University of Burgundy

Masters in Computer Vision and Robotics

Medical Imaging Analysis Report

Segmentation of Left Ventricular Epicardium and Endocardium in Short Axis MRI

By

AkshayKumar Dudhagara

Vamshi Kodipaka

Supervisor:
Dr. Alian LALANDE

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INTRODUCTION

From the reports of world Health Organization (2002) 29 percent of passings were influenced via cardiovascular disease in that 32 percent were women and 27 percent were men. These figures have made the increase in research into the diagnosis and curing the cardiovascular diseases. [1]

First and foremost, conventional strategies for cardio imaging like cardiac ultrasound and angiography were utilized. Because of less SNR, later 3D ultrasound and x-ray where used, these were also suffered in some areas later on some contrast agents were used by which the patient's health were affected and also the agent is affected to reach apex of the heart. After that, cardiac magnetic resonance (MRI) which is rapidly advancing in heart diseases where used. Because of its High Contrast and topographical view between the soft tissues without using a contrast agent made it very popular.

In the paper we choose (M.Lynch's Implementation) does segmentation of lv cavity in two phase approach which is illustrated in the fig 1. Here in first phase the aim is to automatically locate and segment out the lv cavity whereas in second phase we will use the thickness of the interventricular septum for segmentation remainder of epicardium.
This paper was organized as follows:

1) Preprocessing with a short description of the segmentation algorithm.

2) Focusing on the auto detection of the lv cavity and calculate the ejection fraction.

3) Moving onto the heuristics involved in segmenting the outer wall of the myocardium.

4) The results are shown and evaluated.

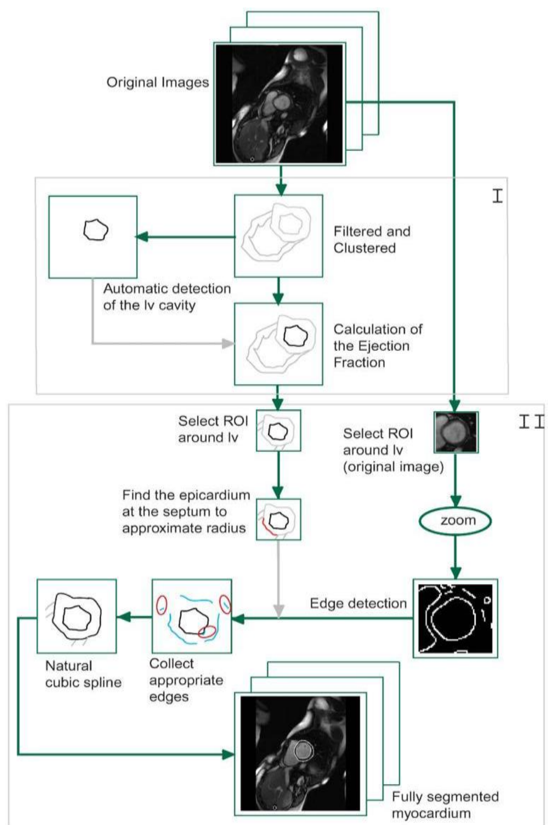


Figure 1: M.Lynch's Implementation

OUR PROJECT DESCRIPTION:

Based on the segmentation, we propose an algorithm. For the segmentation of the endocardium of the left ventricle we have used k-means clustering method whereas for the epicardium we have used region growing technique to find the border of the epicardium and watershed algorithm.

PREREQUISITES

Before getting into the details of our project implementation, is must to know the long and short axes of the heart and find the LV region to segment. Also, it is crucial to the importance of MRI Imaging in the Segmentation process. Here below, we explain the Image planes sectioning of the Heart. Figure 2 and Figure 3 are self –explanatory for this, the white dotted-line indicates long axis and the blue dotted lines indicates the Short axis of the heart (perpendicular to the long axis). The slices are to be considered with respect to the blue lines indicated in the figure 3.

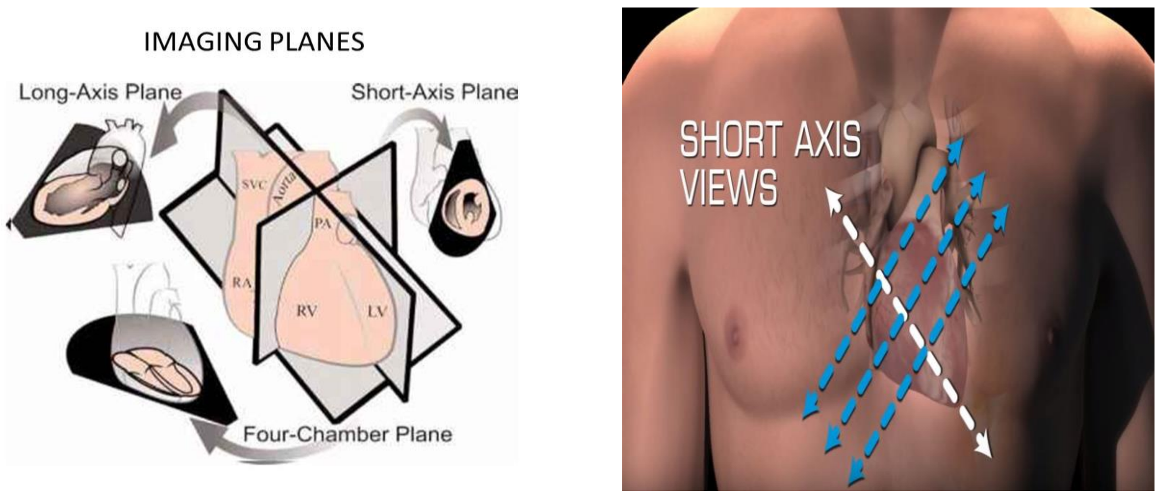


Figure 2&3: Heart Short Axes Representation

METHODOLOGY

3.1 ENDOCARDIUM SEGMENTATION

The endocardium is the innermost layer of tissue that lines the chambers of the heart. Its cells are embryo-logically and biologically like the endothelial cells that line blood vessels. The endocardium also provides protection to the valves and heart chambers.

The endocardium underlies the much more voluminous myocardium, the muscular tissue responsible for the contraction of the heart.

Because of the presence of the papillary muscles and trabecula ions inside the heart chamber which has the same intensity of the myocardium we face some difficulties to segment the endocardium.

Region of Interest (ROI):

It is the base of our segmentation. In order to perform epicardium and endocardium segmentation, the very first thing is we must find the Region of interest (ROI). We define ROI according to the user's choice. When user select the center of the left ventricle, the certain size around a user defined point will be cropped which is the ROI of selected image. Refer Figure 4.

K-means clustering

K-means clustering is one of the simplest and popular unsupervised machine learning algorithms.

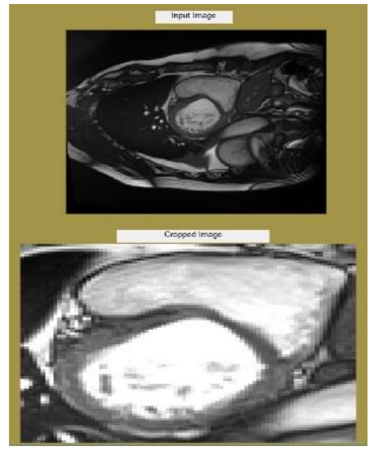


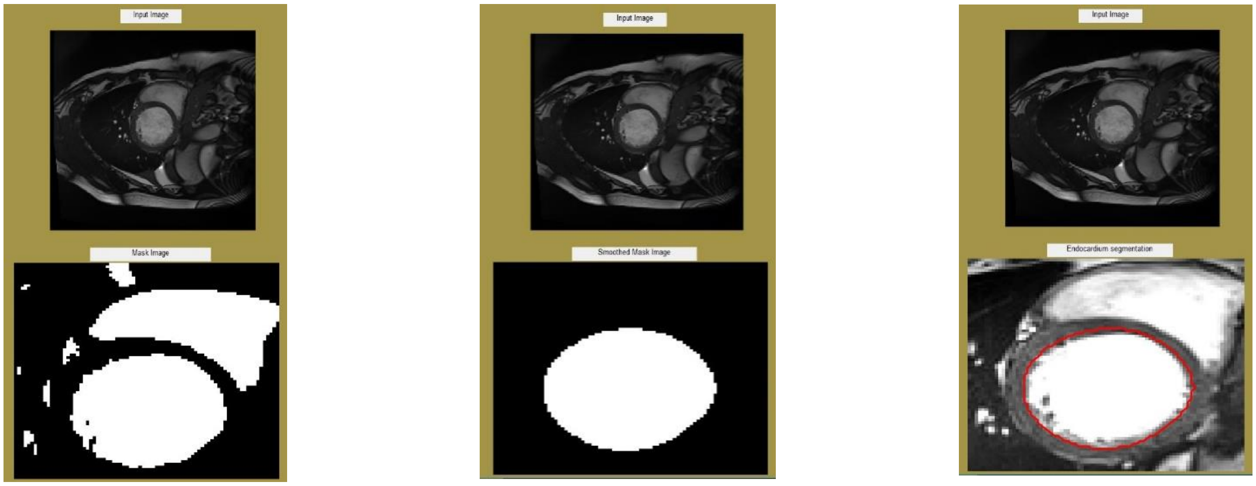
Figure 4: ROI

The *'means'* in the K-means refers to averaging of the data; that is, finding the centroid.
The objective of K-means is simple: group similar data points together and discover underlying patterns. To achieve this objective, K-means looks for a fixed number (k) of clusters in a given input image.
In other words, the K-means algorithm identifies k number of centroids, and then allocates every data point to the nearest cluster, while keeping the centroids as small as possible. Every data point is allocated to each of the clusters through reducing the in-cluster sum of squares.

<u>Algorithm:</u>

- A cluster refers to a collection of data points aggregated together because of certain similarities. we'll define a target number *k (In our case, k =2)*, which refers to the number of centroids we need in the data.
- A centroid is the imaginary or real location representing the center of the cluster. To find each pixel to the center of the cluster, we will initially choose the centers of the cluster.
- We will calculate the distance from each center to each pixel and calculate the distance from the first pixel to each center and then determine the smallest distance between the pixel and centers. According to the calculations, center is shifted in the space.
- We will compare the distance from each pixel to the centers and according to that we will assign the pixels into the clusters.
- The process will repeat, until the pixels stay in the same clusters, the centroids have stabilized or there is no change in their values because the clustering has been successful. The defined number of iterations has been achieved.

At the end, we get the image mask which have two colors (black and white). The result is shown in figure 5. we can see the shape of the parts of the left ventricle. We know that the shape is a circle but, on the image, there are unnecessary elements and we have to remove them. For that we will do the smoothing and then we use **MATLAB in-built bwconvhull** function in order to generate convex hull image. We use 8 connectivity to get big object.



K-mean Smoothing Segmentation

Figure 5: Sgmentation of Endocardium

To find the boundaries of the endocardium, we create the mask of the object and find its parameters which will give the boundaries of the endocardium. We note the x and y co-ordinates of the boundaries and will use it to draw on our object.

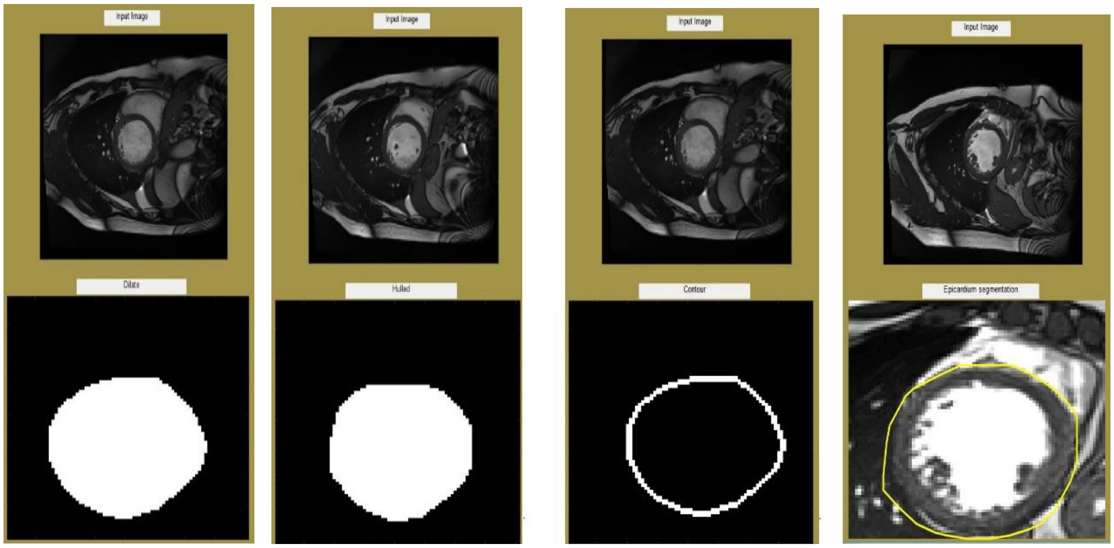
3.2 EPICARDIUM SEGMENTATION

The outer layer of the heart is termed epicardium and the heart is surrounded by a small amount of fluid enclosed by a fibrous sac called the pericardium. We have used watershed algorithm and region growing technique in order to segment the epicardium.
Around the epicardium there are different tissues (i.e. fat, and lung) that have different intensities and because of the poor contrast between these tissues and the myocardium [2], we face some difficulties to segment the epicardium.

Watershed is a transformation defined on a grayscale image. The name refers metaphorically to a geological watershed, or drainage divide, which separates adjacent drainage basins. The watershed transformation treats the image it operates upon like a topographic map, with the brightness of each point representing its height, and finds the lines that run along the tops of ridges.

Using the watershed, we compute the mask of the epicardium. For that, we find the Euclidean distance between the center and the elements and among the connected elements we choose the one which is closest to the left ventricle (For watershed: put *help watershed* in MATLAB).

We compute the convex hull of the mask and dilate the resulting image. Then we convert our images from rectangular domain to polar domain. We can see in the figure 6, the Contour of the epicardium is the difference between dilated and convex hulled images.



Dilate Hulled Contour Segmentation

Figure 6: Segmentation of Epicardium

We use Region growing technique to find the boundaries of the epicardium. It is a simple region-based image segmentation method and classified as a pixel-based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region. The main goal of segmentation is to partition an image into regions. Some segmentation methods such as **thresholding** achieve this goal by looking for the **boundaries between regions based on discontinuities in grayscale** or colour properties. Region-based segmentation is a technique for determining the region directly.

We took the difference between a pixel's intensity value and the mean of the region for this technique and we set the threshold in order to stop the growth of the area. If the difference of the intensity is larger than a threshold value, the region growth will be stop.
The figure 6 shows the segmentation of the epicardium.

3.3 GUI DESIGN

Step1: Click on **"Load Button"** to load nifti image.

Step2: Select the number of slice that you wish to segment.

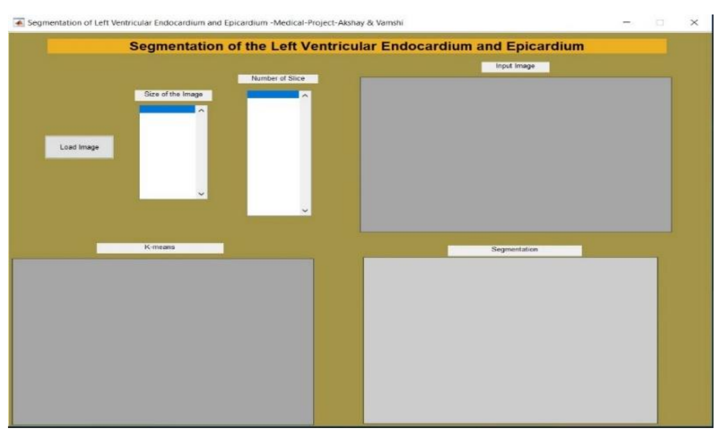


Figure 7: Initial GUI Design

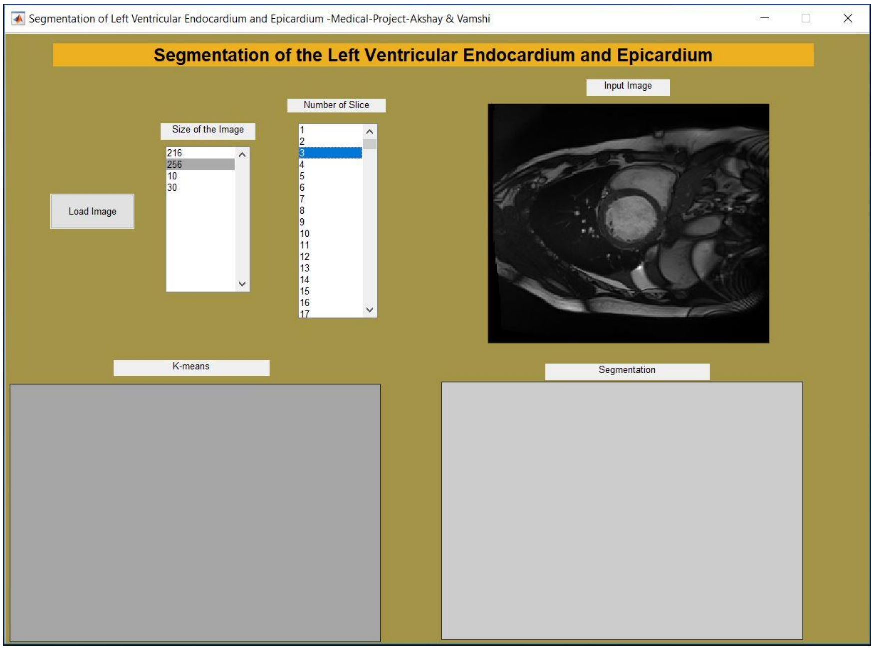


Figure 8: GUI after loading image – ready for segmentation

Step3: Right click on the selected region, finally you will get "Segmented" image that you required to find.

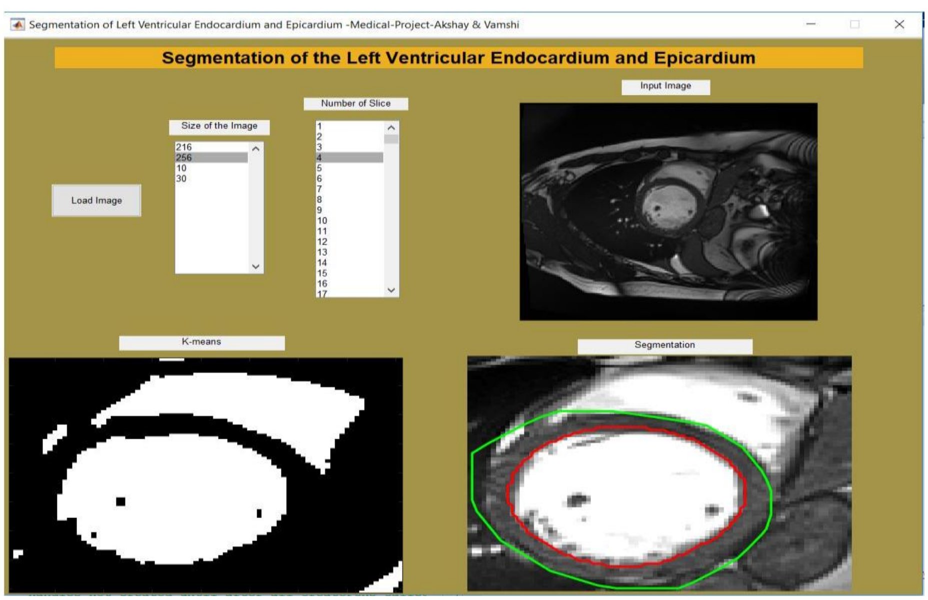


Figure 9: Output Segmented Image of the Left ventricle both Epicardium and Endocardium Rings

CONCLUSION

Through this project, we realized the need for the segmentation of the endocardium and epicardium that especially useful in diagnose and determining the functioning of heart. We use the MRI Imaging technique to segment the left ventricle both Endocardium and Epicardium in their short-axis.

Thus, we can also calculate the thickness of the involuntary muscle called myocardium which can be crucial to the check abnormal heart beats. We also observed that nifti images provide the sources for the MRI images in segmentation of heart (each image by slices).

FUTURE WORK

Now, Segmentation of heart alone does not provide the work function. It just gives the site of existence. But the main motto is to find the geometry that is the Volume of each slice (area multiplied by the thickness of the slice). This gives the volume for one slice thickness.

We calculate the same for the all other slices and integrate them to find the overall volume of left ventricle. We will then obtain the Volume of the LV which can be used to measure the amount of blood that left ventricle can hold during systole and diastole.

REFERENCES

[1] M. Lynch, O. Ghita, P.F. Whelan, "Automatic segmentation of the left ventricle cavity and myocardium in MRI data"

[2] U. Morbiducci's "Left Ventricle Segmentation in Cardiac MRI Images"

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