



INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

SEGMENTATION OF CORONARY ARTERIES OF HEART

SHARAYU DEOTE¹, POONAM GADGE², RUPALI GULANDE²

1. Assistant Professor, CE Department, Cummins College of Engg, Nagpur.

2. Assistant Professor EXTC Department, RAIT, Navi Mumbai.

Accepted Date: 27/02/2014 ; Published Date: 01/05/2014

Abstract: In this paper, segmentation of coronary arteries of heart is done. The source data is filtered using two dimensional DICOM (Digital imaging & Communications in Medicine) images taken from the 64 Slice Computed tomography Scan Data of the heart, using a filter to highlight only the coronary arteries regions. The work has been implemented using an Intel (R) Core (TM) i3 at 2.20GHz using MATLAB version 7.8.0.347. Segmentation of coronary arteries of heart has been done on 2-Dimensional CT (Computed Tomography) isolated data. The system has been developed using different image processing functions in MATLAB software.

Keywords: Computed Tomography; DICOM (Digital imaging & Communications in Medicine), Coronary Artery Diseases; Segmentation; Morphological operations; Hessian.

Corresponding Author: MS. SHARAYU DEOTE



PAPER-QR CODE

Access Online On:

www.ijpret.com

How to Cite This Article:

Sharayu Deote, IJPRET, 2014; Volume 2 (9): 33-42

INTRODUCTION

Coronary artery diseases are one of the leading causes of death all over the world.

Every year, much of dollars have been spent in the treatment of coronary artery disease. So there is a need to diagnose the Coronary artery diseases at their early stage so that proper measure actions could be taken to cure coronary artery diseases [1-4]. Calcifications in the coronary arteries are the main indicators of Coronary Artery Diseases. These calcifications are detected mostly in the five main coronary arteries, the Left Circumflex (LCX), Left Anterior Descending (LAD), Posterior Descending (PDA), Right Coronary artery (RCA) and the Left Main (LM) artery. A technique for imaging of the

Coronary artery disease is highly desirable, which is non-invasive. The coronary angiography is time consuming, costly and risks are associated with it. There is a non invasive technique that depends on the radiographic views taken from different imaging techniques like Computed Tomography, Magnetic resonance Imaging and other imaging techniques. Coronary computed tomography angiography (CTA) is an imaging test for heart that helps us to determine deposition of fat or calcium or plaque in the artery that have narrowed a patient's coronary arteries [5].

The 64-slice CT scan machine can visualize the image of the heart in much low time, helps in detecting calcifications in blood vessels and other heart problems that are not easily detectable with other techniques. Image segmentation facilitates delineation of hard structures of body and other regions of interest. Segmentation is one of the most difficult tasks in image processing and decides the outcome of analysis and evaluation of pathological regions. There should be a proper segmentation technique to visualize the coronary arteries of heart. We have used the 64- slice CT scan isolated data to segment the coronary arteries of heart in the MATLAB environment using different image processing toolbox functions [6-8].

II. LITERATURE SURVEY

Segmentation of the blood vessels will facilitate volumetric display and will enable quantitative measurements of vascular sizes & shapes. There are several approaches to vessel enhancement. Some of them work at a fixed scale and use nonlinear combinations of finite difference operators applied in a set of orientations [10-12]. Orkisz *et al.* [13] presents a method that applies a median filter in the direction of the vessel. All these methods have performed on a fixed scale analysis and shown problems to detect vessels over a large size range. Multi-scale approaches to vessel enhancement include "cores" [14] and assessment of

local orientation through Eigen value analysis of the Hessian matrix which is second order local structure of the image [19, 15]. The multi-scale approach to vessel enhancement is cited by the work of Sato *et al.* [19] and Lorenz *et al.* [14] who use the Eigen values of the Hessian to determine locally the likelihood that a vessel is present. We consider all Eigen values and giving the vesselness measures an intuitive, geometric interpretation. Yezzi presented a global approach for image segmentation [16], but it brings too much computational cost. The geodesic active region model presented by Nikos [17], who integrates boundary-based with region-based active contour approaches, is more effective than region-based snake segmentation methods, because prior knowledge about ROI is introduced. The important problems in the region-based approaches include the design of region-based models. We have used Vessel Enhancement Diffusion filtering developed by Frangi to enhance/Segment the vessels/Coronary arteries.

III. METHOD

The two dimensional isolated CT scan data of heart from the DICOM image obtained from the 64- slice CT scan machine which is an image reconstructed from the sequence of images taken from different projections by rotating the gantry mounted with sources of X rays & detectors. This image provides the view of some of the coronary arteries of the heart at that projection at which we have chosen an image to process further for segmentation. For the segmentation of arteries in the heart, we must filter the image in such a proper way that can visualize us only the vessels and other regions in the image of the heart got lighter and filtered just like noise. The used steps in the method are described below.

Vessel Enhancement Diffusion Filter: A vessel ness measure is obtained on the basis of all Eigen values analysis of the Hessian which is a second order local structure of the image. We have considered the vessel enhancement as a filtering process that searches for geometrical structures which can be regarded as tubular. Since vessels are of different sizes it is important to introduce a measurement scale which varies within a certain range to search for vessels of all sizes. The main objective of Eigen value analysis of the Hessian is to extract the principal directions in which the local second order structure of the image can be decomposed which directly gives the direction of smallest curvature. The vessel enhancement diffusion filter of Frangi takes into account two geometric ratios, based on the second order ellipsoid. The first ratio accounts for the deviation from a blob-like structure but cannot distinguish between a line- and a plate-like pattern [18].

$$R_u = \frac{\text{Volume}^{4/3} / \beta}{(\text{Largest Cross Section Area} / \pi)^{2/3}} = \frac{|I_u|}{\sqrt[3]{|I_{xx} I_{yy}|}} \quad (1)$$

This ratio attains its maximum for a blob-like structure and is zero whenever $\lambda_1 \approx 0$, and λ_1 and λ_2 tend to vanish. The second ratio accounts for the aspect ratio of the two largest second order derivatives. This ratio is essential for distinguishing between plate-like and line-like structures.

$$R_d = \frac{\text{Largest Cross Section Area} / \pi}{(\text{Largest Area Deriv Length})^2} = \frac{|I_u|}{|I_y|} \quad (2)$$

The two geometric ratios are grey-level invariant. This ensures that our measures only capture the geometric information of the image. We define the following measure of "second order structure ness",

$$S = \|H\|_F = \sqrt{\sum_{j \in D} \lambda_j^2} \quad (3)$$

This measure will be low in the background where no structure is present and the Eigen values are small for the lack of contrast. In regions with high contrast compared to the background, the norm will become larger since at least one of the Eigen values will be large. For 2D images we will have the following vesselness measure,

$$v_0(s) = \begin{cases} 0 & \text{if } \lambda_2 > 0, \\ \left(\exp\left(\frac{-s\lambda_1}{2\beta^2}\right) \right) \left(1 - \exp\left(\frac{-s\lambda_1}{2\beta^2}\right) \right) & \end{cases} \quad (4)$$

Segmentation of Coronary Arteries of Heart

where β and C are thresholds which control the sensitivity of the line filter to the measures and the response of the line filter will be a maximum at a scale that approximately matches the size of the vessel to detect.

We have final estimate of vesselness measure provided by the filter response at different scales:

$$V_0(\gamma) = \max_{s_{\min} \leq s \leq s_{\max}} V_0(s, \gamma) \quad (5)$$

where s_{\min} and s_{\max} are the maximum and minimum scales at which relevant structures are expected to be found. They can be so chosen as to cover the range of vessel widths [18]. The gray scale image obtained after conversion from the original input image and the images obtained after the application of Vessel Enhancement Diffusion Filter are shown as follows



Fig.1 (a) Grayscale Image obtained from Original Input Image



(b) Image obtained after Vessel Enhancement Diffusion Filter

Morphological Operations:

Morphology is a study of size & shapes of the objects. Morphological operations are broad set of image processing operations that process images based on shapes. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. Morphological operations apply a structuring element to an input image, creating an output image of the same size. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image [9].

Structuring Element: An essential part of the morphological operations is the structuring element used to probe the input image. A structuring element is a matrix consisting of only 0's and 1's that can have any arbitrary shape and size. The pixels with values of 1 define the neighborhood. The pixel on the center of the structuring element is the main site of operation of the structuring element [9].

Flat Structuring Elements		Non-flat Structuring Element	
arbitrary	diamond	arbitrary	ball
disc	line		
pair	periodicline		
square	rectangle		
octagon			

Table 1.1 Different Structuring Elements

Two-dimensional, or flat, structuring elements are typically much smaller than the image being processed. The center pixel of the structuring element, called the origin, identifies the pixel of

interest -- the pixel being processed. The pixels in the structuring element containing 1's define the neighborhood of the structuring element [9].

Morphological Opening and Closing: The definition of a morphological opening of an image is erosion followed by dilation, using the same structuring element for both operations. The related operation, morphological closing of an image, is the reverse: it consists of dilation followed by erosion with the same structuring element. You can use morphological opening to remove small objects from an image while preserving the shape and size of larger objects in the image [9].

IV. EXPERIMENTS AND RESULTS

To evaluate the described method, we used the 5 data sets of DICOM images obtained from subject; the described method gave satisfactory results by segmenting the arteries of heart from the input data. The original Input DICOM image from the CT scan Machine of a subject and the Image with desired segmented Coronary arteries is as follows:

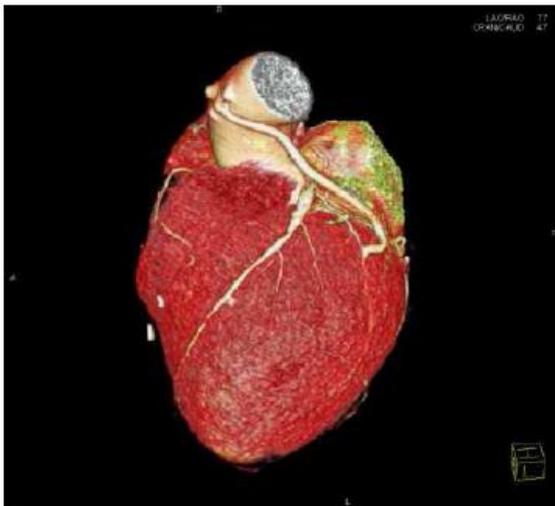


Fig2. (a) Original Input DICOM Image



(b) Image with segmented arteries

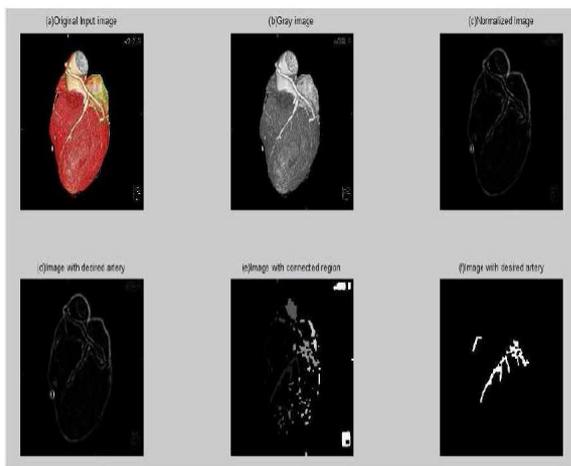


Fig.3 Images at Different stages (a) Original RGB DICOM image; (b) Gray scale image obtained from RGB image; (c) Image after normalization; (d) Image after Filtering; (e) Image with Connected Regions; (f) Image with segmented coronary arteries.

V. CONCLUSIONS

We have described a method for the segmentation of coronary arteries/vessels in the heart of a person which may or may not have calcifications in the arteries/vessels. The method was applied on the data obtained from the 64 slice Computed Tomography Scan Machine. The method was implemented on the Intel(R) Core (TM) i3 at 2.20GHz using MATLAB version 7.8.0.347 and tested with many DICOM files obtained from different orientation of CT scan

machine to provide different Coronary Arteries of Heart The output of the method is showing the segmented arteries.

REFERENCES

1. K. Nieman, et.al, "Coronary angiography with multi-slice computed tomography", *Lancet*, Volume 357, Issue 9256, pp. 599-603, 2001.
2. P. O'Malley, et.al, "Prognostic value of coronary electron-beam computed tomography for coronary artery disease events in asymptomatic populations", *American Journal of Cardiology*, Volume 87, pp. 1335-1339, 2001.
3. P.G. Danias et.al, "Diagnostic performance of coronary magnetic resonance angiography as compared against conventional X-ray angiography: A Meta-Analysis", *Journal of American College of Cardiology*, Volume 44, Issue 9, pp. 1867-1876, 2004.
4. J.P. Finn, et al, "Cardiac MR imaging: state of the technology", *Radiology*, Volume 241, Issue 2, pp. 338-54. 2006.
5. <http://www.radiologyinfo.org/en/info.cfm?pg=angiocoroct>.
6. A.J. Duerinckx, "Coronary Magnetic Resonance Angiography", New York: Springer-Verlag, pp. 342, 2002.
7. P. De Feyter, G. P. Krestin, "Computed Tomography of the Coronary arteries", United Kingdom: Taylor & Francis, pp. 208, 2005.
8. O.M. Vanovermeire, et.al, "A practical approach to 64-slice Coronary CT Angiography" *JBR-BTR*, Volume 89, pp. 1-7, 2006.
9. S. S.Varshney, et.al, "Comparative Study of Image Segmentation Techniques and Object Matching using Segmentation", *Proceeding of International Conference on Methods and Models in Computer Science*, pp. 1-6, 2009.
10. L. Aurdal et.al, "Image Segmentation beyond Thresholding", Norsk Regnesentral: Norwegian Computing Center, 2006.
11. A. Ganoun, et.al, "A new fast level set method", *Proceedings of the 6 the Signal Processing Symposium*, pp. 232-235, 2004.

12. M. M. Orkisz, et.al, "Improved vessel visualization in MR angiography by nonlinear anisotropic filtering", *Magnetic Resonance in Medicine*, Volume 37, Issue 6, pp. 914-919, 1997.
13. C. Lorenz, et.al, "Multi-scale line segmentation with automatic estimation of width, contrast and tangential direction in 2D and 3D medical images", *Proceedings of First Joint Conference, Computer Vision, Virtual Reality and Robotics in Medicine and Medical Robotics and Computer-Assisted Surgery*, Volume 1205, pp. 233-242, 1997.
14. T.M. Koller et.al, "From Data to Information: Segmentation, Description and Analysis of the Cerebral Vascularity", *Dissertation ETH No. 11367, Swiss Federal Institute of Technology ETHZ*, 1995.
15. Jr. Anthony Yezzi, et.al, "A fully global approach to image segmentation via coupled curve evolution equations", *Journal of Visual Communication and Image Representation*, Volume 13, pp. 195-216, 2002.
16. P. Nikos, et.al, "Geodesic active regions: A new framework to deal with frame partition problems in computer vision", *Journal of Visual Communication and Image Representation*, Volume 13, pp. 249-268, 2002.
17. A. F. Frangi, et.al, "Multiscale vessel enhancement filtering, MICCAI'98 Medical Image Computing and Computer-Assisted Intervention", *Lecture Notes in Computer Science, Springer Verlag*, Volume 1496, pp. 130–137, 1998.
18. Y. Sato, et.al, 3D multi-scale line filter for segmentation and visualization of curvilinear structures in medical images, *IEEE First joint conference on Computer Vision, Virtual Reality and Robotics in Medicine and Medial Robotics and Computer*.