Blood vessel segmentation in coronary angiogram image

[1]Harsha P. Jawale, [2]Prof.K.S.Bhagat
[1] Student, [2]Assistant Professor
[1]Department of E&Tc Engineering
[1]J.T.Mahajan College of engineering, Faizpur. India

***Abstract*- Coronary heart disease has been one of the main threats to human health. Coronary angiography is taken as the gold standard for the assessment of coronary artery disease. However, sometimes the images are difficult to visually interpret because of the crossing and overlapping of vessels in the angiogram. Also due to the low contrast of the image between the backdrop and the small blood vessels, the blurred and fuzzy background of coronary artery image, a new blood vessel segmentation method using morphology is presented in this paper. Firstly the original angiogram image is preprocessed using Top hat operator which enhances the contrast of image. Then morphological close operation is used for vessel segmentation. After thresholding the blood vessels of coronary angiogram are extracted. Using this method, both the coronary artery trees and most of smaller distal vessels could be extracted clearly.**

***Index Terms* - coronary angiogram, vessel segmentation, morphology.**

I. INTRODUCTION

According to the World Health Organization, cardiovascular diseases such as coronary heart disease are the first worldwide cause of death [1]. Cardiovascular disease takes away more than 12 million lives each year[1]. It is often caused by coronary artery stenosis and blockage. Coronary artery play an extremely important role in the supply of blood to the heart and coronary atherosclerosis is the main reason of heart damage and myocardial infarction[2].A coronary angiogram is a special X-ray test done to find out if your coronary arteries are blocked or narrowed, where and by how much. Vessel extraction from X-ray angiograms has been a challenging problem for several years. There are several problems in the extraction of vessels including: weak contrast between the coronary arteries and the background, unknown and easily deformable shape of the vessel tree and strong overlapping shadows of the bones.

X-ray Coronary angiography is taken as the best for visualizing the morphology and the assessment of coronary artery disease. In order to improve the level of clinical diagnosis, the extraction and segmentation of coronary artery from X-ray angiographic images is very necessary. At the same time extracting distinct vascular patterns is a crucial premise to vascular quantitative analysis.

II.BASIC MORPHOLOGICAL OPERATIONS

Blood vessels of preprocessed coronary angiograms are extracted by segmentation method using morphological operations. The basic morphological operators are: dilation, erosion, opening and closing.

Dilation

The dilation process is performed by laying the structuring element B on the image A and sliding it across the image in a manner similar to convolution .The difference is in the operation performed. It is best described in a sequence of steps: 1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel. 2. If the origin of the structuring element coincides with a 'black' in the image, make black all pixels from the image covered by the structuring element. A structuring element is simply a binary image (or mask) that allows us to define arbitrary neighborhood structures.. It is denoted by A⊕ B.

Erosion

The erosion process is similar to dilation, but we turn pixels to 'white', not 'black'. As before, slide the structuring element across the image and then follow these steps: 1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel. 2. If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the center of the structuring element falls) from ‘black’ to a 'white'. It is denoted by A Θ B

Opening

These two basic operations, dilation and erosion, can be combined into more complex sequences. The most useful of these for morphological filtering are called opening and closing . Opening consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element. In this case the structuring element is often called a probe, because it is probing the image looking for small objects to filter out of the image. It is denoted by A◦B = (AΘB)⊕ B

Closing

Closing consists of a dilation followed by erosion and can be used to fill in holes and small gaps. The closing operation has the effect of filling in holes and closing gaps. Closing and opening will generate different results even though both consist of erosion and dilation. Opening and closing are dual of each other. It is denoted by

$A \bullet B = (A \oplus B) \Theta B$.

III. PROPOSED METHOD

This section describes an automatic segmentation of vessels from X-ray angiograms. The method contains two main stages: (1) Preprocessing of angiograms (2) Vessels segmentation from the preprocessed angiogram. Both stages are explained in detail as follows:

1.Preprocessing of angiograms

Low contrast images could occur often due to several reasons, such as poor or non uniform lightning condition, nonlinearity or small dynamic range of the imaging sensor, i.e. illumination is distributed non-uniformly within the image. Therefore it is necessary to deepen the contrast of these images to provide better transformation representation for subsequent image analysis steps. The morphological Top hat technique is used for preprocesseing. Morphological top hat filtering computes the morphological opening of image and then subtracts the image from the original image. The top-hat transform is an operation that extracts small elements and details from given images. There exist two types of top-hat transform: The white top-hat transform is defined as the difference between the input image and its opening by some structuring element. The black top-hat transform is defined dually as the difference between the closing and the input image. Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement and others.

As the Top-Hat operator is able to detect the logical elevations on arbitrary backgrounds, we can use it for enhancing vessel part. The significant components of the operation are the size and shape of the structure element. From the definition of Top-Hat operator, if the size of structure element is bigger enough than the object which we interested in ,unexpect objects will possibly be detected. On the other hand, if the size of structure element is smaller than the object ,then the background can not be detected surely. So in order to enhance vessel parts clearly, it is necessary to choose the structure element nearly the same or slightly larger in size than the diameter of vessel. Here the disc shaped structure element is selected and the size of structure element is selected 18×18. The top-hat transformation of a gray-scale image A is defines as a minus its opening.

$$\text{Top-Hat}=A-D(E(B,A),A)$$

Where A is original image and B is structuring element.

2) Vessels segmentation from the preprocessed angiogram

The preprocessed image is reversed and processed by the morphological Top-Hat operator [7,8]. Morphological close operation is used for the segmentation purpose. The morphological close operation is a process that morphologial dilation followed by erosion. The most important factor or element which is necessary for closing operation is structuring element. Two kinds of structuring elements are present, first one is flat structuring element and second one is non-flat structuring element [1]. In this project I am using disc structuring element. The output image is obtained by the using this close operation is the blood vessel extracted from background [17]. The closing operation A by B is obtained by dilation of A by B followed by erosion of resulting structuring element by B. Closing operation is defined by $A \bullet B = A \oplus B \Theta B$.

The thresholding is applied on the extracted angiogram vessels. After applying a threshold the background is eliminated and the properly segmented image of the angiogram vessel is obained. The threshold image is the binary image either 0 or 1. Thresholding is the simplest non-contextual segmentation technique. I am choosing Otsu's thresholding. It is used to automatically perform clustering-based image thresholding or the reduction of a graylevel image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two these classes . After thresholding the blood vessels of coronary angiogram are extracted. In order to express the implementation process of the proposed method clearly, the overview of the proposed framework for the segmentation of X-ray angiograms is shown as follows:

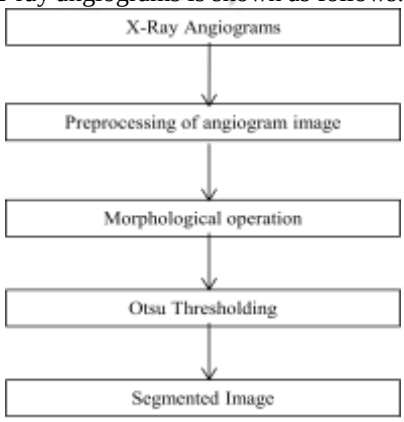


Figure1 Flowchart of proposed method

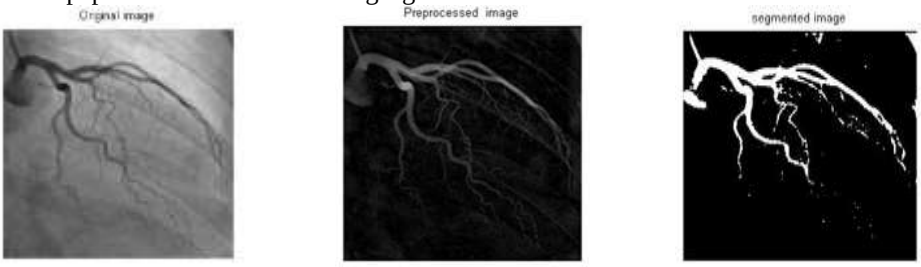
IV. PROPOSED MORPHOLOGICAL ALGORITHM

Step1: The input coronary angiogram image is read.
Step2: For preprocessing morphological Top Hat operation is carried out on the input image.
Step3: Morphological Closing operation i.e. Dilation and erosion is applied on the image with disk shaped structuring elements.
Step4: The image obtained after morphological operation is then thresholded using Otsu's thresholding .

Step5: After thresholding segmented image is obtained..

V. EXPERIMENTAL RESULTS

The experiments are performed on various coronary angiograms and the segmentation results obtained from proposed method indicated in this paper are shown in following figure.



(a) Original image (b) Preprocessed image (c) Segmented image

Figure2 Morphological segmentation

In this way, the morphological segmentation method is carried out on ten images from database[18] and for all these images parameters jaccard index, variance and standard deviation are calculated.

Table1.Performance results of morphological segmentation

Image	Jaccard Index	Standard deviation	Variance
a	0.1288	0.3363	0.1131
b	0.0788	0.2695	0.0726
c	0.1209	0.3445	0.1187
d	0.1633	0.3697	0.1367
e	0.0770	0.2571	0.0713
f	0.1185	0.3242	0.1051
g	0.1327	0.3395	0.1152
h	0.0968	0.2987	0.0892
i	0.1196	0.3247	0.1054
j	0.1187	0.3235	0.1046

The graphical representation of morphological segmentation on all the images is as shown in following figure.

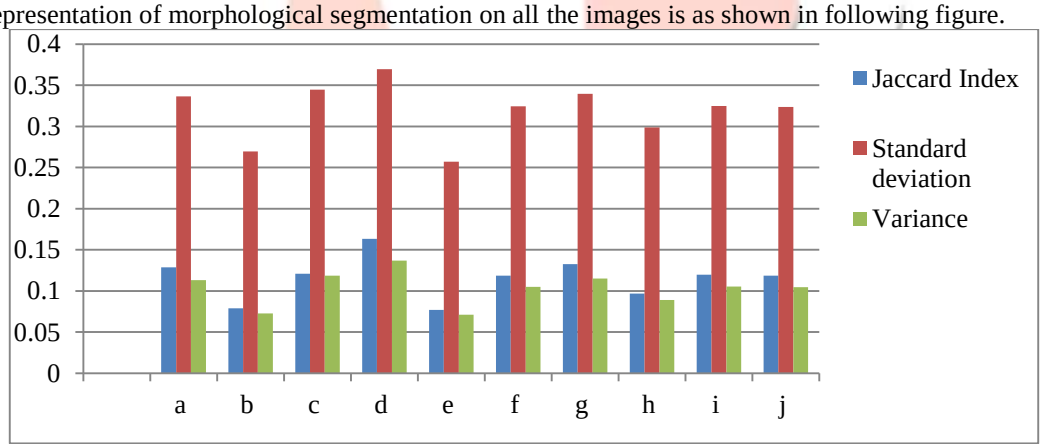


Figure 3.Graphical representation

VI. CONCLUSIONS

Blood vessels of coronary angiogram are segmented using morphology. The method is performed on ten images For each image jaccard index, standard deviation and variance is calculated. We know that, lowest jaccard index indicates better segmentation. Experimental result shows that segmentation using morphology gives jaccard coefficient lower so segmentation is good. As the value of standard deviation is lower, it is near to mean which indicates good performance of segmentation. In our experimental result standard deviation is upto 0.35 which is low. Also from graphical representation, variance is upto 0.12. As the value of variance is lower, it is near to mean which indicates good performance . It is a simple and easier method performing expected segmentation. It becomes easy to analyze the morphology of the coronary artery with reduced operator's work and the method will be useful for the quantitative analysis of coronary arteries.

REFERENCES

[1]World Health Organization, "Cardiovascular diseases (cvds), fact sheet n317," September 2012.
[2] P S Rao, "Balloon valvuloplasty and angioplasty in pediatric practice," Pediatr Therapeut, vol. 1, pp. e103, 2011.
[3] R. M. Haralick, S.R. Sternberg and X.H. Zhuang. Image Analysis Using Mathematical Morphology. IEEE Trans. Pattern Anal. Machine Intell, vol.9, No.7, (1987) pp.532-550.
[4] Jean Serra, "Image Analysis and Mathematical Morphology", Volume 1,1982;Volume2,1988, Academic Press.

[5]L.Vincent. Morphological grayscale reconstruction in image analysis: Applications and efficient algorithms. IEEE Trans. Image Processing, vol.2, No.8 (1993) pp.176-201.
[6]Serge Beucher , "Segmentation Tools In Mathematical Morphology", Handbook of Pattern Recognition and ComputerVision~pp.443- 456,1989 World Scientific Publishing Company.
[7] Eiho S., Qian Y. "Detection of coronary artery tree using morphological operator.", Proc. IEEE Comput. Cardiol. 1997:525–8.
[8]Y Qian, S Eiho, N Sugimoto, M Fujita," Automatic Extraction of Coronary Artery Tree on Coronary Angiograms by Morphological Operators",IEEE conference on computers in cardiology 1998.
[9]F. Zana, J.C. Klein." Segmentation of Vessel-Like Pattern Using Mathematical Morphology and Curvature Evaluation." IEEE Trans. Image Processing, vol. 10, No.7, (2001) pp.1010-1019.
[10] Kaiqiong Sun, Shaofeng Jiang and Yu Wang "Segmentation of Coronary Artery on Angiogram by Combined Morphological Operations and Watershed" 2nd International Conference on Biomedical Engineering and Informatics, IEEE2009. BMEI '09.
[11] K. Sun, Z. Chen, and S. Jiang, "Local morphology fitting active contour for automatic vascular segmentation", IEEE Transactions on Biomedical Engineering, vol. 59, no. 2, pp. 464-473, February 2012.
[12] Zulong Yu and Kaiqiong Sun," Vessel Segmentation on Angiogram using Morphology Driven Deformable Model" IEEE 2010 3rd International Conference on Biomedical Engineering and Informatics (BMEI 2010).
[13] K. Haris, S. N. Efstratiadis, N. Maglaveras *et al*, "Model-based morphological segmentation and labeling of coronary angiograms," *IEEE Trans. on Med. Imag.*, USA, 18(10), pp. 1003-1015, Oct. 1999.
[14] S.M.Pizer, E.O.P.Amburn and J.D.Austin, "Adaptive histogram equalization and its variation," Computer Vision Graphics Image Process,vol.39 ,pp.355-368,1997
[15] K. Sun, Z. Chen, S. Jiang, and Y. Wang, "Morphological multiscale enhancement, fuzzy filter and watershed for vascular tree extraction in angiogram," J. Med. Syst., May 15, 2010. DOI: 10.1007/s10916-010-9466-3.
[16]M. Ashoorirad and R. Baghbani, "Blood vessel segmentation in angiograms using fuzzy inference system and mathematical morphology", International Conference on Signal Processing Systems, pp. 272-276, May 2009.
[17] B. Sindhu, J. B. Jeeva," Automated Retinal Vessel Segmentation Using Morphological Operation And Threshold", International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May-2013.
[18] http://www.osirix-viewer.com/datasets/


IJEDR