assembled pump, and the edge detection is a step in the process of estimating the pose (position and orientation) of the pump. Canny operator is based on three criteria. The basic idea uses a Gaussian function to smooth image firstly. Then the maximum value of first derivative also corresponds to the minimum of the first derivative. In other words, both points with dramatic change of gray-scale (strong edge) and points with slight change of greyscale (weak edges) correspond to the second derivative zero-crossing point. Thus these two thresholds are used to detect strong edges and weak edges.

II. CANCER CELL DETECTION

Cancer is a disease characterized by uncontrolled growth of abnormal cells. Cancer cells are cells that grow and divide at an unregulated, quickened pace. Although cancer cells can be quite common in a person they are only malignant when the other cells fail to recognize and/or destroy them. The body is made up of many types of cells. These cells grow and are controlled to produce more cells as they are needed to keep the body healthy. When cells become old or damaged, they die and are replaced with new cells. Sometimes this process of controlled production of cells goes wrong. When this happens, these cells do not die but form a mass of tissue called a tumor. It has been identified a range of Sobel threshold values from S_{min} to S_{max} that could be used to produce a reasonable estimate of the location of the leading edge of the spreading populations, it has been scaled these values so that they corresponded with a range of cell density contours, from C_{min} to C_{max}. Results indicate that varying the threshold S corresponds to a consistent variation in the spatial distribution of cell density in the spreading cell population.

III. RESULTS AND DISCUSSIONS

The following figures show the outputs for different edge detection techniques. Fig 4 shows the taken input colour image and fig 5 shows the converted grayscale image with Gaussian noise. Figures from 6 to 9 shows the outputs for Robets, Prewitts, Sobel, Canny algorithms respectively. In fig 10 the blue coloured cells are the affected cancer cells. Fig 11 shows the output for Canny algorithm .Fig 12 shows output for Sobel algorithm.

Fig 4

Fig 5

Fig 6

Fig 7

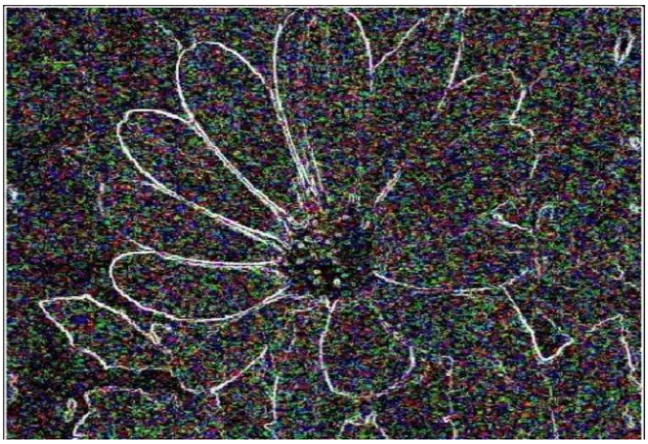

Fig 8

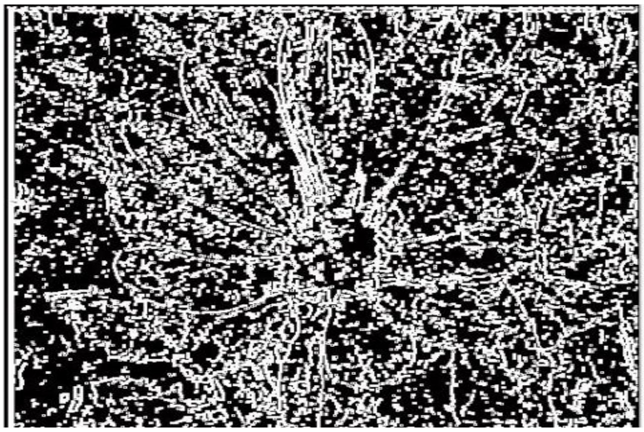

Fig 9

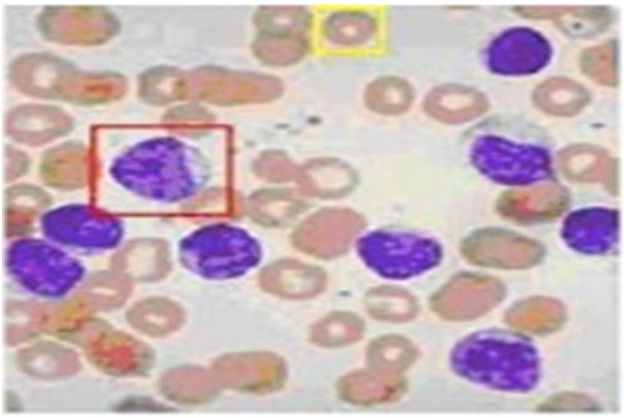

Fig 10

Fig 11

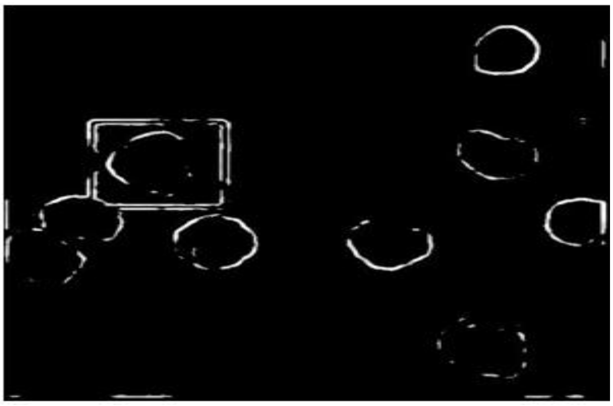

Fig 12

Fig: (4) Input image (5) grayscale image with noise (6) Roberts Output (7) Prewitt Output (8) Sobel Output (9) Canny Output (10) Cancer cell (11) canny output for cancer cell (12) sobel output for cancer cell

IV. CONCLUSIONS

Although the Sobel operator is slower to compute, it's larger convolution kernel smoothes the input image to a greater extent and so makes the operator less sensitive to noise. The larger the width of the mask, the lower its sensitivity to noise and the operator also produces considerably higher output values for similar edges. Sobel operator effectively highlights noise found in real world pictures as edges though the detected edges could be thick. The Canny edge detector and similar algorithm solved these problems by first blurring the image slightly then applying an algorithm that effectively thins the edges to one-pixel. This may constitute a much slower process, hence, Sobel operator is highly recommended in massive data communication found in image data transfer. 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 gradient approximation which it produces is relatively crude, in particular for high frequency variations in the image. From simulation results it has been observed that for threshold value of 100, edges can be detected more clearly. However, for a high intensity image such as cancer cells, cell boundaries can be detected clearly if the threshold value is 150.

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