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RESEARCH ARTICLE

SEGMENTATION OF MAJOR VESSEL IN X-RAY ANGIOGRAPHIC IMAGES WITH IMAGE PROCESSING TECHNIQUE

Yiğit Ali ÜNCÜ [1]

[1]Vocational School of Technical Sciences, Akdeniz University, 07070, Antalya, Turkey

ABSTRACT

Recently, image processing techniques, especially various vascular disorders such as hypertension, diabetes and cardiovascular risk, early detection is very important. The most commonly used method to detect these vascular disorders is the X-ray angiography system. In addition, it is also important to detect vascular disorders from angiography images. The proposed method, where image quality and accuracy are the key factors of research, depends on the process of image quality assessment and enhancement, as the enhancement phase where image processing methods are used with the Frangi filter. The segmentation principles and improved region of the object of interest are obtained, which are used as the basis for feature extraction. Normality comparison is made based on general features. The coronary angiographic images are obtained in the literature. The vessel structure of angiographic images has been obtained to achieve better results from the angiographic images through image processing with the Frangi filter in this research. The proposed method includes vessel structures with the Frangi filter, enhancement of the image, and finally segmentation of the images.

Keywords: Angiographic images, Image processing, Frangi filter, Vessel segmentation

1. INTRODUCTION

Many medical imaging techniques contain contrast agents that improve the images was obtained via diagnostic methods for medical diagnosis as angiography, ultrasonography (US), nuclear imaging, and magnetic resonance imaging (MRI). The most common method used in vessel imaging methods is angiography. It is an imaging method using sensitive contrast agents that are ingested intravenously or injected via a catheter to increase the contrast between anatomical structures. [1-2].

Angiography is the visualization of all vascular arteries, veins, heart cavities, brain sinuses by using a contrast agent that can be noticed in the system or device to be imaged. The vascular imaging adventure that started with angiography methods today has developed in parallel with the developments in both device and imaging technology. In this way, angiography can be performed more clearly, in a much shorter time, and with fewer patient doses [2-3].

X-ray angiography is an important method used for the diagnosis of coronary diseases, one of the causes of death in the world [4-6]. The coronary arteries are derived from X-ray coronary angiography from real time catheterization. Catheterization was performed femoral or radially with catheters and coronary angiograms were obtained for DICOM format digitally [4].

The vessel segmentation is widely used for the diagnosis and treatment of many diseases such as hypertension, diabetes, and cardiovascular diseases, etc. Blood vessel images are segmented automatically, and a characteristic feature matrix is extracted in order to identify the segmented binary blood vessels. Blood vessel segmentation consists of four stages as preprocessing, blood vessel enhancement, pixel-based classification, and post-processing. The vessel region is selected prior to

*Corresponding Author: yuncu@akdeniz.edu.tr
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vessel region expansion, gray level transform, and vessel light reflex removal processes are implemented in pre-processing [7-13].

The purpose of pre-processing methods for vascular segmentation such as Median filter, Gabor filter, and water segmentation. The Frangi, Gauss, and Gabor filter are applied separately beforehand, the morphological top-hat transform which extracts details from an image as blood vessel enhancement methods [8]. In addition, vessel segmentation was performed by converting to black-white images using the Otsu method [7]. In the literature, the most used method is the Frangi filter for vessel segmentation [8]. In the pixel-based classification stage, rule-based methods using thresholding, unsupervised methods using clustering, and supervised classification approaches using machine learning methods are implemented. Then, post-processing methods are applied to binary vessels and performance evaluation is performed.

The vessel images are obtained prior to feature points extraction and a characteristic feature matrix is structured in order to use for image registration as a future process [10]. There are several approaches to vessel enhancement. However, few studies have been done on a new imaging system to obtain a high-resolution vessel structure of coronary angiograms [4-6]. The aim of this study is to segmentation of major vessels for angiographic images aim of vessel segmentation.

2. MATERIAL and METHODS

Frangi filtering method, which is frequently used in the literature, was used to obtain the vascular structures. The Frangi method developed was used to determine the vascular (tubular) structures in the image. This approach assuming that the veins are cylindrical structures, these structures are designed to strengthen these structures more than the background objects of the image and obtain the veins. The eigenvalues of the Hessian matrix consisting of two-dimensional (2D) and partial second (2^{nd}) derivative components of the images were used. Thus, it was aimed to detect tubular structures resembling vessel structures in images. Eq. 1 gives the structure of the eigenvalues of the Hessian matrix [8].

$$H = \begin{bmatrix} Ixx & Ixy \\ Iyx & Iyy \end{bmatrix} \tag{1}$$

Where, H, Hessian matrix, Ixx, Ixy, Iyx, and Iyy components show the 2^{nd} derivatives of the image. The 2^{nd} derivation of the image can be accomplished by putting that image into the convolution process with the 2^{nd} derivative of the Gauss function on the s scale (standard deviation),

where s_{min} and s_{max} are for maximum and minimum scales in which the respective structures are expected to be found in Eq.2, respectively, and chosen to cover the range of vessel structures in 2D and 3D images, is recommended,

$$V = \max_{s_{min} \leq s \leq s_{max}} V(s) \tag{2}$$

where, c for the value of the threshold depends on the grayscale range of the image, and half the value of the maximum Hessian norm has been proven to work in most cases. In cases, where s the response of the line filter is approximately maximum on a scale matching the size of the vessel in order to determine, and then integrate the vessel size provided via the filter response at different scales to obtain the final estimate of vesselness;

$$\mathrm{V(s)} = \begin{Bmatrix} 0 & \lambda_2 > 0 \\ \exp\left(-\frac{R_B^2}{2\beta^2}\right)\left(1 - \exp\left(-\frac{s^2}{2c^2}\right)\right) & \lambda_2 \leq 0 \end{Bmatrix} \tag{3}$$

Partial 2nd derivative components in the Hessian matrix are also calculated in this way. Then the eigenvalues $\lambda 1$ and $\lambda 2$ of the Hessian matrix are calculated. These values are $|\lambda 1| < |\lambda 2|$ are ordered to be. In the last case, the vessel value calculated on the s scale is given in Eq. 3.

where β is thresholds which control the sensitivity of the line filter to the measures s and R_B. Here, β is fixed 0.5, $R_B^2 = |\lambda_1| \ / |\lambda_2|$ and $S = \sqrt{\lambda 1^2 + \lambda 2^2}$ are the blobness measure in 2D and accounts for the eccentricity of the 2nd ellipse [8].

In this research, vessel values of all pixels were found with this method, primarily with the Frangi approach. These vessel values are then binarized with a certain threshold value. Finally, the sections connected in the image are grouped separately. Vessel groups can be distinguished by obtaining improved blood vessels by selecting the maximum *V(s)* value for each pixel. In the images obtained by the Frangi filtering method, the noises are suppressed and the veins are obtained without background objects.

3. RESULT and DISCUSSIONS

The preparing the data set, the vascularity of the angiographic images was extracted using the Frangi filtering method. Integrated measurement provided via the filter response at scales to obtain the estimate of the vessels and vessel structure the values of all pixels were found with this method, primarily with the Frangi approach. These vessel values are then binarized with a certain threshold value. Finally, the sections connected to each other in the image are grouped separately. Vessel groups can be distinguished by obtaining improved major blood vessels and noises are suppressed and the veins are obtained without background objects for example of three original images (image1, image2, image3) [14] by the Frangi filtering method (Figures 1-3). In order to the results, the images were resized to 512×512 as input, and then, Frangi filtering was implemented in MATLAB 2020b.

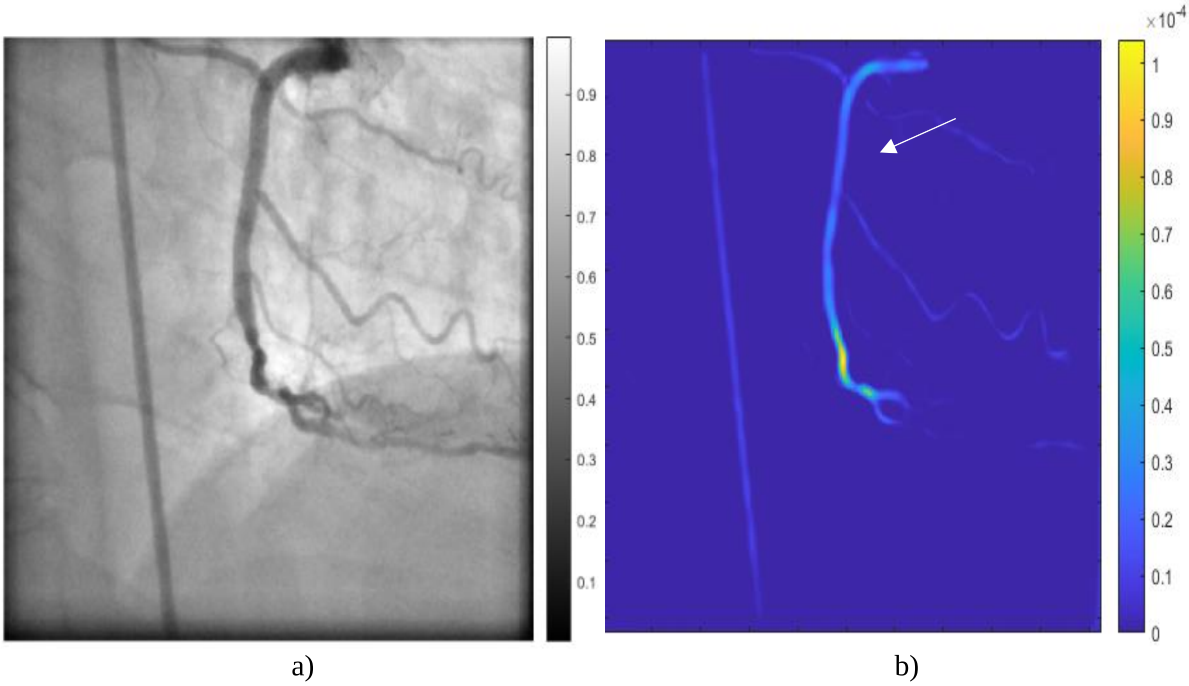

Figure 1. (a) Example of angiographic image (image1), (b) Obtaining the major vascular structure from the angiographic image after filtering

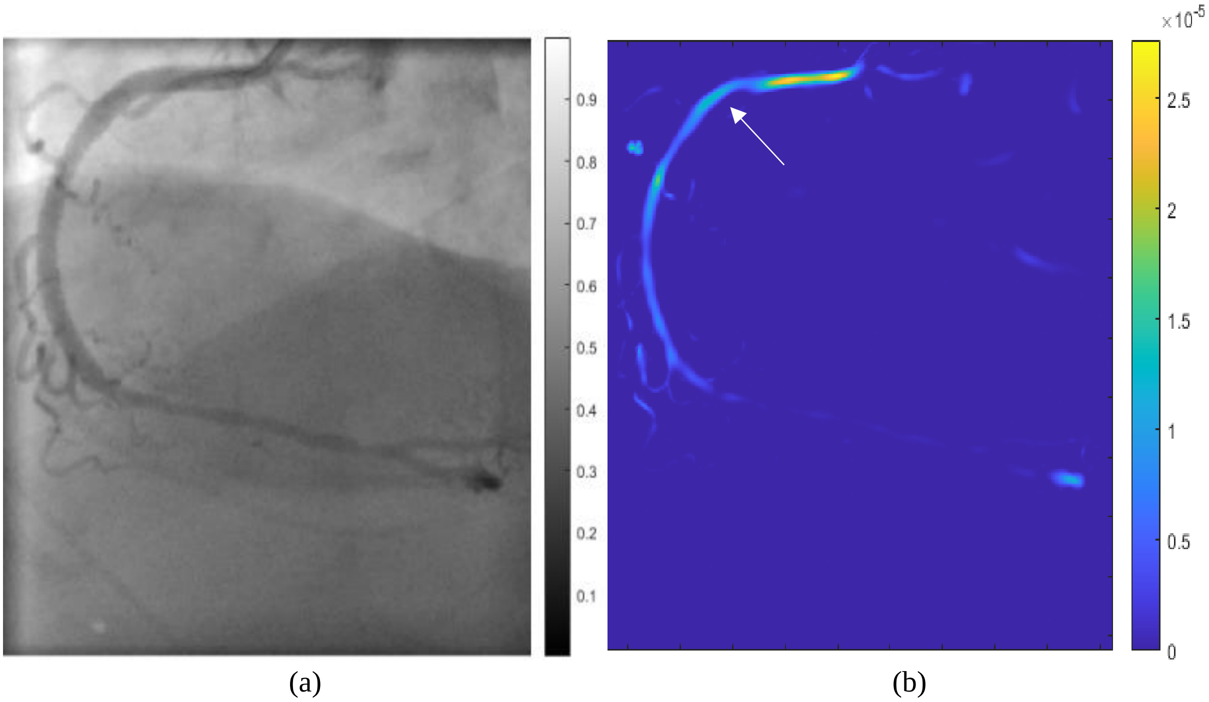

Figure 2. (a) Example of angiographic image (image2), (b) Obtaining the major vascular structure from the angiographic image after filtering

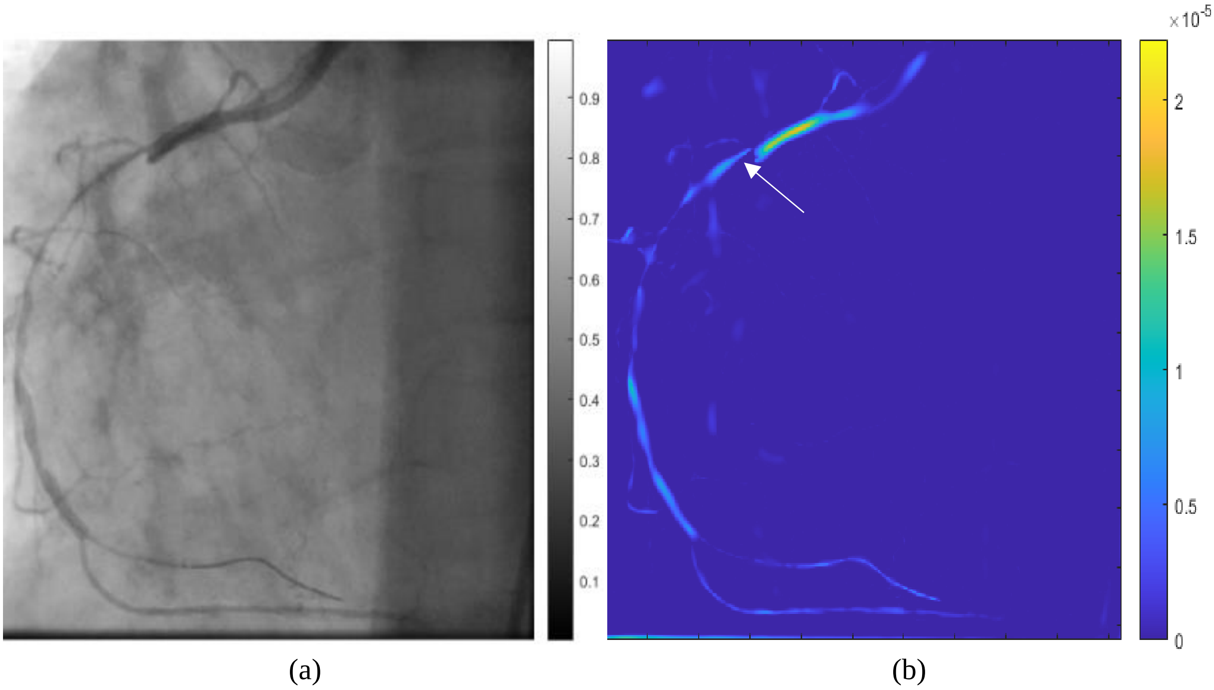

Figure 3. (a) Example of angiographic image (image3), (b) Obtaining the major vascular structure from the angiographic image after filtering

The Frangi filtering as vessel enhancement was subsequently used in the segmentation procedure for obtaining quantitative measurements of vessel structures in all images. Therefore, the Frangi filter was used to better determine the major vascular structure. Using the filtering procedure, the images were reduced to a single pixel thickness. The vessels tend to be compared to the original input dataset for the segmentation of major vessels (Figures 1-3). Among them, the sample that provides the highest

Haussdorf fractal dimension value is selected for the evaluation. Fractal dimensions provide valuable information in shape analysis and classification problems. This situation provides the density of the vessels in a given for all image in Figures 1-3(b).

An image enhancement method has been developed for large vessel segmentation; The time factor was taken into account to discover anomaly problems for vessel structures in the input images. The proposed technique is important in that the segmentation procedures are a region of interest basis for achieving feature extraction.

4. CONCLUSION

There is more background disturbance in the original images in Figures 1-3(a). Nevertheless, the vessels tend to be narrower in the vessel segmentation of the image compared to the original input dataset. The Frangi filter as vessel segmentation should be used to obtain measurements on major vessel structures for a segmentation procedure subsequently. Then, images of major vascular structures were obtained by image processing studies of vascular structures in Figures 1-3(b).

The propose of the method is based on the local structure and examining the local 2^{nd} order ellipsoid with vessel enhancement filtering and use the information of the 2^{nd} ellipsoid for all eigenvalues. This approach is a general issue of other existing approaches. They have used the information for the detection of major vessel structures.

They are important to obtain a segmentation of the vascular structures in this study. If only an accurate pattern of the typical luminance in the vertical direction of the vessel is known, an estimate of the size of the vessels should be made based on the response of the filter on the scales. The vascular structures were obtained by the image processing method with the Frangi filter. The major vascular structures can be classified using artificial neural network algorithms in future studies.

CONFLICT OF INTEREST

The author stated that there are no conflicts of interest regarding the publication of this article.

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