Volume 4, Issue 10, October 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

A Comparison of various Filtering Methods for Edge Detection of Breast Cancer Cells

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***Abstract:** The aim of the present work is the implementation of various filters used in image processing and apply these filters in detecting the cancerous cells responsible for breast cancer. The present paper implies the edge detection techniques for the cancer cell detection purpose. Two operators in image processing are Gradient and Laplacian operators have been used and implemented. The case study deals with observation of breast cancer classification through Image Processing using the various filters which are mainly gradient based Roberts, Sobel and Prewitt edge detection operators, Laplacian based edge detector and Canny edge detector. The various aspects and the implementation of above mentioned filters has been put across in the present paper. The images and data sample have been taken from the American cancer society and an endeavor has been made for the detection of malignant cells responsible for cancer.*

***Keywords:** Canny, Laplacian, Prewitt, Robert, Sobel.*

I. INTRODUCTION

The filters are used in the process of identifying the image by locating the sharp edges which are discontinuous. These discontinuities bring changes in pixels intensities which define the boundaries of the object. The object is breast and a new methodology is applied to identify the breast type using its morphological features. Here, it is applied for different 2D filters, comparative studies and displays the result. In this edge detection method the assumption edges are the pixels with a high gradient. A fast rate of change of intensity at some direction is given by the angle of the gradient vector is observed at edge pixels.

In Fig. 1, an ideal edge pixel and the corresponding gradient vector are shown. At the pixel, the intensity changes from 0 to 255 at the direction of the gradient. The magnitude of the gradient indicates the strength of the edge. If we calculate the gradient at uniform regions we end up with a 0 vector which means there is no edge pixel. In natural images we usually do not have the ideal discontinuity or the uniform regions as in the Fig.1 and we process the magnitude of the gradient to make a decision to detect the edge pixels. The elementary processing is applied for a threshold. If the gradient magnitude is larger than the threshold, we decide the method in corresponds to the edge pixel. An edge pixel is described by using two important features, primarily the edge strength, which is equal to the magnitude of the gradient and secondarily edge direction, which is equal to the angle of the gradient. Actually, A gradient is not defined at all for a discrete function, instead the gradient, which can be defined for the ideal continuous image is estimated using some operators. Among these operators "Roberts, Sobel and Prewitt" are gradient based edge detector.

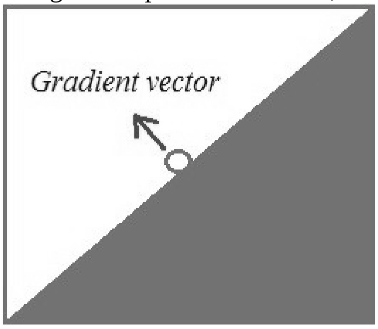

Fig.1 The gradient and an edge pixel. The circle indicates the location of the pixel.

. We apply the Laplacian based edge detection in the sample of breast cancer and identify its type. The noise which is present in the image should be filtered out before edge detection [8]. To achieve this, “Laplacian of Gaussian” is used. This method combines Gaussian filtering with the Laplacian for edge detection. In Laplacian of Gaussian edge detection uses three steps in its process. The First one is filter which is the image object. Secondly, it enhances the image object and finally detects. That can be identified through the breast cancer type case study. Here, Gaussian filter is used for smoothing the image**.** In this approach, at first the noise is reduced by convoluting the image with a Gaussian filter [4].

A morph is constructed using individual selected points which will work better. It also should be noted that this method suffers the same drawbacks as the previous method, due to large contrast between images and the inability to handle the large translations of features[15].

Laplacian Edge Detection

It wishes to build a morphing algorithm which operates on Features extracted from target images automatically. It can be a good beginning to find the edges in the target images.

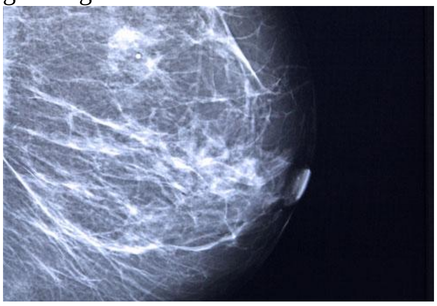

Fig.2 The two dimension Laplacian of Gaussian(LoG)

In this the LoG mainly uses two methods which are mathematically similar. At first, let us convolve the image object with Gaussian smoothing filter and then compute with the Laplacian result. Secondly, we shall convolve the image object with the linear filter which is the Laplacian of the Gaussian filter. This is also the case in the LoG. Smoothing (filtering) is performed with a Gaussian filter. The enhancement is done through transforming edges into zero crossings and the detection is done by detecting the zero crossings for the various samples of breast images primarily to identify its type.[17].

II. METHODOLOGY

There are many ways to perform the edge detection. However, it may be grouped into two categories, that are gradient and Laplacian. The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image. The Laplacian method searches for the zero crossings in the second derivative of the image to find edges. This below Fig shows the edges of an image detected using the gradient method (Roberts, Prewitt, Sobel) and the Laplacian method (Canny filter). It can compare the feature extraction using the Sobel edge detection with the feature extraction using the Laplacian [3]. It seems that although it is better for some features but it still suffers from mismapping some of the lines. A morphological approach is constructed using individual selected points which will work better.

2.1 Robert Filter

The Roberts cross operator is used in image processing and computer vision for edge detection.. 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.

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. 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 operator consists of a pair of 2×2 convolution kernels as shown in Figure 2. One kernel is simply the other rotated by 90°[4]. This is very similar to the Sobel operator. The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. 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 operator consists of a pair of 2×2 convolution kernels as shown in Figure 2.1. One kernel is simply the other rotated by 90°. This is very similar to the Sobel operator.

+1	0
0	-1

Fig(a)

0	+1
-1	0

Fig(b)

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*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient. The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

|G|=|Gx|+|Gy

The angle of orientation of the edge giving rise to the spatial gradient is given by:

ϕ=arc tan(Gx/Gy)

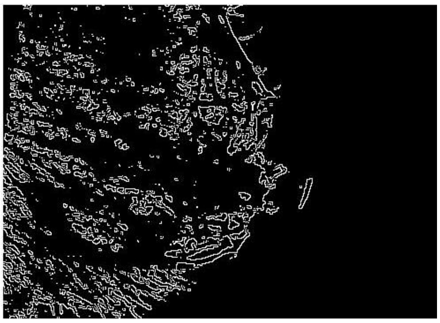

Fig.2.1 Robert Filter

2.2 Sobel Filter

The operator consists of a pair of 3×3 convolution kernels.

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid, one kernel for each of the two perpendicular orientations.

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

Fig(c)

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

Fig(d)

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*). These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient [3]. The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

$|G|=|Gx|+|Gy|$

The angle of orientation of the edge giving rise to the spatial gradient is given by:

$\phi=\arctan(Gx/Gy)$

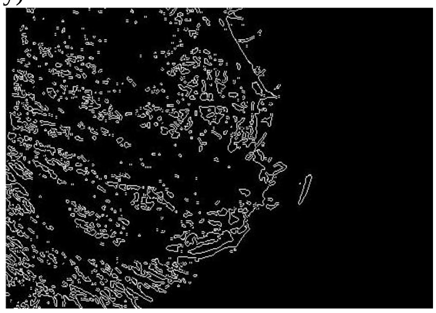

Fig.2.2 Sobel Filte

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. 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 [1]. The operator 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.

2.3 Prewitt's Filter

Prewitt's operator [5] is similar to the Sobel operator and is used for detecting vertical and horizontal edges in images. 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 directions 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.

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define A as the source image, and GX and GY are two images which at each point contain the horizontal and vertical derivative approximations, the latter are computed as:

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

Fig(e)

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

Fig(f)

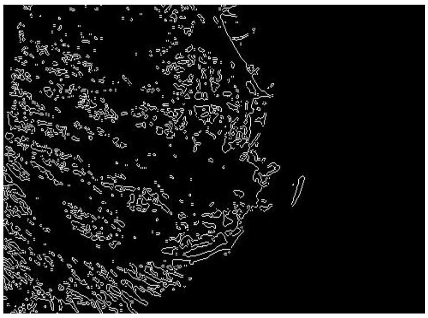

Fig.2.3 Prewitt's Filter

2.4 Laplacian of Gaussian Filter

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. The operator normally takes a single gray level image as input and produces another gray level image as output. The Laplacian L(x,y) of an image with pixel intensity values l(x,y) is given by:

$L(x,y)=\partial^2 I/\partial x^2 + \partial^2 I/\partial y^2$

The Laplacian of an image L(x,y) with pixel intensity values l(x,y) is given by this equation.

1	1	1
1	-8	1
1	1	1

Fig(g)

-1	2	-1
2	-4	2
-1	2	-1

Fig(h)

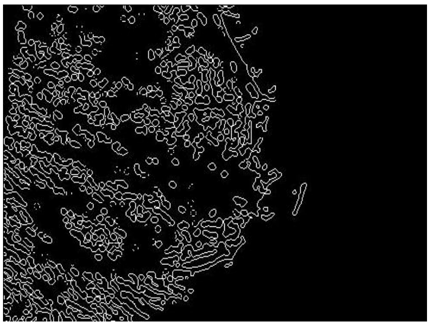

Fig.2.4 Laplacian of Gaussian Filter

2.5 Canny Edge Detection Algorithm

The Canny edge detection algorithm is known to many as the optimal edge detector. Canny's intentions were to enhance the many edge detectors. "A Computational Approach to Edge Detection"[11]. In his paper, he followed a list of criteria to improve current methods of edge detection. The first and most obvious is low error rate. It is important that edges occurring in images should not be missed and that there be no responses to non-edges. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum. A third criterion is to have only one response to a single edge. 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 the 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 (non maximum suppression). The gradient array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds and if the magnitude is below the first threshold, it is set to zero (made a non edge). If the magnitude is above the high threshold, it is made an edge. And if the magnitude is between the 2 thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a gradient.

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

Gx

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

Gy

The magnitude or edge strength,of the gradient is then approximated using this formula:

$$G|=|Gx|+|Gy|$$

The direction of the edge is computed using the gradient in the x and y directions. However, an error will be generated when sumX is equal to zero. So in the code there has to be a restriction set whenever this takes place.

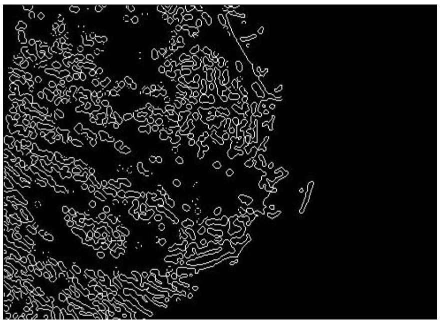

Fig.2.5 Canny Filter

III. COMPARISON OF VARIOUS FILTERS

Edge detection of all five types of filters was performed on Figure [3]. Canny yielded the best results. This was expected as Canny edge detection accounts for regions in an image. Canny yields thin lines for its edges by using non-maximal suppression. Canny also utilizes hysteresis with thresholding.

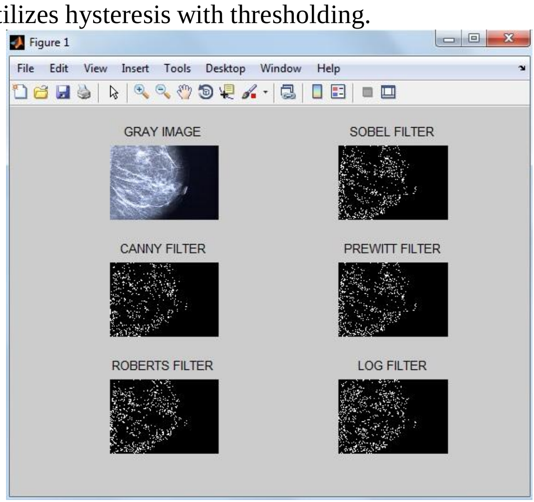

Fig.3 Comparison of all the filters techniques

As edge detection is a fundamental step in computer version. 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. In this respect, we first present some advantages and disadvantages of Edge Detection Techniques classical sobel operator, prewitt operator is responsible for their simplicity as well as detection edges and orientation. It is sensitive to noise too.

IV. CONCLUSIONS

The edge detection is the primary step in identifying an image of an object, so it is essential to know the advantages and disadvantages of each edge detection filters. In the present paper we have adopted edge detection techniques of Gradient-based and Laplacian based. Edge Detection Techniques are compared with case study of identifying the breast cancer cell. It has been observed that the Gradient-based algorithms have major drawbacks in sensitive to noise. The performance of the Canny algorithm relies mainly on the changing parameters. The size of the Gaussian filter is controlled by the greater value and the larger size. The larger size produces more noise, which is necessary for noisy images, as well as detecting larger edges. Canny's edge detection algorithm is more costly in comparing to Sobel, Prewitt and Robert's operator. Even though, the Canny's edge detection algorithm has a better performance instead of all the others filters. Canny filter is responsible for improving signal to noise ratio as well better detection capability. The evaluation of the images showed that under the noisy conditions, Canny, LoG, Sobel, Prewitt, Roberts's are exhibited better performance, respectively. The various methodologies of using edge detection techniques namely the Gradient and Laplacian transformation. It seems that although Laplacian does the better for some features, it still suffers from mismapping some of the lines.

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