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Edge Detection in Angiogram Images Using Modified Classical Image Processing Technique

S. Deepak Raj[1] Harisha D S[2]
[1,2]Asst. Prof , Dept Of ISE,
Sai Vidya Institute of Technology, Bangalore, India

Deepak M[3] Pruthvi Kumar K .R[4]
[3,4]Asst. Prof , Dept Of CSE,
Sai Vidya Institute Of Technology, Bangalore, India

Abstract:- **Blood vessels of human body can be made available for study using medical imaging methods like as X-ray, Computed Tomography (CT), and Magnetic Resonance (MR). Extraction of blood vessel images from noisy backgrounds is necessary in medical image processing. Also must be ensured clarity to aid in drawing accurate inferences in diagnosis. One such application is a procedure used in observation of blood vessels called Angiography. Determination of area covered by vessels and vessel length are two basic tasks involved in it. Such tasks are achieved through enhancement and segmentation. Segmentation can be defined as a process of dividing a given image into several non-overlapping regions. Such partitioning is made with Edge detection. Complex algorithms have been modeled for detection of edges of blood vessel images which are currently available in literature. This paper detects edges of vessels in an angiogram image, using proposed algorithm utilizing using classical image processing techniques. Steps involved are, a Preprocessing step, where noise is removed using either a simple filter and Histogram equalization technique, replacing Canny edge Detector. Proposed algorithm is not complicated. It is accurate and involves very simple steps.**

Keywords- Angiogram image, Segmentation, Vessel extraction, Canny edge detector, filtering, Image enhancement, Histogram equalization

I. INTRODUCTION

Detecting and analysing blood vessels in an angiogram image depends vitally upon Segmentation. It is a process of partitioning an image into several non-overlapping regions. It is used to extract vascular regions from other background regions. Based on partitioning results thus obtained, surfaces of vasculatures can be extracted, modeled, manipulated, measured as well as visualized. Hence it is used in detection of vascular diseases. Developing a reliable and robust image segmentation method is therefore imperative for making angiography effective and efficient. This endeavor has been the priority of researchers as shown by other active research groups in [4, 10]. Segmentation simply subdivides an image into parts or objects that constitute it. Autonomous segmentation is one of the very difficult tasks of image processing.

Segmentation algorithms for monochrome images are generally based on two following basic properties of gray level values:

i) Discontinuity and
ii) Similarity.

It is challenging to perform image segmentation in angiography. Angiograms can be analyzed using computers to detect the blood vessel boundary as a first step. In literature, this is performed using, magnitude of image gradient but this method does not provide sufficient information for locating the boundary of blood vessel and hence; performance of segmentation becomes complicated as shown conclusively in [1, 2, 6, 8]. Thus, the quality of image segmentation can be improved using our proposed histogram equalization technique, rather than the gradient magnitude.

Edge detection is done to segment blood vessels from angiogram images. Edge detection algorithms are followed by linking and boundary detection procedures. Edge detection is used for detecting discontinuities in gray level. First and second order digital derivatives are implemented to detect edges in an image. Edge can be defined as a boundary between two regions with relatively distinct gray-level properties. An edge is a set of connected pixels that lie on the boundary between two regions [3, 5]. The complexity of an image is reduced by detecting its edges. Such simplified images can be then used to measure parameters related to blood flow or to locate some patterns in relation to vessels in angiographic images. Thus edge detection is done using first order derivative (Gradient operator), Second-order derivative (Laplacian operator) and also using Sobel and Prewitt algorithms [7, 9].

Canny proposed the hysteresis thresholding method in which two threshold values have to be fixed. However, its performance was not good enough with respect to detection, localization, and resolution and noise rejection. The percentage of true edges detected is also less, when compared to other algorithms proposed in literature [14].

In this paper, edges of vessel in an angiogram image are detected using our proposed algorithm which involves a pre-processing step, where noise is removed using the Median filter and Histogram equalization technique, which replaces the

Canny edge Detector. Median filtering is useful in eliminating intensity spikes while it preserves edges in a better manner. Histogram equalization stretches or compresses an image, which is used to detect the edges of a blood vessel.

II. EDGE DETECTION

Edges are significant local changes of intensity in an image. Causes for intensity include:

- Geometric events
  - ➢ surface orientation (boundary) discontinuities
  - ➢ depth discontinuities
  - ➢ color and texture discontinuities
- Non-geometric events
  - ➢ illumination changes
  - ➢ specularities
  - ➢ shadows inter-reflections

The figure drawn below shows discontinuities in the image.

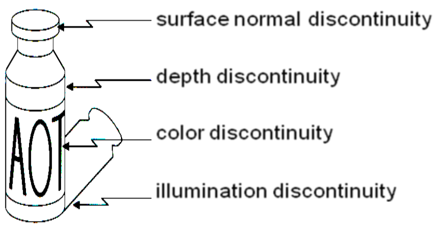

Fig. 1. Discontinuties in the Image

A. Goal of Edge Detection

The goal of edge detection is to produce a line "drawing" of a scene from an image of that scene.

B. Advantages of Edge Detection

- Important features can be extracted from edges of an image (e.g., corners, lines, curves).
- These features are used by higher-level computer vision algorithms (e.g., recognition).

C. Edge Detection Methods

The edge detection methods include:

- ➢ 1st Derivative Estimate
  - ❖ Gradient edge detection
  - ❖ Compass edge detection
  - ❖ Canny edge detector
- ➢ 2nd Derivative Estimate
  - ❖ Laplacian
  - ❖ Difference of Gaussians
- ➢ Parametric Edge Models

We are concentrating on the existing method, namely canny edge detector for comparing edge detection with proposed method.

D. Canny Edge Detector

Canny edge detection operator was created by John. F. Canny in the year 1986. It uses a multi-staged algorithm to detect edges in images over a wide range. Following are its various stages.

Noise Reduction

Canny edge detector makes use of first derivative of a Gaussian as filter. It filters noise by convolving input raw image with Gaussian filter. A slightly blur version of an input image is hence obtained which is not affected by even a single noisy pixel to a significant degree. Thus, it is a strong tool used to remove noise present in raw unprocessed data.

- Intensity Gradient

The algorithm makes use of four filters to detect various edges in blurred input images. An edge in a image may point in various directions, horizontal, vertical and diagonal. Whenever edges are to be detected, it can be done by calculating the gradient of a pixel relative to its neighborhood. A good approximation of first derivate is given by two Sobel operators. As the derivatives enhance noise; smoothing effect produced is a particularly attractive feature of Sobel operators. First derivatives are implemented using magnitude of gradient.

For a function f (x, y), the gradient f at co-ordinate (x, y) is defined as the 2-dimesional column vector

$$\Delta f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \partial f / \partial x \\ \partial f / \partial y \end{bmatrix}$$

$$\Delta f = mag(\Delta f) = \left[G_x^2 + G_y^2\right]^{1/2}$$

$$= \left[(\partial f / \partial x)^2 + (\partial f / \partial y)^2\right]^{1/2}$$

$$\cong |Gx| + |Gy|$$

If a (x,y) represents the direction angle of the vector ∇f at (x,y), then, $\alpha(x, y) = \tan^{-1}\left[\frac{G_x}{G_y}\right]$. Thus, the direction of an edge at (x,y) is perpendicular to the direction of the gradient vector at that point. Edge direction angle is here rounded to one of the four angles each representing one of vertical, horizontal and the two diagonals (0, 45, 90 and 135 degrees).

- Non - maximum suppression

  The edges are still colored to indicate direction. When estimates of an image's gradient are given, we make a search to determine if gradient magnitude assumes a local maximum in gradient's direction.

  Thus for example,

a. In case, rounded angle is zero degrees and if intensity is greater than the intensities in north and south directions the point will be considered to be on the edge,

b. In case rounded angle is 90 degrees, and if its intensity is greater than the intensities in west and east directions the point will be considered to be on the edge,

c. In case rounded angle is 135 degrees, and if its intensity is greater than the intensities in north east and south west directions, the point will be considered to be on the edge

d. In case rounded angle is 45 degrees, and if its intensity is greater than the intensities in northwest and south east directions. the point will be considered to be on the edge

This is achieved by passing a grid of dimension 3 x 3 over an intensity map out of which are obtained a set of edge points, in the form of binary images. This is referred to as "non - maximum suppression" and is also called as "thin edges". In most cases it is impossible to specify the threshold at which intensity gradient switches from being an edge, when it is traced through the image and hysteresis. Hence, Canny used threshold and hysteresis. This required two thresholds – high and low. With this assumption, edges are traced along continuous curves in an image. This allows us to follow a faint section of given line while discarding all noisy pixels that do not constitute a line but yet have an equally high intensity gradient. Thus, this is done by applying high threshold. Finally edges are traced starting from here, with the help of directional information derived earlier. While tracing an edge, lower threshold is applied, which allows tracing faint sections of edges as long as the starting point is found. Thus, finally a binary image is obtained. Every pixel, from this binary image, is then marked as either an edge pixel or a non- edge pixel. The binary edge map obtained thus, can also be treated as a set of edge curves. On further processing such curves can be represented as polygons in image domain.

- Differential Geometric Formulation

  A greater refined approach to obtain edges with sub-pixel accuracy is, using differential edge detection. Here the requirement of non-maximum suppression is formulated in terms of second as well as third order derivatives computed from a scale-space representation, as proposed by Lindeberg in the year 1998.

- Parameters

  The Canny algorithm contains a number of adjustable parameters, which may affect its computation time and effectiveness.

a. The size of Gaussian filter used in stage one, directly affects results of canny algorithm used later. Smaller filters cause lesser blurring, and allow detection of small but sharp lines. On the other hand, larger filters cause more blurring, thereby smearing out a given pixel over a larger area of image. Larger blurring radii are more useful in detecting larger, smoother edges.

b. Thresholds: the use of double thresholds with hysteresis allows greater flexibility than that is available in a single threshold approach. But general problems of thresholding approaches continue. A threshold set too high may miss required information.

III. PROPOSED METHOD – Classical Image Processing Techniques

A new algorithm is proposed to overcome the above said drawbacks using classical image processing techniques as shown in the flow diagram below.

Proposed Algorithm:

Step 1: Read the given angiogram image, and convert it into a matrix form where each pixel value is in the range from 0-255.

Step 2: Apply median filtering to remove noise.

Step 3: Take Histogram of the given input image.

Step4: Obtain a uniform histogram using histogram equalization or linearization technique.

Step 5: Repeat the above process again.

Step 6: 2D FIR filter is used to detect the edges of the angiogram image.

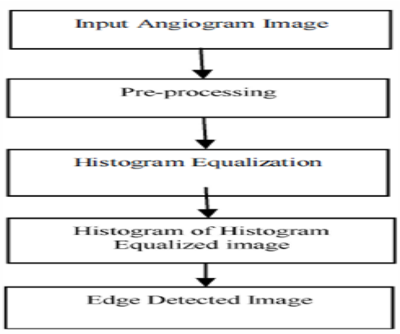

Fig. 2 Proposed flow chart for Edge Detection

In Fig. 2, first the input image is preprocessed using median filter to remove noise and then the histogram of input angiogram image is obtained. Then by a technique called histogram equalization, uniform histogram is obtained. Again, the histogram of histogram equalized image is obtained. Finally, the edges of the vessel from the given angiogram image is obtained.

Thus, the above mentioned algorithm is used to detect the edges of the vessel from the given angiogram image.

A. Image Enhancement

Image Enhancement process consists of a collection of techniques which seek to improve visual appearance of an image. Thus the basic aim is to make an image look better. The objective of enhancement technique is to process an image so that the resultant image is more suitable than the original. Suitability is of course dependent on specific applications. Image enhancement refers to either accentuation of, or sharpening of image features such as edges, boundaries or contrast to make graphic display more suitable for display and analysis. Image enhancement may include tasks like, gray level and contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification, pseudo coloring.

B. Histogram Equalization

A Technique which is used to obtain uniform histogram is known as Histogram Equalization or Histogram Linearization. Let r represent the grey levels in the image to be enhanced. Assume r to be normalized in the interval [0, 1], with r = 0 representing black and r = 1 representing white. For any value r in the interval [0,1], the image transformation is given as,

$$\boxed{S = T(r),\ 0 \le r \le 1}$$

A level s for every pixel value r in the original image is produced by this transformation. The function T(r) satisfies the following conditions,

• T(r) is single valued and monotonically increases in the interval $0 \le r \le 1$ (ie., it actully preserves order from black to white in output image) and

$0 \le T(r) \le 1$ for $0 \le r \le 1$ (ie., guarantees that the output gray levels will be in the same range as the input levels)

The Inverse transformation is given as,

$$\boxed{r = T^{-1}(s),\ 0 \le s \le 1}$$

• If gray levels in an image can be viewed as random variables in the interval [0,1], then $P_r(r)$ and $P_s(s)$ denote probability density functions of random variables r and s.

• If $P_r(r)$ and T(r) are known $T^{-1}(S)$ satisfies the first condition, then the probability density function of transformed variables is determined by gray level probability density function of input image and by the chosen transformation function.

C. Edge Detection

Magnitude of first derivative can be used in detection of edges. The sign (zero crossing) of the second derivative can be used to detect an edge. The same idea can be extended into 2-D.

2-D derivatives should be used. The magnitude of the gradient and sign of the Laplacian are used.

Thus, a 2 D FIR filter is used to compute the result using a two-dimensional correlation. The filter is rotated 180 degrees in order to perform two-dimensional correlation which basically involves two-dimensional convolution to detect edges. Usually one dimension process is carried in literature but here a 20 FIR filter is used to improve the results of detection process.

IV CONCLUSION

Proposed algorithm here detects edges of blood vessels from an angiogram image by implementing classical image processing techniques. We have found that edges thus segmented are both accurate and clear. Steps involved in our algorithm are also simple and easy for implementation. Results prove that detection of algorithms are efficient and effective in determining edges. Future work is aimed at detection of blockages and clots in capillaries and vessels.

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