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AUTOMATIC BLOOD VESSELS DETECTION IN RETINAL IMAGE USING EDGE DETECTION TECHNIQUES

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Abstract Image Processing is a method for performing operations on an image with a goal of getting an improved image. It is likewise used to mining to get the hidden information in an image. Edge detection is the technique for finding the boundaries of object in the image. Recently image processing strategies are being utilized in the prediction of diseases, where it assists with expanding the classification accuracy. In this paper various edge detection methods are applied to find out the blood vessels in Retinal Image from DRIVE database. Blood vessels, one of the main retinal anatomical structure is dissected for analysis of numerous diseases like retinopathy and numerous other vision related diseases. The outcomes show that the best edge detection method for blood vessel detection.

1 Introduction

Image Processing is a method of performing operations on an image with a goal of getting an improved image. It is likewise used to mining to get the hidden details in an image. Image processing is considered as a sort of signal processing, where the input is given an image and output may be image or features identified within the image. Nowadays, image processing is getting grown rapidly. The effectiveness of many image processing also computer vision processes relies on the perfection of identifying significant edges. The need for edge detection in image processing is getting expanded in a critical way.

The way toward classifying and placing sharp discontinuities in an image is known as the edge detection. The discontinuities are prompt changes in pixel concentration which recognize the blood vessels in a retinal image. Traditional techniques for edge detection connect with convolving the image through an operator, which is developed to be perceptive to enormous gradients in the image although returning values of zero in uniform regions. There is a lot of edge detection methods available, every method intended to be perceptive to particular kinds of edges. Factors concerned in the choice of an edge detection operator include of Edge orientation, Edge structure and Noise. The geometry of the operator sets up a characteristic direction in which it is generally perceptive to edges.

Operators can be enhanced to search for vertical, horizontal, or diagonal edges. Edge detection is a troublesome task in noisy images, since both the edges and noise hold high- recurrence content. Efforts to decrease the noise bring about unclear and distorted edges. Strategies utilized on noisy images are regularly larger in scope; therefore they can common enough information to remove localized noisy pixels. This outcome is less perfect localization of the identified edges. Not all edges include a state change in intensity. Things such as refraction or diminished focus can bring about objects through boundaries characterized by a standard change in intensity. The strategy needs to be picked to be receptive to such a regular change in those cases. In this way, there are few issues of fake edge identification, edge localization, missing true edges, issues because of noise and high computational time and so forth. Henceforth, the goal is to do the comparison of different edge detections and investigate the performance of the various methods in different conditions.

In this paper an attempt is made to apply different edge detection methods for finding blood vessels in retinal image and furthermore performance of those strategies is applied for an image by using MATLAB software. Section 2 presents the various techniques applied for blood vessel detection that are generally utilized in the literature. Section 3 gives a comprehensive theoretical and mathematical foundation for different edge detection and discloses various computing approaches to deal with edge detection. Section 4 presents the comparison of different edge detection techniques with a Retinal image. Section 5 contains a quick discussion about the inspected works and conclusion.

2 Related Works

MendoncÂÿa and Campilho [8] have developed vessels segmentation algorithm using vessel center lines followed by the vessel filtering process. Multiscale morphological enhancement method was utilized to improve the contrast of the blood vessels. Palomera-PÂt'erez et al. [11] have applied feature extraction based region growing algorithm for the segmentation of blood vessels. The domain partitioning based parallelism was utilized to group the vessels. Fraz et al. [4] applied ensemble classifier to segment the vessels. The gradient vector field and Gabor transform were developed and utilized as the feature in ensemble classifier.

Xiao et al. [15] have applied spatial constraint based Bayesian classifier for segmenting the blood vessels. The modified level set approach was used to extract the vessel boundaries in the retinal images. The energy function was utilized to differentiate the vessels from the background pixels. Manoj et al. [10] have utilized feed forward back propagation neural network classifier for blood vessel segmentation. The features like gradient vector regions, morphological transformation vectors, and line strength vectors were extracted from the retinal images.

Bansal and Dutta [2] have introduced fuzzy algorithm for the segmentation of vessels. The block wise fuzzy rules were developed for the classification of vessels and nonvessels. MarÂt'Äśn et al. [7] have introduced grey level and moment feature based supervised classifier for blood vessel segmentation.The background homogenization was used to improve the contrast of the retinal blood vessels.

Budai et al. [1] have applied extended version of Frangi algorithm for the segmentation of blood vessel tree from the retina. Soares et al. [14] have utilized 2D-Gabor wavelet transform and supervised classifier for the detection and segmentation of blood vessels in retinal images. This paper presents the comparison of different edge detection techniques with a Retinal image.

3 Edge Detection Techniques

The edge representation of an image considerably decreases the amount of information to be processed, yet it holds essential information with respect to the shapes of objects in an image. This clarification of an image is straightforward to include into a lot of object recognition algorithms utilized in computer vision alongside other image processing applications. The numerous property of the edge detection methodology is its capability to extract the particular edge line with great direction even as more about edge detection has been accessible within the past three decades. Then again, there is not yet any standard performance directory to judge the performance of the edge detection methods. The performance of an edge detection methods are constantly judged personally and independently dependent to its application.

Edge detection is a basic tool for image segmentation. Edge detection techniques convert original images into edge images benefits from the changes of grey tones in the image. In image processing particularly in computer vision, the edge detection treats the limitation of significant variations of a gray level image and the detection of the physical and mathematical properties of objects of an image. It is a basic process recognizes and outlines of an object and boundaries among objects and also the background within the scene. Edge detection is that the most familiar methodology for detecting critical discontinuities in intensity values.

Edges are local changes in the image intensity. Edges regularly occur on the boundary between two regions. The primary features can be extracted from the edges of the scene. Edge detection has important feature for image analysis. These features are utilized by advanced computer vision techniques. Edge detection is utilized for object detection which serves different applications like medical image processing, biometrics and so forth. Edge detection is an active area of research as it facilitates more significant level in image analysis. There are three distinct kinds of discontinuities in the grey level like point, line and edges. Spatial masks can be utilized to identify all the three kinds of discontinuities in a scene.

There are many edge detection methods in the literature for image segmentation. The most regularly utilized discontinuity based edge detection strategies are reviewed in this section. Those methods are Roberts edge detection, Sobel Edge Detection, Prewitt edge detection, LoG edge detection,Canny Edge Detection, Zerocross Edge Detection.

3.1 Roberts Edge Detection

The Roberts edge detection is presented by Lawrence Roberts (1965). It plays out a simple, fast to compute, 2-D spatial gradient measurement on the scene. This strategy emphasizes regions of high spatial frequency which frequently correspond to edges. The input to the operator is a grayscale image equivalent to the output is the well-known use for this strategy. The pixel values of every point in the result gives the assessed complete magnitude of the spatial gradient of the input image. [12].

A simple approximation to the gradient magnitude of the Roberts edge detection is

$$G[f[i,j]] = |f[i,j] - f[i+1,j+1]| + |f[i+1,j] - f[i,j+1]|$$

Using convolution masks, the about equation derived as :

$$G[f[i,j]] = |G_x| + |G_y|$$

Then the values of Gx and Gy are found with the following masks:

Table 1. Masks used by Roberts Operator

$G_x =$

1	0
0	-1

$G_y =$

0	-1
1	0

3.2 Sobel Edge Detection

The Sobel edge detection technique is presented by Sobel in 1970 (Rafael C.Gonzalez (2004)). The Sobel edge detection technique finds the edges utilizing the Sobel approximation to the derivative. It goes before the edges at those points where the gradient is highest. The Sobel strategy plays out a 2-D spatial gradient quantity on the scene thus highlights regions of high spatial frequency that correspond to edges. In general it is utilized to discover the assessed absolute gradient magnitude at every point in n input grayscale image. In conjecture at any rate the operator comprises of a pair of 3x3 complication kernels as given away in under table. One kernel is essentially the other rotated by 90o. This is similar to the Roberts Cross operator[6].

On the arrangement of pixels are about the pixel [i, j] shown in the Table 2. The magnitude of the gradient with the Sobel operator is calculated by

$$M\sqrt{s_x^2 + s_y^2}$$

Then the partial derivatives are calculated by using

$$s_x = (a_2 + ca_3 + a_4) - (a_0 + ca_1 + a_6)$$
$$s_y = (a_0 + ca_1 + a_2) - (a_6 + ca_5 + a_4)$$

With the constant c = 2.

The gradient operators of Sx and Sy can be computed with the following convolution masks.

Table 2. Masks used by Sobel Operator

$S_x =$

−1	0	1
−2	0	2
1	0	1

$S_y =$

1	2	1
0	0	0
−1	−2	−1

This Sobel operator is applied on an emphasizing pixel that is closer to the center of the mask. The Sobel operator is one of the most basically used edge detectors.

3.3 Prewitt Edge Detection

The Prewitt edge detection is introduced by Prewitt in 1970 (Rafael C.Gonzalez [6]. To appraise the magnitude and orientation of an edge, Prewitt is a right way. The various gradient edge detection needs a quite time consuming calculation to estimate the direction from the magnitudes in the x and y-directions, the compass edge detection acquires the direction straightforwardly from the kernel with the highest response. It is restricted to 8 potential directions; anyway knowledge shows that most direct direction estimates are very little more perfect. This gradient based edge detector is assessed in the 3x3 neighborhood for 8 directions. All the 8 convolution masks are determined. One complication mask is then chosen, namely with the end goal of the largest module [6].

Equation of the Sobel operator is also used for the Prewitt operator, where constant c = 1.

Table 3. Masks used by Prewitt gradient Operator

$S_{\boldsymbol{x}} =$

−1	0	1
−1	0	1
−1	0	1

$S_{\boldsymbol{y}} =$

1	1	1
0	0	0
−1	−1	−1

Unlike the Sobel operator, the Prewitt operator does not place any emphasis on pixels that are closer to the masks center [13]. Compared to the Sobel detection, the Prewitt detection is quite simpler to implement computationally, but this detection technique tends to generate the results with some noise.

3.4 LoG Edge Detection

The Laplacian of Gaussian (LoG) was developed by Marr(1982)[9]. The LoG of an image L(x,y) is a second order derivative defined as,

$$L(x, y) = \frac{\partial^2 I}{\partial x^2} + \frac{\partial^2 I}{\partial y^2}$$

It has two effects, it smoothes the image and it processes the Laplacian, which yields a double- edge image. Locating edges then comprises of finding the zero crossings between the double edges. The digital implementation of the Laplacian function is generally made through the mask below,

$G_x =$

0	−1	0
−1	4	−1
0	−1	0

$G_y =$

−1	−1	−1
−1	8	−1
−1	−1	−1

This Laplacian function is generally utilized to compute whether a pixel is in the dark or light side of an edge.

3.5 Canny Edge Detection

In industry, the Canny edge detection method [3] is one of the standard edge detection strategies. It was first introduced by John Canny for his MasterâĂŹs thesis at MIT in 1983, and still outperforms huge numbers of the newer algorithms that have been created. To discover edges by isolating noise from the scene before discover edges of image the Canny is a significant technique. Canny method is a best edge detection technique without disturbing the features of the edges in the retinal image a while later it applying the tendency to find the edges and the thresholdâĂŹs serious value. The algorithm steps of Canny method are as follows.

(i) Convolve scene $f(r,c)$ with a Gaussian function to get smooth image $f^\wedge(r,c)$.

$$f^\wedge(r,c) = f(r,c) * G(r,c,6)$$

(ii) Use first difference gradient operator to find edge strength.

(iii) Next the edge magnitude and direction are acquire as in the past.

(iv) Use non-maximal or critical suppression with the gradient magnitude.

(v) Apply threshold value to the non-maximal suppression image.

Compare to Roberts and Sobel techniques, the Canny operation is not very susceptible to noise. If the Canny detector worked well it would be superior.

3.6 Zero Crossing Detection

The zero crossing detector [5] searches for places in the Laplacian of the retinal image where the estimation of the Laplacian goes through zero i.e. points where the Laplacian changes sign. Such points regularly occur at ‘edges’ in scenes i.e. points where the intensity of the image changes quickly, however they additionally occur at places that are not as simple to associate with edges. It is ideal to consider the zero crossing detector as some kind of feature detector instead of as a particular edge detector. Zero crossings consistently lie on closed contours. So the zero crossing detector generally produces the output of a binary image with single pixel thickness lines which indicates the positions of the zero crossing points.

A more exact methodology is to play out some kind of interpolation to assess the position of the zero crossing to sub-pixel precision.

4 Experimental Results

This section presents the relative performance of different edge detection techniques such as Roberts edge detection, Sobel Edge Detection, Prewitt edge detection, LoG edge detection,Canny Edge Detection, Zero cross Edge Detection.

The edge detection strategies were executed by using MATLAB R2018a, and tested with a retinal image. The goal is to create a clean edge map by extracting the principal edge features of the image. The original image and the image got by utilizing different edge detection strategies are given in the following figures.

Roberts, Sobel and Prewitt results actually deviated from the other edge detection techniques. It is observed from the below figures, Canny result is superior by far to the output of other techniques.

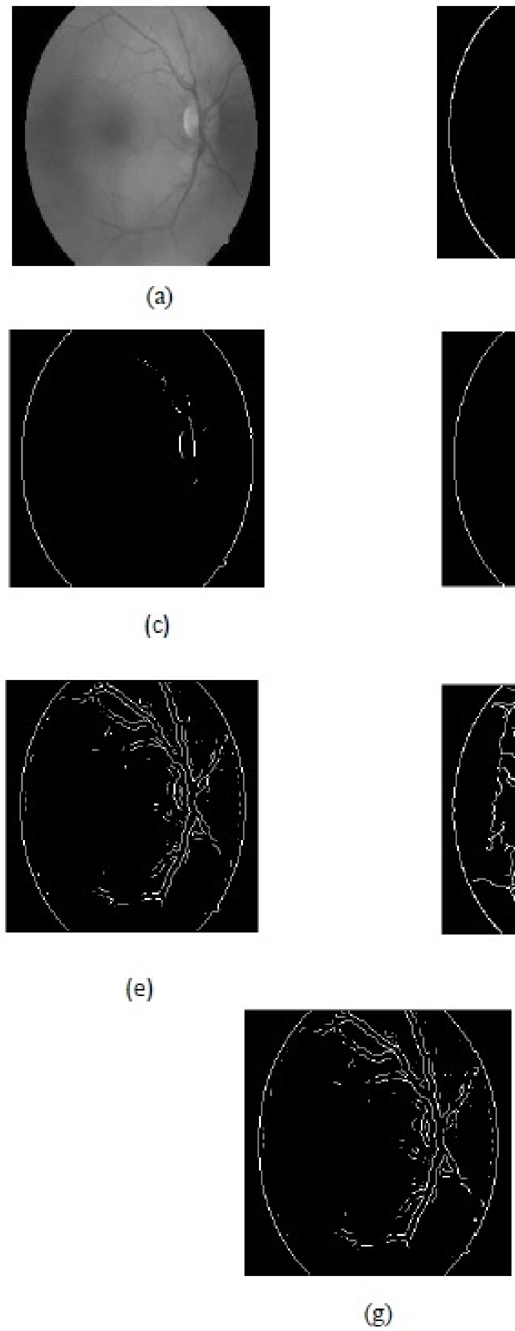

Figure 1. Comparison of Edge Detection Techniques. a) Original Image b) Roberts edge detection c) Sobel Edge Detection d) Prewitt edge detection e) LoG edge detection f) Canny Edge Detection g) Zerocross Edge Detection

5 Conclusion

In the discipline of computer vision, image processing is a rapidly moving field. Its development has been powered by innovative advances in digital imaging, computer processors and mass storage devices. In this paper an attempt is made to apply the edge detection techniques to retinal image. The relative performance of different edge detection techniques is done with retinal image by utilizing MATLAB software. It is seen from the outcomes LoG and Canny edge detectors produce almost same edge map. Canny result is better one when compared to all for a retinal image since various edge detectors work better under various conditions.

References

[1] A. Budai, R. Bock, A. Maier, J. Hornegger, and G. Michelson, *Robust vessel segmentation in fundus images*, International Journal of Biomedical Imaging, (2013).

[2] N. Bansal and M. Dutta, *Retina vessels detection algorithm for biomedical symptoms diagnosis*, International Journal of Computer Applications, **71(20)**, 41–46, (2013).

[3] J. F. Canny, *Finding edges and lines in images*, Master's thesis, MIT. AI Lab. TR-720, (1983).

[4] M. M. Fraz, P. Remagnino, A. Hoppe et al., *An ensemble classification-based approach applied to retinal blood vessel segmentation*, IEEE Transactions on Biomedical Engineering, **59(9)**, 2538–2548, (2012).

[5] R. Gonzalez and R. Woods, *Digital Image Processing*, Addison-Wesley Publishing Company, 442–443, (1992).

[6] Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, *Digital Image Processing Using MATLAB*, Pearson Education Ptd. Ltd, Singapore, (2004).

[7] D. MarÂť Äśn, A. Aquino, M. E. Gegundez-Arias, and J. M. Bravo, *A new supervised method for blood vessel segmentation in retinal images by using gray-level and moment invariants-based features*, IEEE Transactions on Medical Imaging, **30(1)**, 146–158, (2011).

[8] A. M. MendoncÂÿa and A. Campilho,*Segmentation of Retinal blood vessels by combining the detection of centerlines and morphological reconstruction*, IEEE Transactions on Medical Imaging, **25(9)**, 1200–1213 (2006).

[9] D. Marrand and E. Hildreth, *Theory of edge detection*, 187–217, (1980).

[10] S. Manoj, Muralidharan, and P. M. Sandeep, *Neural network based classifier for retinal blood vessel segmentation*, International Journal of Recent Trends in Electrical and Electronics Engineering, **3(1)**, 44–53, (2013).

[11] M. A. Palomera-Perez, M. E. Martinez-Perez, H. Ben Âť ÂťÄśtezPerez, and J. L. Ortega-Arjona,*Parallel multiscale feature Âť extraction and region growing: application in retinal blood vessel detection*, IEEE Transactions on Information Technology in Biomedicine, **14(2)**, 500–506, (2010).

[12] L. Roberts, *Machine Perception of 3-D Solids*, Optical and Electro-optical Information Processing, MIT Press, (1965).

[13] Seif, A.,et.al., *A hardware architecture of Prewitt edge detection*, Sustainable Utilization and Development in Engineering and Technology, 99–101, (2010).

[14] J. V. B. Soares, J. J. G. Leandro, R. M. Cesar Jr., H. F. Jelinek, and M. J. Cree, *Retinal vessel segmentation using the 2-D Gabor wavelet and supervised classification*, IEEE Transactions on Medical Imaging, **25(9)**, 1214–1222, (2006).

[15] Z. Xiao, M. Adel, and S. Bourennane, *Bayesian method with spatial constraint for retinal vessel segmentation*, Computational and Mathematical Methods in Medicine, (2013).

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