

TRACKING OF ARTERIES TREE GROWING IN COMPUTED TOMOGRAPHY ANGIOGRAPHY (CTA) SCANS.

¹ G TEJASWINI, ² Prof. KOMPELLA VENKATA RAMANA

¹M.TECH SCHOLAR, ²PROFESSOR

Department of Computer Science & Systems Engineering,
Andhra University College of Engineering (A), Visakhapatnam, India.

Abstract: CT Angiogram of peripheral arteries is conducted to identify the vessel abnormalities in the body. Our proposed system is for vessel centreline extraction in 3-D computed tomography angiography (CTA) scans of peripheral arteries and tracking of arteries in CTA scans. The main steps in this system are, candidate seed selection, artery tree tracking, which includes centreline extraction, and vessel tree region growing. The final tree-growing step can be instantiated in semi-automated fashion by selecting seeds. This method was evaluated on 25 CTA scans comprising lower and upper limbs arteries in multiple fields of view. Finally this method finds the diameter and curvature of vessels at different standard deviations.

Keywords: tree growing, centerline extraction, tree tracking, curvilinear structure of trees.

I. INTRODUCTION

PERIPHERALS in human body means other than brain and coronary arteries. Now a days peripheral arterial diseases are common diseases which causes narrowing of blood vessel due to stenosis in arteries. PAD is caused due to various reasons like diabetes, smoking, drinking, and cholesterol or through heredity. Higher level of PAD may result in loss of body parts like legs, limbs etc. CTA is the method used to identify and undergo diagnosis of vessel damages. Region growing in trees which uses single seed point for growing, is the method used to extract the vessel tree from bone and other soft tissues. The tree-growing part of the algorithm builds a vessel tree out of unconnected segments resulting from the segment tracking part of the seed. At the initialization point, defined either manually or automatically, the closest unconnected segment represents an initial vessel tree. The vessel tree is iteratively extended by connecting neighbouring unconnected segments until all of the connection rules are no longer fulfilled. After getting the vessel tree, centreline extraction is implemented to get skeleton of arteries structure. Centreline extraction is used for efficient observation of stenosis areas in the vessel structure. The main method called tree tracking is then implemented by considering the seed points. The tree is tracked up to 400 seeds from the initial seed. This method is used for diameter estimation of vessel which is used to find the diameter of the affected vessel.

II. TREE TRACKING PROCEDURE

- **Pre-processing includes inversion and thresholding:**

Tree tracking is implemented on images having brighter backgrounds and darker foregrounds. Images should be in the form of above mentioned manner so image inversion technique is used to get the original images in that proposed manner. Image inversion will convert light areas into darker and dark areas into lighter intensities. Finally, thresholding technique is applied to the resultant images in pre-processing step. Thresholding is one of the methods in image segmentation. A constant of desired intensity value is chosen, and the values above the threshold will be replaced with one value, and below the threshold will be replaced with another value.

Advantages: Noise will be removed.

Disadvantages: valuable information may lost, like edges, boundaries etc., this can be overcome through choosing appropriate threshold for comparison.

- **Region growing:**

Region growing is the technique used to allow the foreground area to grow by removing bones and soft tissues. Candidate seed is selected in the foreground to differentiate foreground with background, this differentiation takes place by verifying the neighbouring pixel values with the current seed value and decides whether to add the value in the region or not. Region growing technique performs series of dilation operations. Dilation is a morphological operation performs thinning or expansion of shape of the input image using structuring element. Here, the structuring element is of disk structure.

- **Vessel Centreline extraction:**

This function filters the image with Gaussian kernel followed by calculation of 2nd order gradients, which approximates the 2nd order derivatives of the image. Spatial Filtering of the input CT image is done with the Kirsch's Templates in different orientations. Followed by thresholding, results in the extracted blood vessels. The threshold can be varied to fine tune the output. Vessel centerline is used for diagnosing the diseases and for planning of surgeries.

- **Curvilinear structure of vessels:**

Curvilinear structure is used to identify the correct shape and orientation of the blood vessel, which is used for diagnosing the vessel abnormalities and identifying the bypass cases. This method uses oriented flux responses for curvilinear structure analysis.

- **Vessel tree tracking using candidate seed selection:**

Tracking of artery tree is done to identify the vessel existence and direction, even in the case of low clarity images. Images may lose their clarity due to various types of noises that may arise during the angiogram process. This method tracks blood vessels from a CT images using gaussian process regression and Local Radon transform, which takes four seeds manually as an input to get the output tree. In GP regression, the values of mean, covariance and direction is calculated, and the variance is added to previous direction vector to get the current direction. Images of simple vessel, reflex vessel, bifurcation and crossovers were given as a training data. Gradient decent is a machine learning technique for the training data which is used to estimate the hyper parameter value α by

gradually update its value in inclined direction till it undergo convergence. Tracking and diameter prediction were done using this α (hyper parameter) value.

LOCAL RADON TRANSFORM TO OBTAIN QUALITATIVE RESULTS:

Radon transformation is a machine learning technique. Loading the training data to estimate the diameter and direction of the vessel. Popular vessel datasets like drive, chase etc., are given as training data. Gaussian noise is added to the training image data for the efficiency in the resultant images though noise is remained.

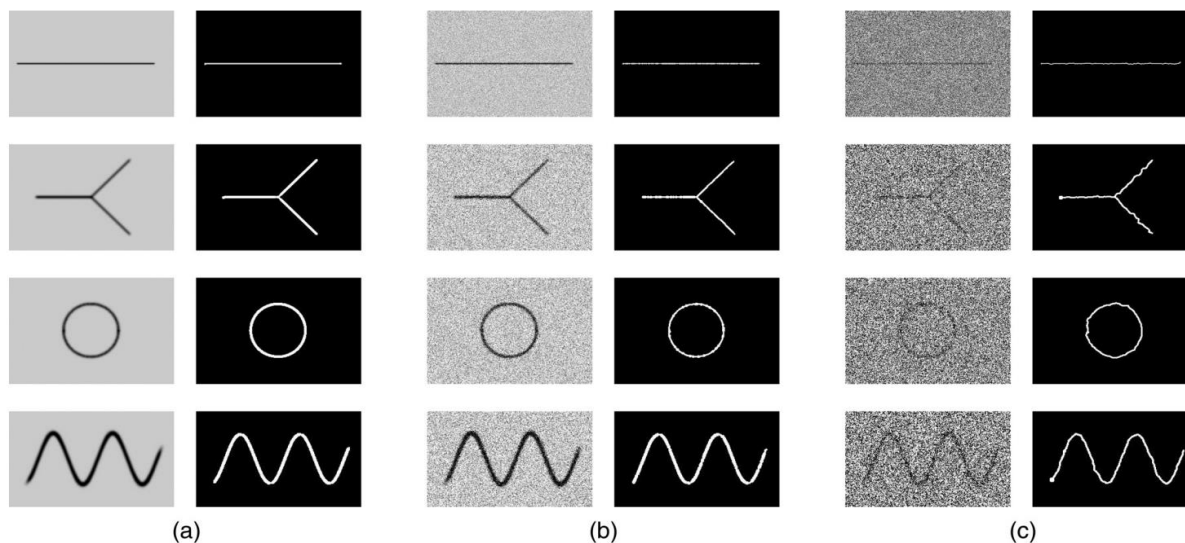


Fig. Phantom images affected by various levels of Gaussian noise (left) used to evaluate the robustness of the proposed algorithm, and their corresponding results (right). Variances in each row are (a) 0,(b) 0.05, and (c) 0.5, respectively.

III. ALGORITHM USED

ALGORITHM FOR IMAGE INVERSION:

- Step 1: load image
- Step 2: choose the desired constant value v
- Step 3: for each and every pixel in the image compare v with i
- Step 4: if($i < v$)
- Step 5: do $i = j - i$
- Step 6: otherwise do $i = j + i$ ($j = 1$ and $v = j$ for image complement)
- Step 7: end if
- Step 5: display resultant complemented image

Note: same algorithm for image thresholding by replacing $i = j - I$ with $i = 0$ and $i = j + I$ with $i = 1$ respectively

ALGORITHM FOR REGION GROWING:

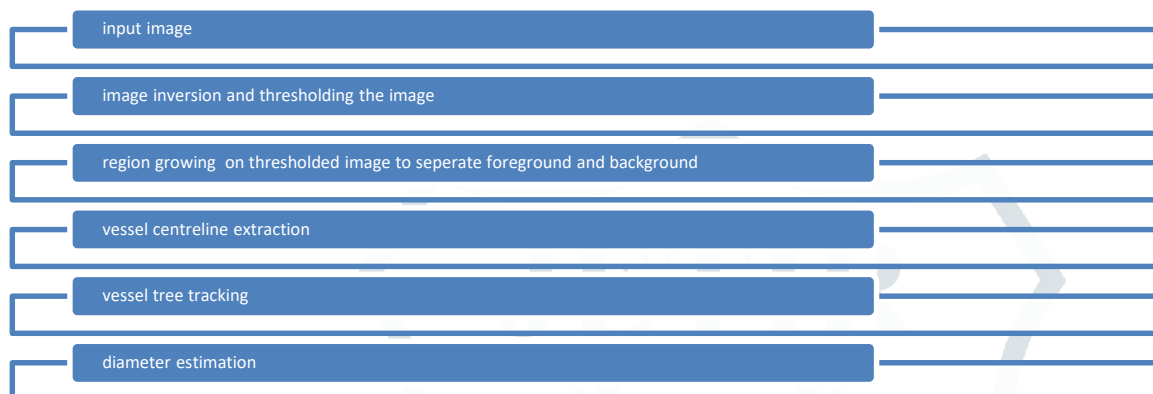
- Step 1: load inverted image
- Step 2: select seed point
- Step 3: consider the seed point's intensity value for calculating the comparison element c for next neighbouring elements n
- Step 4: if $c \geq n$ then
- Step 5: apply dilation method
- Step 6: otherwise,
- Step 7: ignore the element and continue the above process with remaining pixels
- Step 8: display the resultant region grown image.

ALGORITHM FOR BLOOD VESSEL TRACKING AND DIAMETER ESTIMATION:

- Inputs given:** two manual Seed point and vessel initial diameter
- Output obtained:** blood Vessel direction and vessel diameter
- step 1. Load training data and Compute the direction of the vessel using Radon transform for single gaussian process($GP = 0$)
 - step 2. kernel hyperparameter value Estimation
 - step 3. Generation of covariance matrix for direction variation estimation
 - step 4. Calculate the directions at current point, $t1$ and $t2$ are the angles obtained.
 - step 5. calculate the difference between the angles at current point.

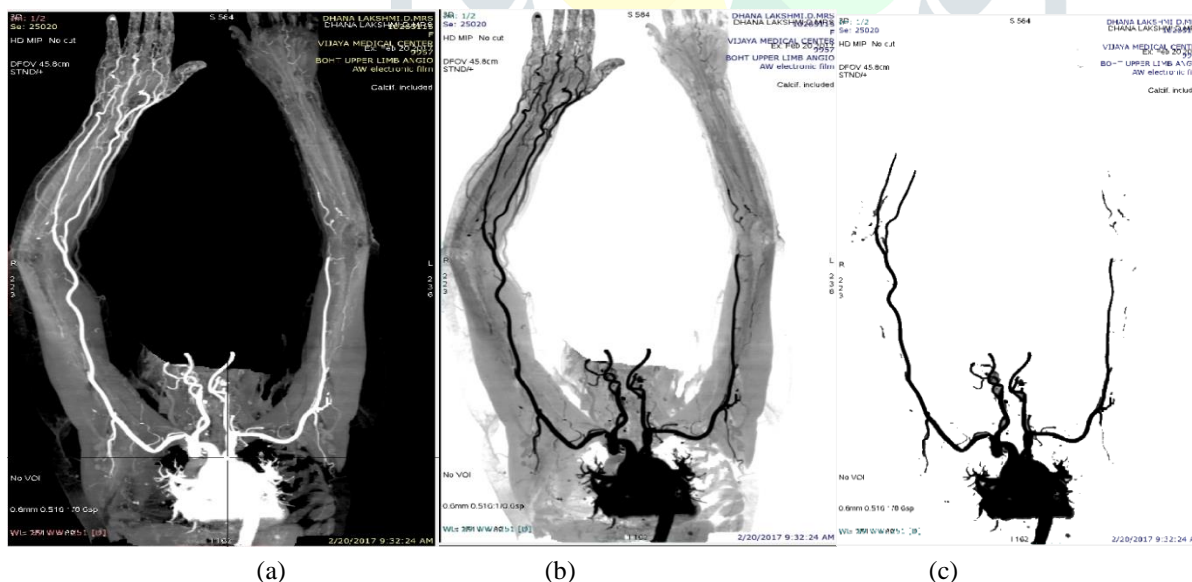
- step 6.** If the difference is greater than 30 degrees
step 7. Confirm the current position as bifurcation
step 8. new vessel directions are estimated for each and every branch
step 9. otherwise
step 10. Confirm the current position having simple vessel
step 11. Choose the minimum angle as directional variation
step 12. new direction estimation
step 13. End if
step 14. Compute features related to diameter- using local Radon transform
step 15. obtain the covariance matrix to estimate the diameter of the blood vessel
step 16. calculating the diameter
step 17. return direction and diameter

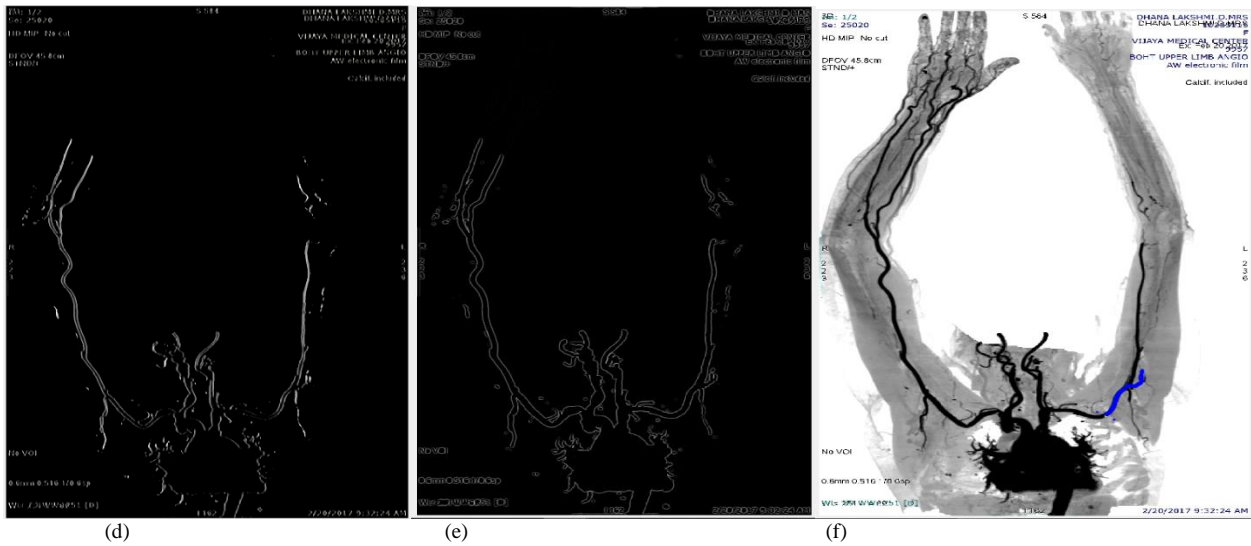
IV. CONTROL FLOW



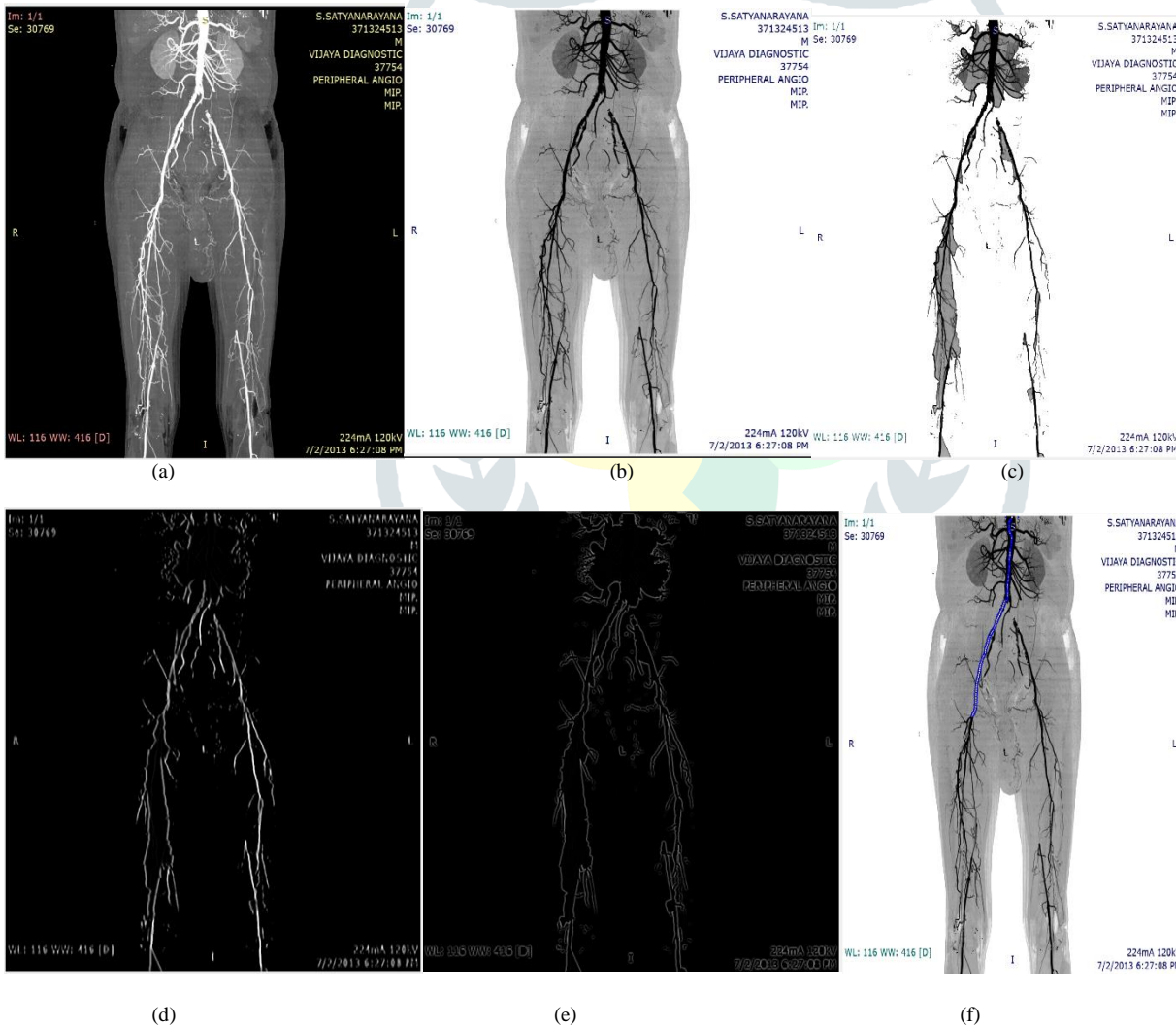
V. RESULTS AND DISCUSSION

Figures shows the results of tree tracking from an input image by using vessel extraction algorithm. Figs. 1, 2, 3(a) shows the original image. (b) is the image obtained by applying complement function to the image. (c) Image after region growing (d) output of vessel centreline extraction. (e) Curvilinear structure of blood vessel. (f) Is the final tree tracking image after selecting the seed points.

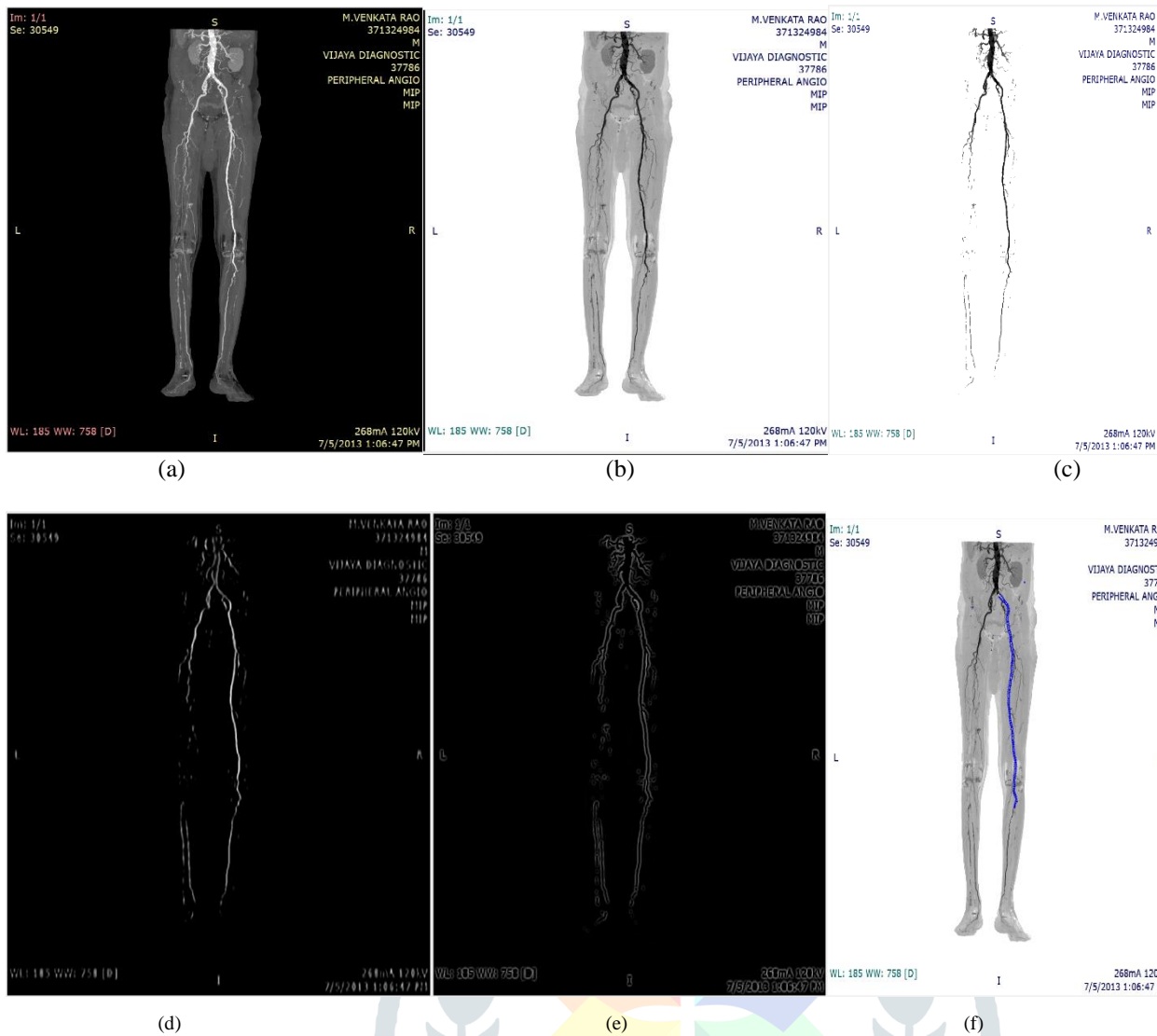




Figs. 1 (a) shows the input image of upper limb. (b) is the image obtained by applying complement function to the image. (c) Image after region growing (d) output of vessel centreline extraction. (e) Curvilinear structure of blood vessel. (f) is the final tree tracking image after selecting the seed points.

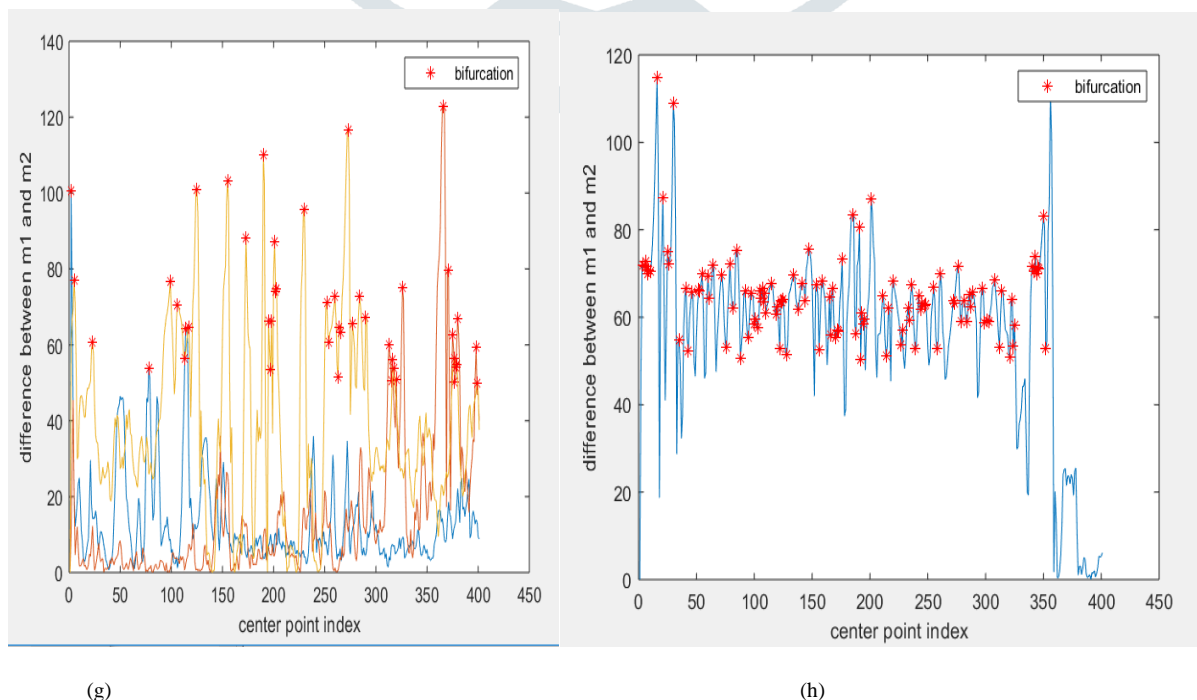


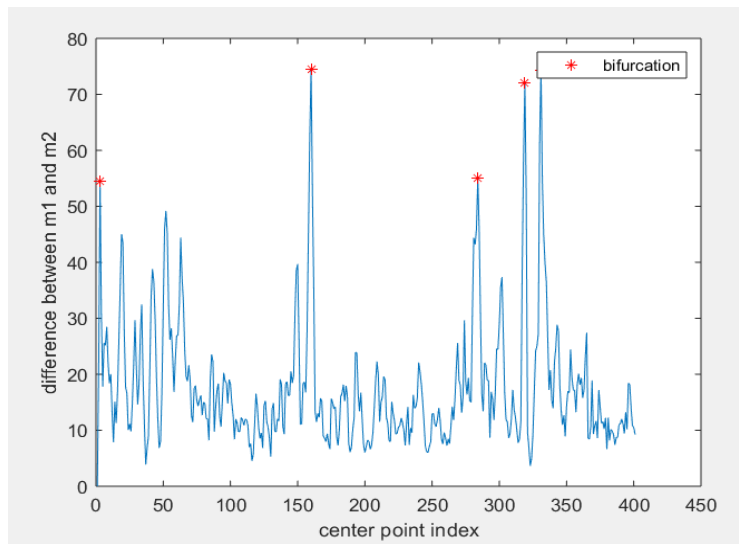
Figs. 2(a) shows the input image of lower limb. (b) is the image obtained by applying complement function to the image. (c) Image after region growing (d) output of vessel centreline extraction. (e) Curvilinear structure of blood vessel. (f) is the final tree tracking image after selecting the seed points.



Figs. 3(a) shows the input image of upper limb. (b) is the image obtained by applying complement function to the image. (c) Image after region growing (d)output of vessel centreline extraction. (e) Curvilinear structure of blood vessel. (f) is the final tree tracking image after selecting the seed points.

Bifurcation is detected, using many number of Gaussian points and the difference between their predicted directions is quantified. For the above three images 1,2,3(a) the bifurcation graphs will be as follows,





(i)

VI. CONCLUSION

We presented a semi-automated vessel tracking framework for centreline extraction in various parts of the human body 3D CTA scans. We have evaluated the algorithm performance on 25 3D CTA scans with different spatial resolution, contrast and image quality. Our algorithm reached high detection and centreline accuracy rates on scans from all parts of the human body. Seed detection and Segment tracking parts of the algorithm can easily find and track the vessels in finding bypass paths to the vessels in the lower and upper limb areas. Finally direction and diameter of vessels are estimated successfully.

VII. REFERENCES

- [1]. ALEXEY A. NOVIKOV, DAVID MAJOR, MARIA WIMMER, GERT SLUTTER, AND KATJA BÜHLER “AUTOMATED ANATOMY-BASED TRACKING OF SYSTEMIC ARTERIES IN ARBITRARY FIELD-OF-VIEW CTA SCANS” *IEEE TRANSACTIONS ON MEDICAL IMAGING*, VOL. 36, NO. 6, JUNE 2017 PP.1359-1371.
- [2]. *J MED IMAGING (BELLINGHAM)*. 2017 JUL; 4(3): 034006. PUBLISHED ONLINE 2017 SEP 12. DOI: [10.1117/1.JMI.4.3.034006](https://doi.org/10.1117/1.JMI.4.3.034006) PMID: 28924571 “TRACKING AND DIAMETER ESTIMATION OF RETINAL VESSELS USING GAUSSIAN PROCESS AND RADON TRANSFORM” MASOUD ELHAMI ASL, NAVID ALEMI KOOHBANANI, ALEJANDRO F. FRANGI, AND ALI GOOYA
- [3]. KANITSAR, D. FLEISCHMANN, R. WEGENKITTL, P. FELKEL, AND E. GRÖLLER, “CPR: CURVED PLANAR REFORMATION,” IN *PROC. IEEE VISUALIZAT.*, NOV. 2002, PP. 37–44.
- [4]. M. W. K. LAW AND A. C. S. CHUNG, “THREE DIMENSIONAL CURVILINEAR STRUCTURE DETECTION USING OPTIMALLY ORIENTED FLUX,” IN *COMPUTER VISION—ECCV*. BERLIN, GERMANY: SPRINGER, 2008, PP. 368–382.
- [5]. F. FRANGI, W. J. NIESSEN, K. L. VINCKEN, AND M. A. VIERGEVER, “MULTISCALE VESSEL ENHANCEMENT FILTERING,” IN *MEDICAL IMAGE COMPUTING AND COMPUTER-ASSISTED INTERVENTION 98*. BERLIN, GERMANY: SPRINGER, 1998, PP. 130–137.
- [6]. SZYMCZAK, “VESSEL TRACKING BY CONNECTING THE DOTS,” *GRAND CHALLENGE CORONARY ARTERY TRACKING (MICCAI WORKSHOP)*, 2008. [ONLINE]. AVAILALBE: [HTTP://HDL.HANDLE.NET/10380/1406](http://hdl.handle.net/10380/1406)
- [7]. U. T. NGUYEN, A. BHUIYAN, L. PARK, R. KAWASAKI, T. Y. WONG, K. RAMAMOHANARAO ET AL., “AUTOMATIC DETECTION OF RETINAL VASCULAR LANDMARK FEATURES FOR COLOUR FUNDUS IMAGE MATCHING AND PATIENT LONGITUDINAL STUDY,” IN *IMAGE PROCESSING (ICIP), 2013 20TH IEEE INTERNATIONAL CONFERENCE ON*. IEEE, 2013, PP. 616–620.
- [8]. SUHEYLA CETIN ; ALI DEMIR ; ANTHONY YEZZI ; MUZAFFER DEGERTEKIN ; GOZDE UNAL , “VESSEL TRACTOGRAPHY USING AN INTENSITY BASED TENSOR MODEL WITH BRANCH DETECTION ”, *IEEE TRANSACTIONS ON MEDICAL IMAGING PUBLICATION INFORMATION*, VOL. 32, NO. 2, 2013, PAGE(S): 348 - 363
- [9]. DILPREET KAUR ET AL “VARIOUS IMAGE SEGMENTATION TECHNIQUES: A REVIEW” , INTERNATIONAL JOURNAL OF COMPUTER SCIENCE AND MOBILE COMPUTING, VOL.3 ISSUE.5, MAY- 2014, PG. 809-814 © 2014, IJCSMC ALL RIGHTS RESERVED 809 AVAILABLE ONLINE AT [WWW.IJCSMC.COM](http://www.ijcsmc.com),