Project Title: ***Quantification of Trabeculae Inside the Heart from MRI Using Fractal Analysis***

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Left ventricular non-compaction (LVNC) is a rare cardiomyopathy (CMP) that should be considered as a possible diagnosis because of its potential complications which are heart failure, ventricular arrhythmias, and embolic events. For analysis cardiac functionality, extracting information from the Left ventricular (LV) is already a broad field of Medical Imaging. Different algorithms and strategies ranging that is semiautomated or automated has already been developed to get useful information from such a critical structure of heart. Trabeculae in the heart undergoes difference changes like solid from spongy. Due to failure of this process left ventricle non-compaction occurred. In this project, we will demonstrate the fractal dimension (FD), manual and semi-automatic segmentation of the Magnetic Resonance Imaging (MRI)/ CMRI of the heart that quantify the trabeculae inside the heart. The greater the value of fractal dimension inside the heart indicates the greater complex pattern of the trabeculae in the heart.

Objectives of the Projects:

1. Understandings of MRI/ CMRI images as well as Trabeculae inside the heart.
2. Study on Fractal Dimension (FD) that can quantify trabeculae inside heart.
3. Implement the MATLAB based GUI that can read dicom (.dcm) CMRI and quantify the amount of Trabeculae inside the heart.
4. Implementing manual and semi-automatic segmentation of the Cardiac Magnetic Resonance Imaging (CMRI)

Methodology

The overall project works are divided into several sub sections that are described below step by step-

For the complexity quantifications of the trabeculae inside heart, we have used Fractal Dimension (FD) parameter that can be calculated using the Algorithm shown in Fig. 1 (a). The block diagram for implementation of this section is shown in Fig. 1 (b).

Step-1: Depending on the size of each grid $r = 1/2^j$, where $j = 1,2, \ldots\ldots, |R|$

Step-2: For all the points in the dataset

Step-3: Selecting the cell that matched requirement

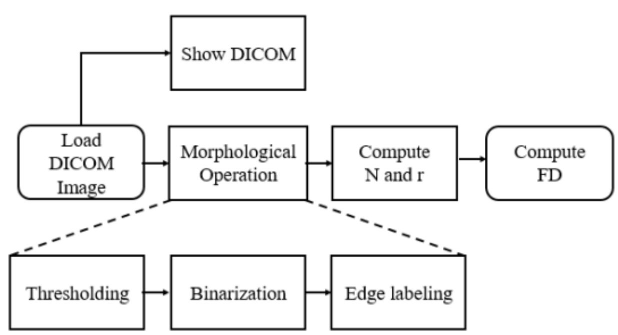
Step-4: Occupancy counter C_i is incremented

Step-5: Summation of the square occupancies calculated $S(r) = \sum_i (C_I)^2$

Step-6: $\log(r)$ and $\log(S(r))$ value given an plot

Step-7: Finding the slope of the linear part from the plot and return FD of dataset A.

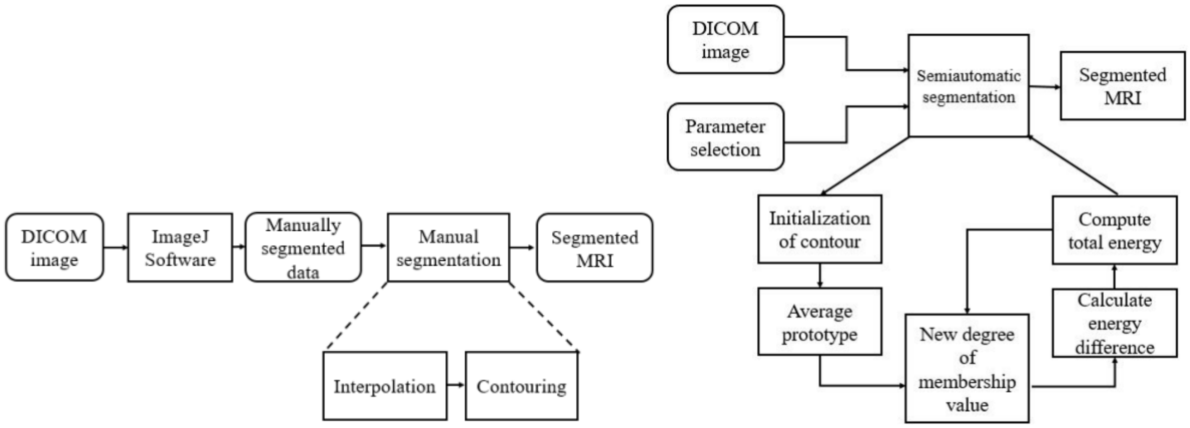
(a)



(b)

Fig. 1: a) Algorithm for calculating FD b) Block presentation of complexity analysis

For the manual segmentations of the CMRI, we have used Fig. 2 (a) that required manually selected the contour and make a dataset using ImageJ software. After getting dataset from ImageJ software, manual segmentation has done which based on the interpolation for the contour from the given dataset. On the other hand, the block diagram for semi-automatic segmentation of CMRI is shown in Fig. 2 (b) which initiated by selecting DICOM image and parameters of initialization. Afterward semi-automatic segmentation of CMRI, integrated into numbers of operation such as Initialization of contour, averaging prototypes, getting new membership values, calculating differences in energy computing total energy and using this new value as feedback.

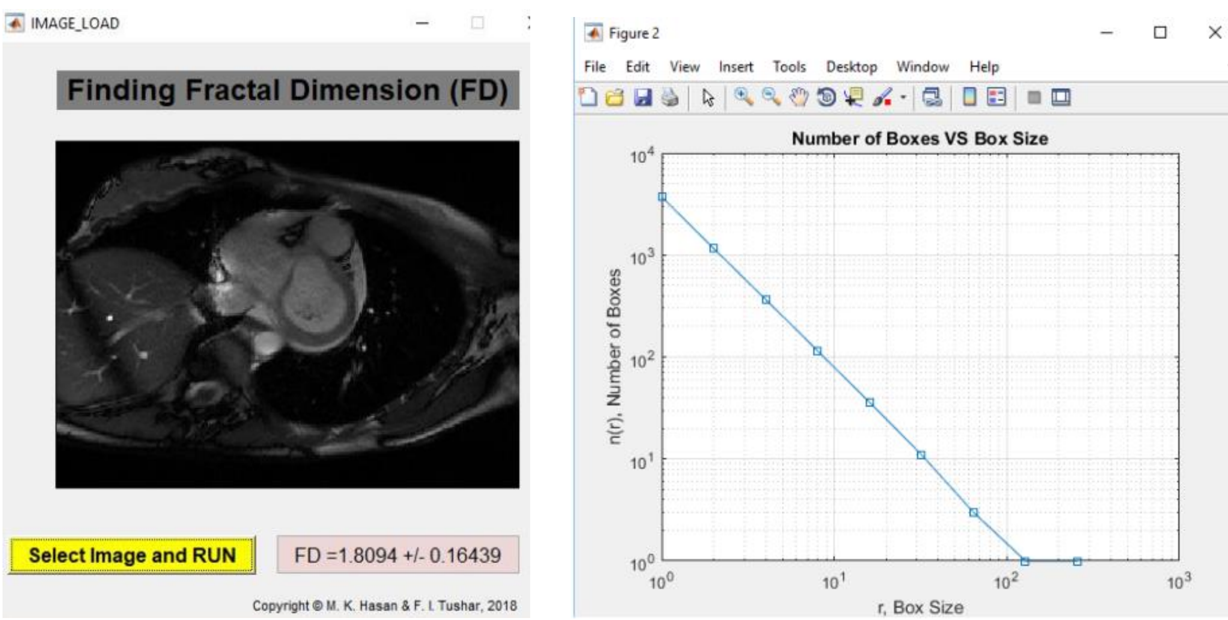


(a) (b)

Fig. 2: Block presentation of a) manual b) semi-automatic segmentation of CMRI

Results and Discussion

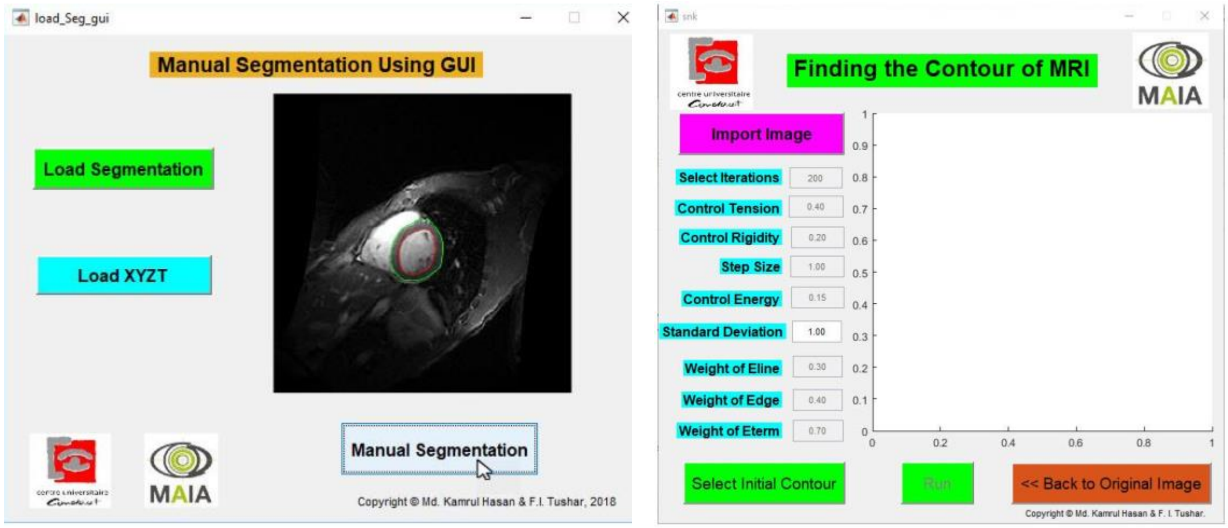
Fig. 3 (a) shows the implemented GUI for finding out the FD where by "*Select Image and Run*" button user selected the target DICOM image after that the process for calculating FD will be started. The FD indicates the amount of the complex geometric pattern of the inner part of the heart. The greater the value of the FD indicates the greater the complexity. For the given slice of MRI data, we see that the FD is 1.809 +/-0.16439 (Standard Deviation). This results in Fig. 3 (b) shows relation between the box scaling and the FD. If the scaling of the boxes increases then the boxes number containing information is decreased exponentially and FD is equivalent to this exponent.



(a) (b)

Fig. 3: a) Visualization of DICOM MRI and FD b) Presentation of Number of boxes w.r.t box sizes

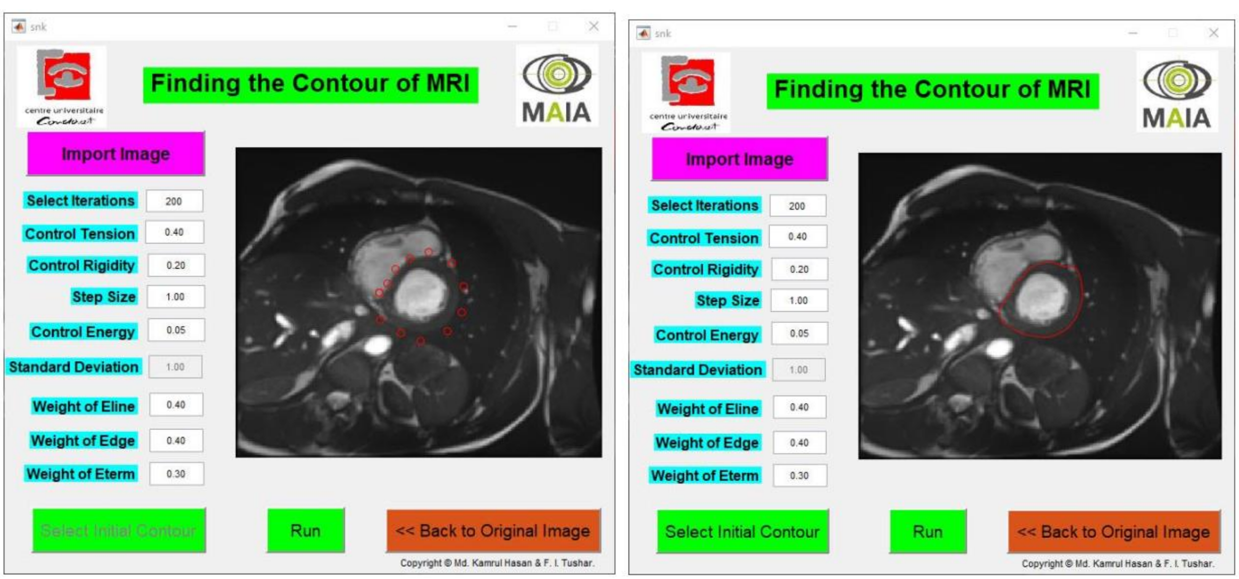
The Graphical User Interface (GUI) that is design for manual segmentation is shown in Fig. 4 (a). After loading DICOM MRI into the ImageJ software, ROI is to be cropped for the manual segmentation then save as a .txt file. This processing repeated depending on the slice number. After that, .txt data has been used in our implemented GUI to perform manual segmentation as shown in Fig. 4 (a). This data has been interpolated and plotting the circle is been done. After all those processing segmented MRI is been achieved which shows the different cardiac border. The Green Circle shown the epicardium border of the heart, where red circle shown the endocardium border of the heart.



(a) (b)

Fig. 4: a) Manually segmented epicardium and endocardium border b) Designed GUI for semi-automatic segmentation

For the semi-automatic segmentation, the designed GUI is shown in Fig. 4 (b). For the segmentation of MRI image using snake algorithm, we need to initialize the contour around the ROI then we need to iterate after defining some parameters required for the iteration. Initialization for the contour for the segmentation using snake algorithm is shown in Fig. 5 (a). Then after selecting all the parameters that are mentioned in Fig. 16, we need to click run button. After some moments, it will provide a semi-automatic contour for the segmentation using snake algorithm as shown in Fig. 5 (b). One of the vital parameters of this semi-automatic segmentation is time of running the program to make a contour. This executions time can be reduced by selecting the proper value of all the parameters that are mention in the GUI in Fig. 5 (b).



(a) (b)

Fig. 5: a) Initialization of the contour for segmentation b) Semi-automated segmentation

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