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Edges Detection on Chromosome Image for Segmentation

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Abstract
Edge detection of chromosome in G-band type image is an important preprocessing step in segmentation. A chromosome type G-band image is generally very noise and poor image quality, lack of contrast and hold in image. Edge detection is one of the most commonly used operations in image analysis, and there are probably more algorithms in the literature for enhancing and detecting edges than any other single subject. The reason for this is that edges form the outline of an object. This paper presents analysis of evaluation chromosome G-band image edge detection. It has been appeared in literature that there are 5 different techniques, i.e. Canny, Laplacain, Robert's, Prewitt and Sobel, on chromosome image type Gband.
Keywords—*Edge detection,Chromosome, Chromosome analysis,Image processing,Karotyping.*

I. INTRODUCTION

Edge detection refers to the process of identifying and locating sharp discontinuities in an 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.

Human chromosome analysis is an essential task in cytogenetics, especially in prenatal screening and genetic syndrome diagnosis, cancer pathology research and environmentally induced mutagen dosimetry [1]. Cells used for chromosome analysis are taken mostly from amniotic fluid or blood samples. The stage at which the chromosomes are most suitable for analysis is the metaphase . One of the aims of chromosome analysis is the creation of a karyotype, which is a layout of chromosome images organized by decreasing size in pairs . The karyotype is obtained by cutting chromosome images from a photograph of a cell, taken using a microscope, and arranging the chromosomes into their appropriate places on the layout according to their visual classification by the cytotechnician.

Karyotyping is a useful tool for detecting deviations from normal cell structure. Abnormal cells can have an excess or deficit of a chromosome and/or structural defects, like breaks, fragments or translocations (exchange of genetic material between chromosomes). However, even today, chromosome analysis and karyotyping are performed manually in most cytogenetic laboratories in a repetitive, time consuming and therefore expensive procedure.

The current system for automatic chromosomes classification uses the image of edge is a fundamental feature. Edge is cause by changes in some physical properties of surfaces of the image. Most of research on image edge feature is always focusing on the detection and extraction method. The goal of edge detection is to recover the information about shapes and reflectance, or transmittance in images [2]. Heydarian et al. [3] proposed a novel method to detecting object edge in MR and CT images, which this method is applying an edge detection method based on the canny algorithm. Mondal et al. [4] applied the canny edge detection algorithm to detect edge information from the cephalograms images. Yo and Acton [5] proposed an automatic edge detection in ultrasound imagery based on normalized gradient and Laplacian operators.

II. MATERIALS AND METHODS

An edge is the boundary between an object and the background, and indicates the boundary between overlapping objects. This means that if the edges in an image can be identified accurately, all of the objects can be located and basic properties such as area, perimeter, and shape can be measured. Since computer vision involves the identification and classification of objects in an image, edge detections is an essential tool. In this paper, we have compared several techniques for edge detection in image processing.

Laplacian Operator

Laplacian operator , for a function(image) f(x,y) of two variables, is defined as defined as

$$\nabla^2 f = \frac{\partial^2 f}{\partial^2 x} + \frac{\partial^2 f}{\partial^2 y} \tag{1}$$

In the x-direction, we have

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y) \tag{2}$$

and similarly in the *y*-direction we have

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y) \quad (3)$$

Therefore ,it follows from the preceding three equations that the discrete Laplacian of two variable is

$$\nabla^2 f(x, y) = f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1) - 4f(x, y) \quad (4)$$

Figure 1 shows the filter mask used to implement this definition.

0	1	0
1	-4	1
0	1	0

1	1	1
1	-8	1
1	1	1

Fig 1 Filter mask of Laplacian operator

Because the Laplacian is a derivative operator, its use highlights intensity discontinuities in an image and deemphasizes regions with slowly varying intensity levels. This will tend to produce images that have grayish edge lines.

Robert's Cross Operator

When diagonal edge direction is of interest, we need a 2-D mask. The Robert's cross operators[8] are one of the 2-D masks with a diagonal preferences. For finding edge strength and direction at location (*x*,*y*) of an image ,*f*,is the gradient, denoted by and defined as

∇f

$$\nabla f \equiv grad(f) \equiv \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \quad (5)$$

The magnitude of vector ∇f, denoted as M(x,y),where

$$M(x, y) = mag(\nabla f) = \sqrt{g_x^2 + g_y^2} \quad (6)$$

is the value of the rate of change in the direction of the gradient vector.

The direction of the gradient vector is given by the angle

$$\alpha(x, y) = \tan^{-1}\left[\frac{g_y}{g_x}\right] \quad (7)$$

measured with respect to the x-axis.The figure 2 shows the filter mask of theRobert's Operator.

-1	0
1	1

0	-1
1	0

Fig 2 Filter mask of Robert's Cross operator

Prewitt Operator

$$g_x = \frac{\partial f}{\partial x} = (z_7 + z_8 + z_9) - (z_1 + z_2 + z_3)$$

$$g_y = \frac{\partial f}{\partial y} = (z_3 + z_6 + z_9) - (z_1 + z_4 + z_7) \quad (8)$$

In these formulations, the difference between the third and the first rows of the 3x3 region approximates the derivative in the x-direction, and the difference between the third and first columns approximate the derivative in the y-direction. Equation (8) can be implemented over an entire image by filtering *f* with the two masks in fig.3

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

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

Fig 3 Filter mask of Prewitt Operator

Sobel Operator

A slight variation of the preceding Equation uses a weight of 2 in the center coefficient:

$$g_x = \frac{\partial f}{\partial x} = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$

$$g_y = \frac{\partial f}{\partial y} = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7) \quad (9)$$

The idea behind using a weight value of 2 in the center coefficient is to achieve some smoothing by giving more importance to the center point.Figure 4 shows the masks used to implement equation (9).

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

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

Fig 4 Filter mask of Sobel Operator

Canny Operator

Canny appro ach is consists of the following basic steps:

(1)Smooth the input image with a Gaussian filter.

(2)Compute the gradient magnitude and angle images.

(3)Apply nonmaxima suppression to the gradient magnitude image.

(4)Use double thresholding and connectivity analysis to detect and link edges.

The mathematical specific description:

Let f(x,y) denote the input image and G(x,y) denote the Gaussian function:

$$G(x,y) = \exp^{-\frac{x^2+y^2}{2\sigma^2}} \tag{10}$$

We formed a smoothed image , $f(x,y)$ by convolving G and f :

$$f_s(x,y)=G(x,y) * f(x,y) \tag{11}$$

This operation is followed by computing the gradient magnitude and direction:

$$M(x,y) = \sqrt{g_x^2 + g_y^2}$$

$$\alpha(x,y) = \tan^{-1}\left[\frac{g_y}{g_x}\right] \tag{12}$$

with $g_x = \partial f_s/\partial x$ and $g_y = \partial f_s/\partial y$

Let d_1, d_2, d_3 and d_4 denote the four basic edge direction for a 3x3 region:horizontal,-45^0,vertical and +45^0 . We can formulate the following nonmaxima suppression scheme for a 3x3 region centered at every point (x,y) in $\alpha(x,y)$:

1.Find the direction d_k that is closest to $\alpha(x,y)$.

2.If the value of $M(x,y)$ is less than at least one of its two neighbors along d_k, let $g_N(x,y)=0$ (suppression); otherwise ,let $g_N(x,y) = M(x,y)$ where $g_N(x,y)$ is the nonmaxima-suppressed image.

The last step of the algorithm is to threshold the candidate edges in order to keep only the significant ones. Canny suggests hysterics threshold instead of a global threshold values. The high threshold is used to find "seeds" for strong edges. These seeds are grown to as long as an edge as possible, in both directions, until the edge strength falls below the low threshold value[7].

III. IMPLEMENTATION AND RESULTS

Fig.5 shows the flowchart of chromosome edge detection. This approach is applied as follows: Mainly it is divided into four main steps the first step is to apply preprocessing techniques that includes reducing the noise and adjust the image intensity by preserving image information in it. Secondly ,the other method of edge detection was applied to edge to detect the chromosome image.

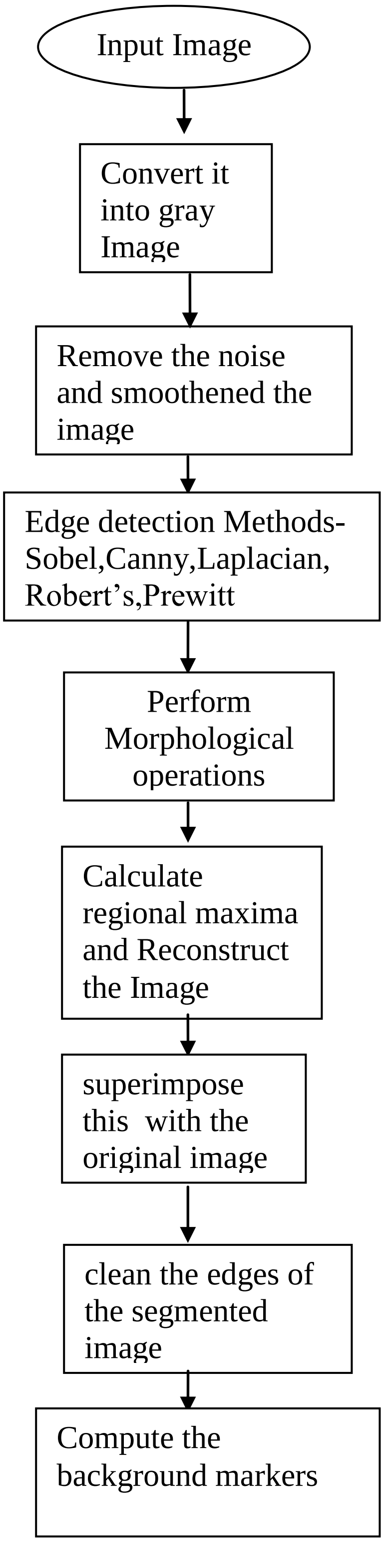

Fig.5 The flowchart of chromosome edge detection.

The next step is pre segmentation processes that includes various morphological [6] operations

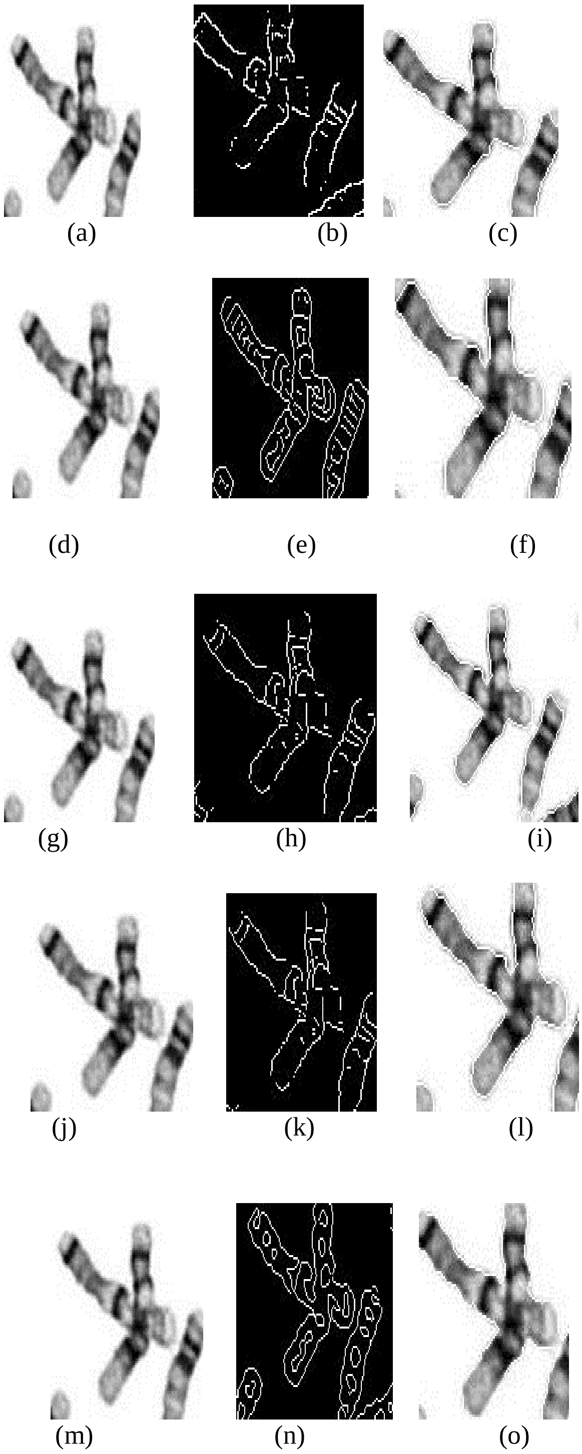

Fig 6 Original images (a),(d),(g),(j) and (m), Edge Operators (b)Roberts, (e)Canny,(h)Sobel,(k)Prewitt and (n)Laplacian Segmented images (c),(f),(i),(l) and (o).

such as finding out regional maxima and mark the foreground objects that help in segmentation process. Then after marking the foreground objects reconstruct the image. In the last step we did the main task of our process that is segmentation. After reconstructing the image we superimpose it with the original image, clean the edges of the segmented image and compute background markers.The method was compared with five traditional methods; Robert's,Canny, sobel Prewitt and Laplacian methods. 30 chromosome spread images are test in our experiment. Figure 6 shows the original image and other figure shows the results comparing between the five methods for edge detection on chromosome cells as well as segmented image.

IV. CONCLUSION

From the result we can say that the Canny method is better than other four algorithms, where as the segmented image of Robert's method is better than the Canny method. Segmentation results are visually acceptable and almost identical segmentation results can always be obtained. The method can be successfully applied for edge detection of boundaries of chromosome image model, specifically as described above for chromosome G-band images. However, we believe that it can be easily applied to several other applications not only chromosome G-band images but generally computer graphics.

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