

Sagittal Image Segmentation from Patients with Abdominal Aortic Aneurysms

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Abstract

Early detection in patients with abdominal aortic aneurysm (AAA) is essential to reduce the rupture risk of aortic wall that cause bleeding and often lead to death. The position and shape of AAA is important to complete the diagnosis of doctors in planning the clinical treatment. The segmentation of sagittal image to get aorta play important rule to them, but manual segmentation methods is time consuming. The characteristics of sagittal image have a gray level that is almost the same between one organs to another so it is difficult segmented. This research proposes an excellent semi-automatic segmentation method to segmentation the sagittal MRI image base connected component labelling method. 5 sagittal image specific from a patient with small AAA is used to implemented this propose method. All images were success segmented. The aorta as a result of this proposes method is the best than the Chan-Vese segmentation method and manual segmentation method.

Keywords: aneurysms, abdominal aortic aneurysms, connected component labels, MRI, sagittal Image

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1. Introduction

The aorta is the largest artery in the human body that serves to distribute the blood that rich of oxygen and nutrients throughout the body. The aorta divided into ascending aorta (thoracic aorta) and the abdominal aorta. The dilatation or enlargement that is locally and permanently in the artery refers to aneurysm. This dilatation could be caused by increasing the diameter at least 50% of the normal arterial diameter [1]. Aneurysm is a disease that not only can occur in arteries but also occur in the brain. Aneurysm aorta can cause aortic wall becomes weak. Therefore, the risk of this disease is the rupture of the aortic wall which will cause major bleeding in patients. Often, the occurrence of bleeding can lead to died.

Information about the condition of the aortic aneurysm is a very important experience for treatment. The doctor's prescribe for patients with Small Abdominal Aortic Aneurysm (SAAA) done with medicine. While, the clinical treatments for AAA patients with a high risk of rupture performed with endovascular surgery or open surgery repair. The effects of endovascular surgery or open surgery repair for patients also need to be taken into account. Therefore, doctors need adequate information in taking appropriate action against AAA patients.

The clinical treatments will be taken if the risk of rupture is more than the risk of surgery. The maximal diameters of AAA can be determined the risk of rupture [2]. In other case, a SAAA are known rupture [3-6]. This case makes a dilemma to the doctor to take the clinical treatment. The wall shear stress of the AAA is a factor that can be use to determined the rupture risk [7]. The shape of AAA has influence for the wall shear stress. The shape of an AAA had an effect on the stresses [8].

To prevent the rupture and make a good decision about clinical treatment of patient SAAA, medical imaging tools such as MRI, CT, ultrasound, and X-Ray can help to know the condition of SAAA. The advantages of MRI compared with another medical imaging is performed without ionizing inspection body, the image obtained with a large enough resolution, and allow it to do with the various protocols according to needs. Medical images that resulted from an MRI examination had a gray-scale image. That produced a cross-sectional image of the

body in accordance with the protocol used. One of the best protocols on MRI to determine the position and shape of AAA is a sagittal protocol.

Research related to medical image segmentation method is highly developed. One sample is research about retinal image to diagnosis diabetic retinopathy [9]. Some existing methods on segmentation from the MRI image to get the center-line of the aorta is done with a structured approach to graph grid semi-automatic [10]. Multi-atlas segmentation method for thoracic and abdominal anatomy from the CT images has done automatically. This method uses the level set approach based on local search [11]. Another segmentation approach is the method with connected component labeling. Related research connected component labeling method for image segmentation performed on microscopis of neurons. Characters microscopy image of a neuron is having similar intensity. Segmentation method on neurons microscopy image is done by PDE algorithm and connected component labeling algorithm [12]. In addition, the connected component labeling method is also used to detect the face of a colored image [13]. The other method that is used to segmentation of medical image is chan-veese methods. This method is also known as active contour without edge [14]. BSpline snake also use in medical image segmentation with addition energy term unify the edge based and region based energy derived from the image data [15].

MRI is performed using sagittal protocol on the heart area can be used to determine the condition of the abdominal aorta. MRI sagittal image results not only in the form of an abdominal aortic but also other objects contained there in. Therefore, for the purposes of the analysis of the abdominal aorta, it is needed to do segmentation on the object of MRI sagittal image. In this research, the propose segmentation method is simply and success to segment the aorta from the MRI sagittal image. The propose segmentation method is based on connected component labeling. The aim of the MRI sagittal image segmentation is getting the object of the abdominal aorta aneurysm to get information about the shape of AAA. This research is preliminary study, the object AAA will be used to visualize wall shear stress.

2. Research Methods

Image processing is an image quality improvement process in order to obtain useful information. Segmentation is a process which is very important in image processing to isolate the object to be analyzed. Image segmentation algorithms are generally based on the character of the intensity values, the discontinuity and similarity. Segmentation based on discontinuities do with the approach of the intensity value changes drastically or suddenly, for example, is the edges of an image. Principle approach to similarity is done by partitioning the image into regions that are similar according to a set of predefined criteria [16].

The image data in this study is data from MRI of a patient with AAA. MRI is done with the protocol sagittal morphology. Examination of the sagittal slice morphology produced some pictures. In this study, we use 5 image slice MRI examination results. Each slice size is of 256 pixels x 176 pixels. Five data slice image of the results of MRI in the management software using DICOM before being used for the segmentation process.

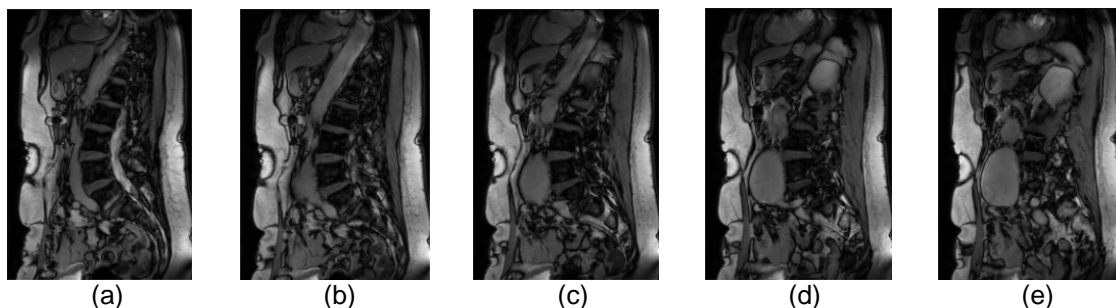


Figure 1. MRI Sagittal image

Figure 1 is a sagittal image as a result of the MRI scanner. There are 5 slices of the image with the distance between slices is 6mm. Each image has dimension 256 pixels x 176 pixels. Image (a) is an image in which the aorta is only visible sliced lengthwise and has not looked the part that suffered an aneurysm. Image (b) and (c) looks aorta lengthwise and looks the part of the aorta that suffered aneurysm. In (d) and (e) of the aorta appear slightly oval, which is part of the aneurysm.

The method used to perform segmentation in this study is a connected component labels. This method was applied twice, first to the input image to obtain a binary image. The second is that this method is applied to the image of result the first steps to examine the connected components to each label to obtain the image of the aorta. Both methods are based on the similarity of image intensity values. The purpose of segmentation is to get the R (ROI). MRI sagittal image segmentation procedure is outlined in the flowchart presented below.

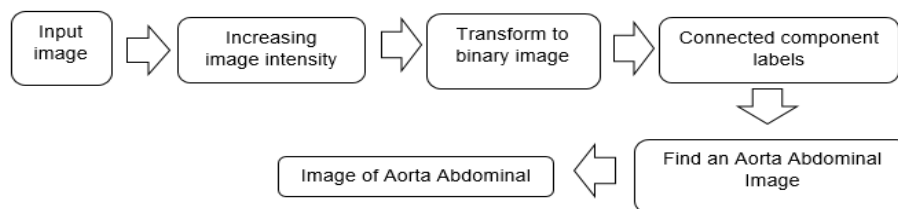


Figure 2. The procedures of image segmentation

Figure 2 explain step by step of segmentation method. MRI sagittal image as an input image have a very low intensity so hard to do the transformation to a binary image. Therefore, the first step of segmentation is done to increase the intensity by multiplication sagittal image with a scalar. The next step is to transform into a binary image of a sagittal image of the results of previous steps. At this stage of the transformation to a binary image examination connected component of the input image is a gray-scale image. The binary image is required as input ideals on connected component labeling method.

2.1. Connected Component Labeling

Connected component labeling is an analysis of the binary image. A binary image can be segmented by the method of connected components. The pixels in the binary image can be grouped into one group if it has a maximum connectedness. To measure maximal connectedness between pixels used operator connected component. Connected component labeling algorithm used to define or divide each component or object in the binary image. Each connected component is given a unique label that can be used to determine how many components are connected in a binary image [17].

The following matrix is a binary image representation which is the background pixels has a value of 0 and pixels that an object has a value of 1. Two pixels that have a value of 1, that p and q are included in the same connected component C if there is a sequence with one pixel value is (p_0, p_1, \dots, p_n) of C where $p_0 = p$ and $p_1 = q$. p_i are a neighborhood of p_{i-1} for $i = 1, 2, 3, \dots, n$ depending on the definition of neighbor. There are two kinds of definitions of neighboring 4-connected and 8-connected. If only the eastern, southern, western and northern part of neighboring resulting in a territory then called 4-connected. But if the note is in addition to four kinds of directions had added four more, namely the southeast, southwest, northwest and northeast, it is called 8-connected [17].

The following matrix shows the change of the connected component to the unique labeling of each connected component. The number of components connected to the matrix is 3. Figure 3(a) is a matrix representation of the binary image with the number of connected components is 3. Each component is given a unique label, so that there are three number of label, ie 1, 2 and 3. Figure 4(a) is a binary image with five objects, and Figure 4(b) connected component labeling for binary image. Each object has one label that is unique.

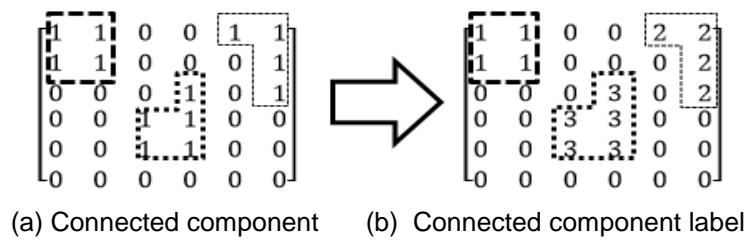


Figure 3. Process of labeling the connected component

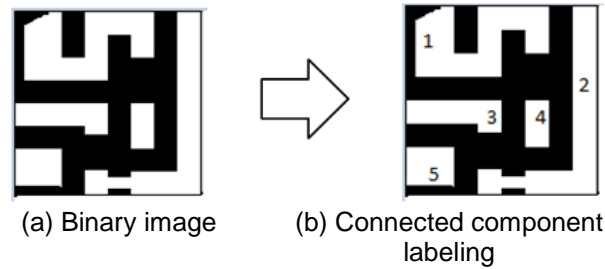


Figure 4. An example of connected component labeling

2.2. Transform to Binary Image with Connected Component Labels

Binary image obtained by applying the method of the components are connected to the gray-scale image. The input image for the connected component is a binary image. The objective of labeling is to get the minimum value of compacity [18]. There are 8 steps to get the binary image that has been well segmented. Each step of the process to obtained binary image described as follows:

1. Labeling image to obtain a homogeneous area with 8 pixel values are connected on the image. The label contains an integer with a value of 0 and 1. The pixel with value 0 is the background and the pixel with value 1 is the object.
2. Calculate the image area, the length of the major axis and the minor axis length of the image of the labeling.
3. Removing small areas and take great area with greater than 100 pixels.
4. Calculate the value compacity of the image. Compacity value obtained from the major axis length divided by the length of the minor axis.
5. Determine the area with minimum compacity.
6. Corrects index for connected component with compacity minimum and have area more than 100 pixels.
7. The next step is recast the image to be displayed.
8. Improving the quality of the image of the transformation into a binary image using morphology fill by filling in holes of the background that can not be achieved by filling the background of the image.

2.3. Flowchart for Finding an Image of Abdominal Aorta

To obtain an image of the abdominal aorta has to be checked each label is an image of the aorta or not. The following image is a flowchart to determine an object that displayed is aorta or not. The result of the segmentation process is in the form of an image of the aorta. Aortic image segmentation result is a binary image. Determining the image of the aorta is done manually by the user.

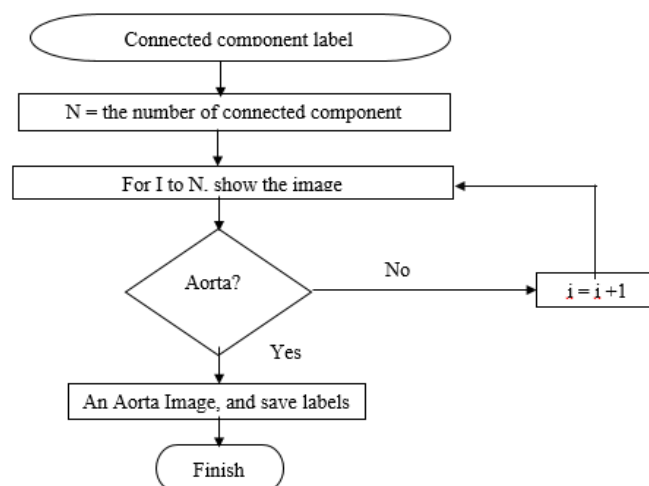


Figure 5. Flowchart for finding an aorta image

3. Results and Discussion

3.1. Result of Proposed Methods

The input image for the sagittal image segmentation is the result of the examination of a patient with AAA that composed of 5 slices. The figure bellow shows the results of each step in the segmentation process.

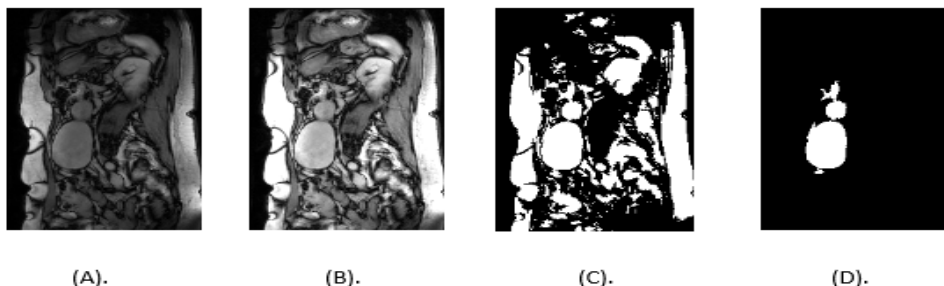


Figure 6. The result of each process

In Figure 6, on figure (A) is an input image which the object of the aorta is marked with arrows. It shows that the input image has a very low intensity, so it is needed to be improved. Figure (B) is a result of an increase in the intensity image with scalar multiplication. Figure (C) is the result of the process binary transform. In this image analysis components are connected by 8-connected, followed by the provision of a unique label for each connected component in the image. Furthermore, each label is shown connected component corresponding to the acquired image of the aorta as on figure (D) as an output of this propose methods.

In Figure 6 the input image is an image (e) in Figure 1. Here is an image segmentation results for all inputs which can be seen in Figure 1. Each input image is segmented by three kinds of methods are chan-veese method, the manual method and the proposed method.

Chan-veese method used to transform the input image into a binary image. Selection of the aorta objects carried by connected component labeling as described in Figure 5. In Figure 7 is given a result of segmentation by Chan-veese method. In the first to third input image, the method veese chan has not managed to segment the image of the aorta. In this input image, the aorta which extends not been successfully obtained. Chan-veese method uses a technique to minimize a function of energy that is influenced by the intensity value. In the picture the elongated aorta, there is a section which is disconnected so difficult to be segmented.

Moreover, the magnitude of the intensity of the aorta in one object has a significant difference and so difficult to be segmented.

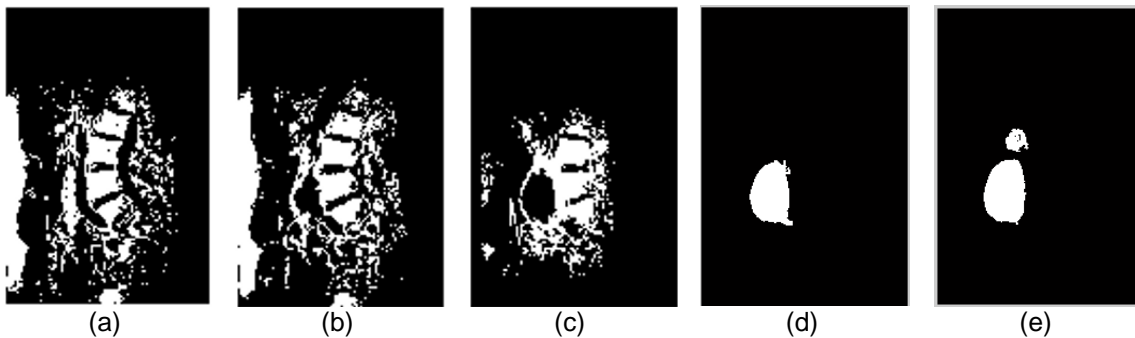


Figure 7. Chan-veese methods

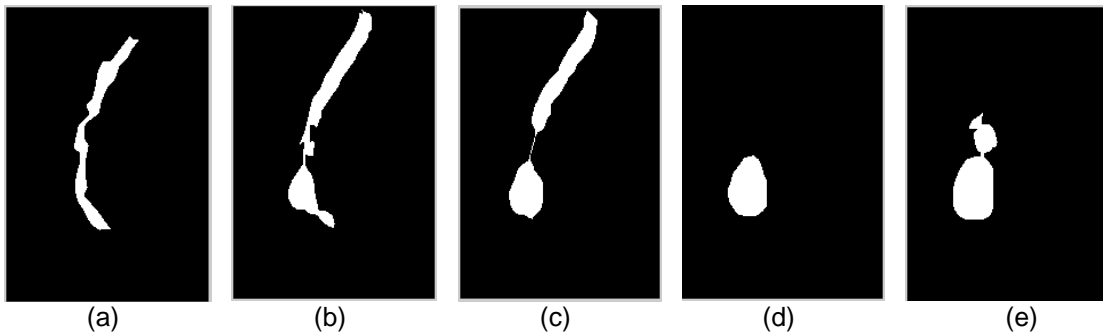


Figure 8. Manual

In Figure 8 can be seen segmentation results with manual. Segmentation by manually done by creating a polygon in the input image to produce a binary image as in Figure 8. A disadvantage of this method is not obtainable two separate images into one segment. Polygon method will take the area enclosed within the polygon, so that if there are two separate objects it must be done manually segmentation 2 times so it is quite time consuming.

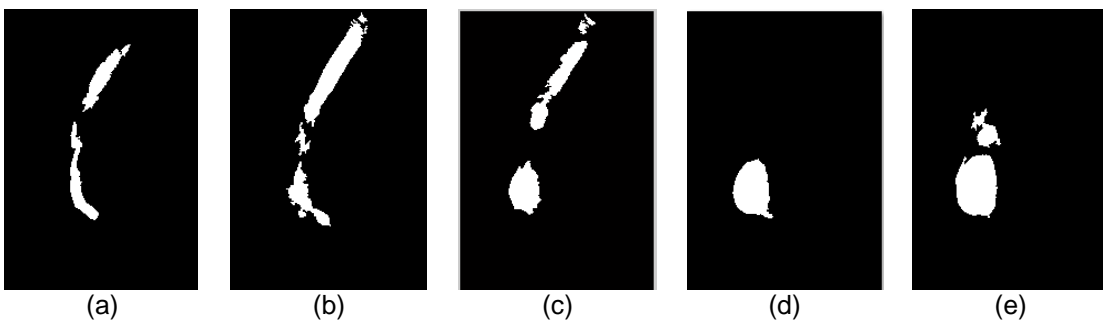


Figure 9. Propose Methods

Figure 9 is the result of segmentation by the proposed method. All of the input image (image 5 in Figure 1) can be segmented and successfully obtained good aorta objects and in accordance with the input image. Figure 9 (a), (b), and (c) is the image of the segmentation of the input image in Figure 1 (a), (b), and (c). In this image can be seen that the object of the aorta is segmented according to the input image in the form of an elongated aorta and had

started to appear part of the aorta that suffered aneurysm. In Figure 9 (c), part of the aorta that extends seemed disconnected, this is due to the process of transformation to a binary image, a section with very low intensity is given a value of zero. In Figure 9 (d) and (e) is an image segmentation results of the input image in Figure 1 (a), (b), and (c). Segmentation results for experiencing aorta aneurysm with the proposed method were successfully obtained very well.

3.2. Discussion

Based on Figure 1 there are 5 input images to the segmentation process. The first image is an image 1 (a) can not be segmented using methods chan-veese, less representative with manual methods with the parts that are not connected, and can be segmented by either using the proposed method. The second and third image that Figure 1 (b) and (c) for the parts that have already aneurysm can be segmented by the method Chan-veese but for part aortic aneurysm is experience can not be segmented. Results for the manual method less representative with the manual method that is the part that is not connected is not visible. As for the segmentation results with the proposed method is very good. The fourth and fifth image is the image 1 (d) and (e) are part of the aorta that undergo aneurysm. This image was successfully segmented using three methods. Segmentation results with Chan-veese method, the manual method and the proposed method is almost the same but the best result is segmentation with propose method.

Sagittal image as an input image can be classified into two groups, one is input image in the form of elongated aorta and aneurysm and second group is input image with section oz. The main difficulty is segmenting the image for the first group experienced Chan-veese methods and manual methods. Sagittal image segmentation methods proposed premises not having problems including an elongated object aorta (the input image for the first group). Objects abdominal aortic as a result of the segmentation process looks good visually. The results of this segmentation can be used for further analysis of AAA patients, for example related to the blood flow model and measurement the diameter of the aortic aneurysm which can be used for treatment.

4. Conclusion

The proposed method in this study has been successfully used to get the abdominal aorta from MRI sagittal image. This segmentation method is based on the principle of connected component labeling. The object of the aorta resulting from segmentation method is quite nice visually. The 5 slices from MRI sagittal image, aortic object for each slice always successfully obtained. But in this proposed segmentation method, determination of aortic object or not is still done manually which at the time was called and displayed on each label connected component corresponding to that label. Therefore, the proposed segmentation method is still a semi-automatic. This proposed method is our preliminary study in case AAA patients. The proposed method still needs to be applicated to another AAA patient.

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