Comparative Study Of Edge Detection Algorithms on Medical Images

K.K. Thanammal[1] and J.S. Jaya Sudha[2]

[1]Department of MCA, S.T.Hindu College, Nagercoil, India.
[2]Computer Science and Engineering,
Sree Chitra Tirunal College of Engineering, Tiruvananthapuram, India.

Detection of edge is a terminology in image processing and computer vision particularly in the areas of feature detection and extraction to refer to the algorithms which aims at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. Edge is a basic feature of image. The image edges include rich information that is very significant for obtaining the image characteristics by object recognition. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. So, edge detection is a vital step in image analysis and it is the key of solving many complex problems. This paper, describes edge detection algorithms for image segmentation using various computing approaches which have got great fruits. Experimental results prove that Canny operator is better than Prewitt and Sobel for the selected image. Subjective and Objective methods are used to evaluate the different edge operators. The performance of Canny, Sobel and Prewitt Edge Detection are evaluated for detection of edges in digital images.

Key words: edge detection, mathematical morphology, feature detection

Edge detection is a fundamental tool, which is commonly used in many image processing applications to obtain information from images and frames[1]. The separation of the image into object and background is a critical step in image interpretation[2]. An edge may be regarded as boundary between two dissimilar regions in image; edge detection is a terminology in image processing and computer vision, particularly in areas of feature detection and feature extraction. Mathematical morphology is a tool for extracting image Components that is useful in representation and description of region shape, such as boundaries, skeletons and convex hull. The technique was originally developed by Mather on and Serra at Ecole des mines in Paris. The language of mathematical morphology is set theory and sets in mathematical morphology represent objects in an image. Mathematical morphology is a set theory of image transformations and image functional. Morphological operations are based on simple expanding and shrinking operations. Mathematical morphology examines the geometrical structure of an image by probing it

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* To whom all correspondence should be adressed.
jayasudhajs@gmail.com

with small patterns, called 'structuring element', of varying sizes and shapes. This procedure results in non-linear image operators which are well suited to explore geometrical and topological structures. They do provide the strong visual clues that can help the recognition process.

Edge detection produces an edge map that contains important information about the image. Edge detection is difficult in noisy images, since both the noise and the edges have high frequency. Noisy images are typically larger in scope, so they pixels. This result is 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 object boundaries defined by a gradual change in intensity[3]. The operator needs to be chosen to be responsive to such a gradual change in those cases. So, there are problems due to noise etc. Therefore, the objective is to compare various edge detection techniques and analyze their performance in different conditions.

The rest of the paper is organized as follows. In section 2, the types of edges, edge detection operators Robert's operator, sobel operator, zero crossing operator, Laplacian operator, Gausian edge detector, prewitt operator, Canny operator. In section 3, the results of edge detection on lung CT scan images. In section4,comparision graph of edge detection operators. In section5 concludes the paper.

Edge Detection For Image Segmentation

There are many techniques in the literature used for edge detection some of them are based on error minimization, maximizing an object function, fuzzy logic, wavelet approach, morphology, genetic algorithms, neural network and Bayesian approach.

Color image segmentation techniques can be roughly classified into four types such as histogram based approaches, neighborhood based approaches, clustering based approaches and hybrid based approaches. Histogram thresholding is widely accepted and easily computable technique in which the images are composed of regions with different gray level ranges. The main disadvantage of this technique is the lack of spatial relationship information of the pixels. The neighborhood based approach applies the uniformity criteria to segment the image i.e., the neighboring pixels within the region should have similar values in intensity, color or texture. E.g. Region based techniques. Clustering based approach uses a fuzzy logic to define membership of the pixels. Hybrid based techniques improve the segmentation result by combining all above methods for segmentation[4] CT scan is more appropriate for showing the detailed information of the parts of human body and it is used for various applications such as detection, classification etc. The analysis of lungs in CT image is used to detect the airway and the vessel present in the lungs[5].

Types of Edges
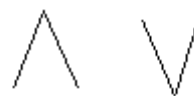
(a) Convex roof edge   (b) Concave roof edge

(c) Concave ramp edge   (d) Step edge

(e) Bar edge

Edge Detection Operators
The Roberts Detection

In Robert cross algorithm the horizontal and vertical edges bring out individually and then they put together for the resulting edge detection.

Table1. The Roberts Detection

+1	0	Gx
0	-1	

0	+1
-1	0

Gy

The two individual images Gx and Gy are combined using the approximation equation G = Gx + Gy or by using G=sqrt (Gx * Gx + Gy* Gy) to get the exact magnitude values. As the Roberts Cross Kernels are relatively small, they are highly susceptible to noise

Sobel Edge Detection

The Sobel edge detection technique is similar to that of the Robert Cross algorithm. Despite the design of Sobel and Robert are common, the main difference is the kernels that each uses to obtain the image is different. The Sobel Kernels are more suitable to detect edges along the horizontal and vertical axis whereas the Robert's able to detect edges run along the vertical axis of 45^0 and 135^{02}

Table 2. Sobel Edge Detection

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

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

Zero Crossing

It uses second derivative and it includes Laplacian operator. It is having fixed characteristics in all directions and sensitive to noise. Haralick proposed the use of zero-crossing of the second directorial derivative of the image intensity function.

Laplacian of Gaussian (LOG)

It was invented by Marr and Hilderth (1980).The Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It finds the correct place of edges and testing wider area around the pixel. The disadvantage of LOG operator is that it cannot finds orientation of edge because of laplacian filter[5].

Gaussian Edge Detectors

Since it reduces the noise by smoothing the image, it gives better results in noisy environment. The noteworthy operators are Canny and ISET (Shen-Castan). It is very time consuming and very complex for computation.

Prewitt Edge Detector

Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edge in images. The strength of the edge at given location is then the square root of the sum of the squares of two derivatives.

Canny Edge Detector

The popular edge detection algorithm Canny was first presented in 1986. The problem with this type of traditional edge detection approach is that a low threshold produces false edges, but a high threshold misses important edges. First requires that the image be smoothened with a Gaussian mask, which cuts down significantly on the noise within the image. Then the image is run through the Sobel algorithm and as discussed before, this process is hardly affected by noise. Lastly, the pixel values are chosen based on the angle of the magnitude of that pixel and its neighboring pixels. Unlike Roberts Cross and much like Sobel, the canny operation is not very susceptible to noise. If the Canny detector worked properly it would be the superior to both Sobel and Roberts Cross, the only drawback is that it takes more time to compute.

The steps in the Canny edge detector are as follows:

Smooth the image with a two dimensional Gaussian. In most cases the computation of a two dimensional Gaussian is costly, so it is approximately by two one dimensional Gaussians, one in the X direction and the other in the Y direction.

Take the gradient of the image. This shows changes in intensity, which indicates the presence of edges. This actually gives two results, the gradient in the X direction and the gradient in the direction.

Non-maximal suppression. Edges will occur at points where the gradient is at a maximum. Therefore, all points not at a maximum should be suppressed. In order to do this, the magnitude and the direction of the gradient is computed at each pixel. Then for each pixel check if the magnitude of the gradient is greater at one pixel's distance away in either the positive or the negative direction perpendicular to the gradient. If the pixel is not greater than both, suppress it.
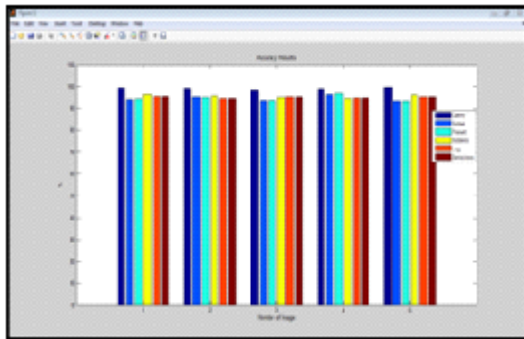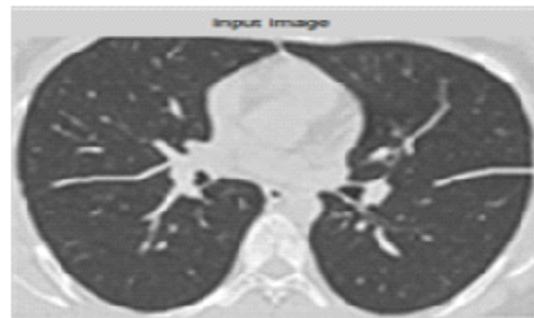
Fig. 2. Comparison of edge detectors

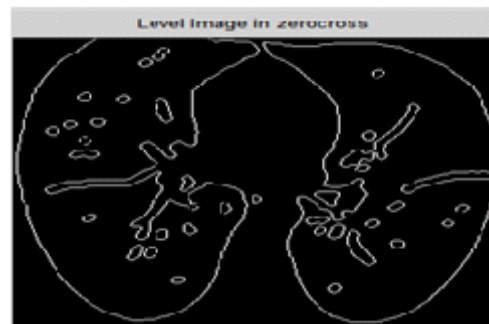**Fig. 3.** Input Image

Fig. 4. Level Image in log

Fig. 5. Level Image in zero cross

Fig. 6. Level Image in Robert
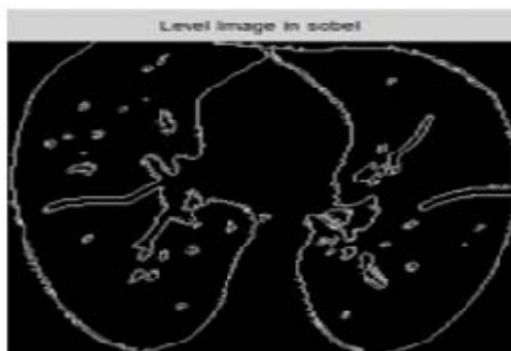

Fig.7. Level Image in Canny

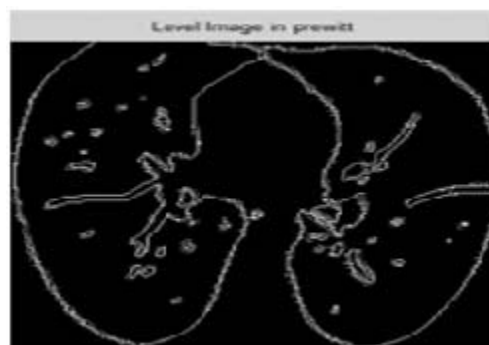**Fig. 8.** Level Image in Sobel

Fig. 9. Level Image in Prewitt

Edge Thresholding. The method of thresholding used by the Canny Edge Detector is referred to as "hysteresis". It makes use of both a high threshold and a low threshold. If a pixel has a value above the high threshold, it is set as an edge pixel. If a pixel has a value above the low threshold and is the neighbor of an edge pixel, it is set as an edge pixel as well. If a pixel has a value above the low threshold but is not the neighbor of an edge pixel, it is not set as an edge pixel. If a pixel has a value below the low threshold, it is never set as an edge pixel.

Mathematical Morphological Operators

Mathematical Morphology is one of the most productive areas in image processing[6]. The content of mathematical morphology is based on the set theory. A structuring element is a special mask filter that enhances input images. It can be of different sizes and of different shapes (square, diamond, and circle). Following are the main mathematical morphological operators:

1. Dilation
2. Erosion
3. Opening
4. Closing

1. Dilation

Dilation is defined as maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. Dilation process expanding image objects by changing pixels with value of"0" to "1".

Erosion

Erosion is just opposite to dilation. It is defined as the maximum value in the window. The image after dilation will be darker than the original image. It shrinks or thins the image. Erosion process shrinking objects or images by changing pixels with a value of"1" to "0".

Opening and Closing

Both parameters are formed by using dilation and erosion. In opening, firstly image will be eroded and then it will be followed by dilation. And in case of closing, firstly image will be dilated and then followed by erosion.

CONCLUSION

From the simulation results, it is concluded that the edge detection using mathematical morphology is more efficient than the traditional methods. From the results and comparison of the different methods of edge detection, it is concluded that the mathematical morphological edge detection is better than the traditional method. In this work, edges of images using mathematical morphological and traditional method like Sobel, Canny, Prewitt and Laplician of Gaussian method has been studied and compared on subjective basis as well as objective manner.

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