AN EFFICIENT APPROACH FOR IMPROVING CANNY EDGE DETECTION ALGORITHM

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ABSTRACT

Edge detection is one of the most important stages in digital image processing and medical image processing. The Canny edge detector is widely used in computer vision and medical imaging to locate sharp intensity changes and to find object boundaries in an image. The Canny edge detection algorithm is most widely used edge detection algorithm because of its advantages. The Canny edge detector classifies a pixel as an edge if the gradient magnitude of the pixel is larger than those of pixels at both its sides in the direction of maximum intensity change. In this paper an efficient approach for improving canny edge detection Algorithm has been proposed which uses variable sigma and thresholding for different parts of the medical image. The results of experiments show that it performs better to find edges for low resolution angiography images.

KEYWORDS: *Edge detection; Canny edge detector; Edge accuracy, Gaussian Filter, Sigma, Entropy.*

I. INTRODUCTION

Edges are significant local changes of intensity in an image. Edges typically occur on the boundary between two different regions in an image. So it has fundamental importance in medical image processing. It is basically a method of segmenting an image into regions of discontinuity. It is a basic tool used in medical image processing, basically for feature detection and extraction, which aim to identify points in a medical image where brightness of image changes sharply and find discontinuities. The purpose of edge detection is significantly reducing the amount of data in an image and preserves the structural properties for further medical image processing [1][2].

Edge detection is one of the fundamental operations in computer vision and medical image processing with numerous approaches to it. In an historical paper, Marr and Hildreth [3] introduced the theory of edge detection and described a method for determining the edges using the zero-crossings of the Laplacian of Gaussian of an image. Haralick [4] determined edges by "tting polynomial functions to local image intensities and "nding the zero-crossings of the second directional derivative of the functions. Canny [5] determined edges by an optimization process and proposed an approximation to the optimal detector as the maxima of gradient magnitude of a Gaussian-smoothed image. Clark [6] and Ulupinar and Medioni [7] independently found a method to "lter out false edges obtained by the Laplacian of Gaussian operator. Bergholm [8] introduced the concept of edge focusing and tracked edges from coarse to "ne to mask weak and noisy edges. A curve fitting approach to edge detection was proposed by Goshtasby and Shyu [9] in which edge contours were represented by parametric curves that "tted to high gradient image pixels with weights proportional to the gradient magnitudes of the pixels. Recent advances in edge detection include a method by Elder and Zucker [10] to determine edges at multitudes of scales, and an adaptive smoothing method by Li [11] to remove noisy details in an image without blurring the edges. Many other edge detection techniques have been proposed. For a survey and comparison of the edge detectors, the reader is referred to the paper by Heath et al. [12]. Among the edge detection methods proposed so far, the Canny edge detector is the most rigorously defined operator and is widely used. The popularity of the Canny edge detector can be attributed to its optimality according to the three criteria of good detection, good localization, and single response to an edge. It also has a rather simple approximate implementation, which is the subject of this paper. We will show examples where this approximate implementation misses some obvious edges. We will also show how to revise the Canny edge detector to improve its detection accuracy.

II. CANNY ALGORITHM

The aim of Canny edge detection algorithm was to have good detection (minimum number of false edges), good localization (closeness of the real edge and the detected edge) and minimal response (one edge should be detected only once). Canny algorithm is a step by step process and the steps are shown in figure(1). The Canny method finds edges by looking for local maxima of the gradient of I. The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds, to detect strong and weak edges, and includes the weak edges in the output only if they are connected to strong edges. This algorithm is therefore less likely than the others to be fooled by noise, and more likely to detect true weak edges.

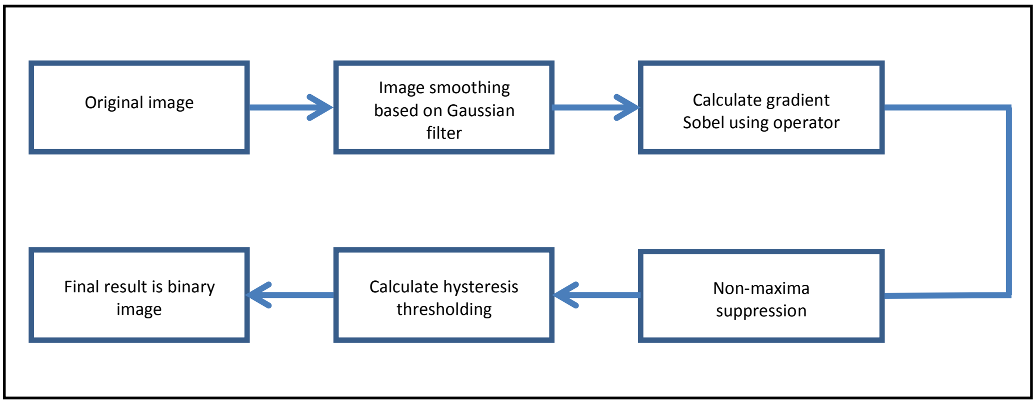
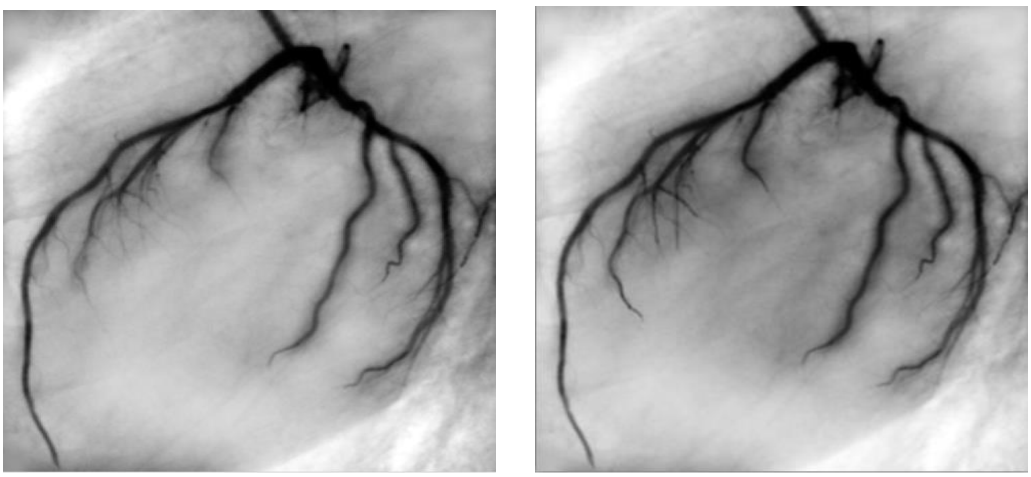


Figure (1) Traditional Canny Algorithm Steps

The Canny edge detector uses a Gaussian filter. The image is convolved with the filter. The filter blurs the image to a degree specified by σ to minimize the effect of unwanted information. Figure 2 (b) is the output of a 5X5 Gaussian filter with σ=1.4 is shown in Equation (1), whose input is figure 2 (a).

$$B = \frac{1}{159} \cdot \begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \quad (1)$$



(a) Original Image (b) Filtered Image

Figure (2) The original angiography image is smoothed with a Gaussian filter to suppress noise

The point of interest in the proposed method is the Gaussian filter of the Canny Edge Detector. The filter is used for blurring the medical image before processing so that unwanted edges or noises are not detected as edges. The Gaussian function is given by:

$$h(x, y)=\exp(-\pi(x^2 + y^2)/\sigma) \qquad (2)$$

where the parameter σ (sigma) determines the width of the filter and hence the degree of blurring i.e. the greater the value of sigma the more the blurring is. But this approach gives average results when there are prominent edges and faint edges in the image both of which may be of great significance. If the value of sigma is very high then faint edges will not be detected. On the other hand if sigma is very low then noise may also get detected as edges.

III. PROPOSED METHOD

An easy but an effective approach is proposed in this paper in which different values of sigma and thresholding are applied in different parts of the image instead of processing the entire image with a single value of sigma and thresholding. In this method, the angiography image is divided into a number of sub-images. This number will determine the level of accuracy of the final output i.e. more number of sub-images will give better results. After dividing the angiography image, the mean pixel value of each sub-image is calculated and depending upon these values each sub-image will be processed by a Gaussian filter with different sigma and thresholding values. It is quite evident that sub-images having very high or very low mean pixel values are likely to have faint edges while the ones with intermediate mean values are likely to have prominent edges. Therefore, the sub-images with higher or lower mean values are processed with small values of sigma and different thresholding.

A. The processed an efficient approach for improved canny edge detection algorithm. *Proposed Algorithm:*

Algorithm: improved Canny Edge Detection approach:

Input: An image I; number of sub-images(s); sigma value (σ) assignment for a corresponding range of mean values.
Output: a binary image of edges (E).
A (1,2,…s)←sub-images of I;
For I =1:s *Do*
S ← S+A(i);
Thresh ← S,
M(i) ← mean A(i);
σ ← f(M(i),S);
C(i) ← Canny(A(i), σ, thresh);
End
Final Stage :
E← reconstruction{C(1), C(2), ……..,C(S)};

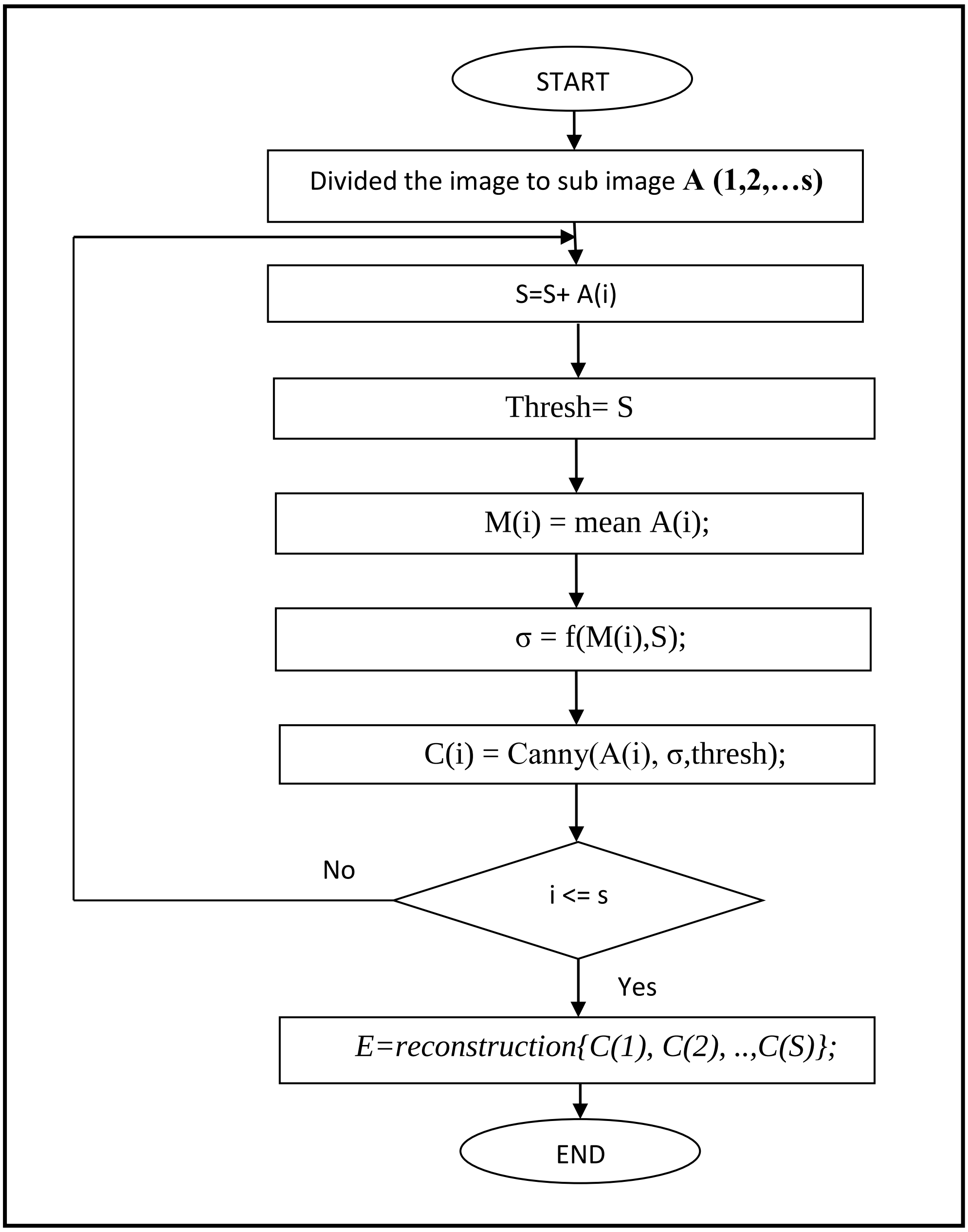
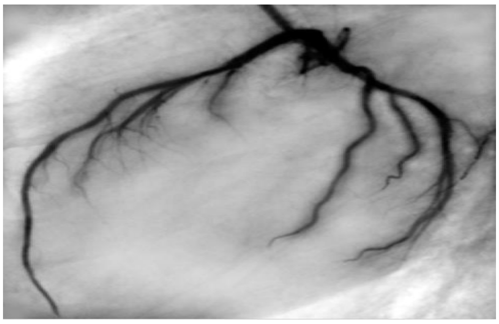


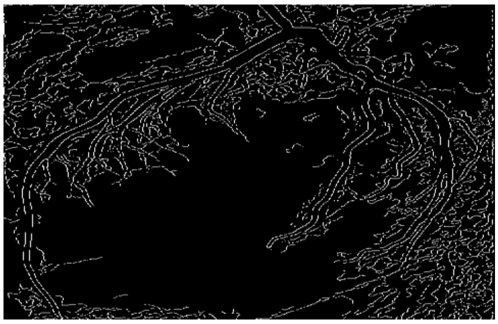
Figure (3) the main steps of the proposed an efficient approach for Improving Canny Edge Detection Algorithm for medical image.

B. Experimental Results

To compare results obtained by the original Canny edge detector and the revised Canny edge detector, a number of experiments were carried out. Experiments were conducted on angiography images and better results were observed. One of them is shown in figure 4(a)-4(f) respectively. From figure 4(f) it is evident that the proposed approach gives better results than the original algorithm. Here sigma is varied and other components e.g. thresholding values are also varied. After the processing the noise and blurring in the angiography image is considerably reduced yet preserving the image boundaries.



(a) Original Image



(b) σ = 0.5

(c) σ = 0.21

(d) σ =0.31

(e) σ = 0.39

(f) σ is variable

Figure (4) Improved Canny Edge Detector with different sigma and thresholding

C. Entropy Calculation

Entropy is defined as measure of average uncertainty and is given by the formula:

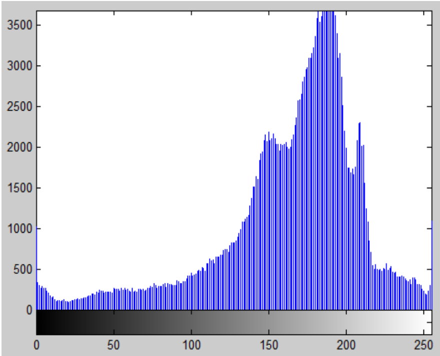
$$H = -\Sigma\, p \log_2 (p) \quad (3)$$

where p is the histogram count.

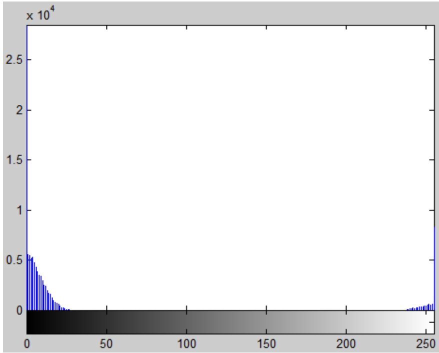
Table I: Entropy of figure. 4(a)- 4(f)

Image	Image Entropy (H)
Original image	**5.6599**
σ=0.5	**4.0351**
σ=0.21	**3.9420**
σ=0.31	**3.5035**
σ=0.39	**3.3720**
Proposed method	**3.1581**

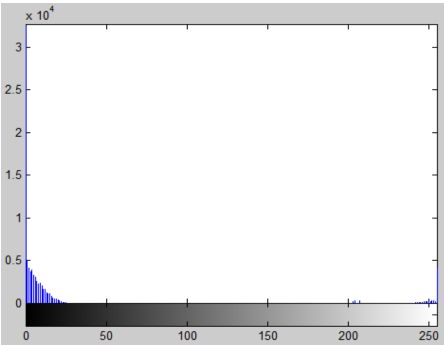
The following figures 5(a)-5(f) show the Histograms of Figure. 4(a)-4(f) respectively.



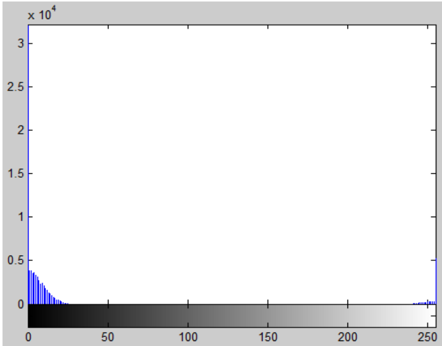
(a) Histogram Original Image



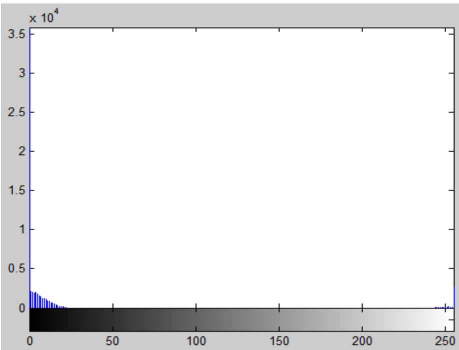
(b) Histogram of Figure. 3(b)



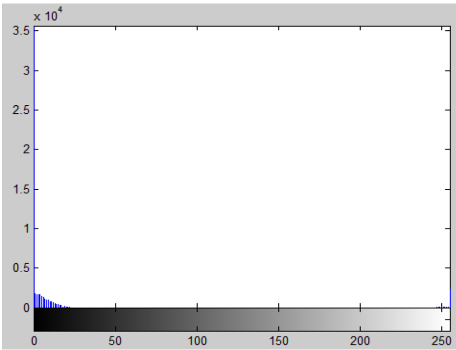
(c) Histogram of Figure. 3(c)



(d): Histogram of Figure. 3(d)



(e) Histogram of Figue.3(e)



(f) Histogram of Figure. 3(f)

Figure (5) Histograms of Figure. 3(a)-3(f) respectively.

IV. CONCLUSION

Edge detection is an important segmentation process carried out in medical image processing. Canny edge detector algorithm is considered as optimal edge detection technique but it responds to false image in noisy environment and is not adaptive in nature. For a high resolution image , this new proposed algorithm performs better than traditional canny operator In this paper, a proposed an efficient approach for improving canny edge detection algorithm to recover edges missed by proposed approach was presented. The improving Canny operator has proved as an optimal edge detector due to due to good localization, detection and only one response to single response. The proposed approach involves a step that looks for further image evidence and connects short edge contours into longer ones and converts open contours into closed ones if image evidence supports that. In future the exact relationship between mean pixel value on edges and sigma may be found out. MATLAB was used for generating the output images.

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REFERENCES

[1] R .Gonzalez and R. Woods, " Digit al Image Processing", Addison Wesley, pp 414 – 428, 1992.
[2] Jonathan M. Black ledge, "Digital Image Processing Mathematical and Computational Methods", Coll House, Watergate, Chic ester, West Sussex, PO20 3QL, England, 2005.
[3] D. Marr, E. Hildreth, "Theory of edge detection", Proc. Roy. Soc. London B-207, 1980.
[4] R. Haralick, "Digital step edges from zero crossing of second directional derivatives", IEEE Trans. Pattern Anal. Mach. Intell. 6, 1984.
[5] J. Canny, "A computational approach to edge detection", IEEE Trans. Pattern Anal. Mach. Intell. 8 (6), 1986.
[6] J.J. Clark, "Authenticating edges produced by zero crossing algorithms", IEEE Trans. Pattern Anal. Mach. Intell. 11 (1), 1989.
[7] F. Ulupinar, G. Medioni, "Refining edges detected by a LoG operator", Comput. Vision, Graphics, Image Process. 51,1990.
[8] F. Bergholm, "Edge Focusing", IEEE Trans. Pattern Anal. Mach. Intell. 9, 1987. [9] A. Goshtasby, H-L. Shyu, "Edge detection by curve fitting", Image Vision Comput. 13 (3), 1995.
[10] J.H. Elder, S.W. Zucker, "Local scale control for edge detection and blur estimation", IEEE Trans. Pattern Anal. Mach. Intell. 20 (7), 1998.
[11] S.Z. Li, "Closed-form solution and parameter selection for convex minimization-based edge preserving smoothing", IEEE Trans. Pattern Anal. Mach. Intell. 20 (9), 1998.
[12] M.D. Heath, S. Sarkar, T. Sanocki, K.W. Bowyer, "A robust visual method for assessing the relative performance of edge-detection algorithms", IEEE Trans. Pattern Anal. Mach. Intell. 19 (12), 1997.

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Shokhan M. H. is currently a M.Sc. in the Department of Computer Science at Al-Anber University. she received his master's degree in image processing from the Department of Computer Science, Al-Anbar University, Iraq in 2013. She joined in 1 October 2013 Computer Sciences Department, Al-Anbar University, Iraq, as lecturer. Shokhan M. H. has worked on various problems in computer vision, image processing, 3D visualization, computer graphics, and geometric modeling. His current research interests are in volume image analysis and representation of free-form shapes with parametric curves, surfaces, and volumes.