MIV: A Cardiac Image Visualizer

Carlos da Silva Santos\textsuperscript{1}, Luis Roberto Pereira de Paula\textsuperscript{1}, Marco Antonio Gutierrez\textsuperscript{2}, Marina S. Rebelo\textsuperscript{2}, Roberto Hirata Jr.\textsuperscript{1}

\textsuperscript{1} Institute of Mathematics and Statistics and \textsuperscript{2} Heart Institute - University of São Paulo (USP) - São Paulo, Brazil

\{csantos, luisrpp, hirata\}@ime.usp.br \{marco.gutierrez, marina.rebelo\}@incor.usp.br

Abstract—In this paper, we present a Medical Image Visualizer (MIV) targeting cardiac SPECT images. The visualizer is built fully on open source image processing and visualization software. The main features of the visualizer are: a semi-automatic procedure for segmenting challenging cardiac images and an implementation of the polar map visualization (Bull's eye diagram) that follows recent recommendations from the American Heart Association (AHA). The features mentioned above and the architecture design of the software make MIV a valuable research tool for the analysis of cardiac SPECT studies.

Keywords—computer vision; image processing; polar map;

I. INTRODUCTION

Single Photon Emission Computed Tomography (SPECT) is a nuclear imaging technique based on measuring the spatial distribution of a radionuclide. In cardiology, SPECT imaging is widely used to assess myocardial perfusion and left ventricular function. Improved information about the time dependent motion of the myocardium is achieved when the SPECT acquisition is gated to the electrocardiogram (ECG) signal [1]. One challenge in the application of gated SPECT studies is the efficient presentation of information, since one single study can generate hundreds of image slices, whose individual examination would be too time consuming [1]. To address this issue, Garcia \textit{et al} proposed the polar map [2], also called bull’s eye display. The polar map is a representation of the 3D volume of the left ventricle as a 2D circular plate. Each point of the display, corresponding to a specific region of the myocardium (see Figure 1 for nomenclature on the diverse regions of the left ventricle), receives a color according to normalized count values.

The polar map became widely used in clinical practice in the last two decades. In 2002, the American Heart Association (AHA) issued a recommendation [3] in order to standardize the display of information from diverse modalities, including SPECT studies and the polar map in particular (see Figure 2). Despite the popularity of the polar map, there is a lack of freely available research tools implementing this type of visualization.

In this work we present MIV (an acronym for \textit{Medical Image Visualizer}), a research tool to segment and analyze SPECT images in cardiology. The motivation for MIV is two-fold. Firstly, it implements a semi-automatic image segmentation procedure developed for some challenging gated SPECT studies we found in our ongoing work. Secondly, it provides the first (to the best of our knowledge) open-source implementation of the polar map visualization to follow the new AHA recommendations [3]. We envision MIV as an integrated tool for the analysis of SPECT images, eventually incorporating other image processing and visualization techniques.

Figure 1. Definition of the planes for displaying tomographic images in cardiology. LV: left ventricle. RV: right ventricle. Adapted from [3]

Figure 2. Standard AHA recommendations for polar map display. The left ventricle should be divided into 17 segments, whose names are shown in the figure. Adapted from [3]

II. SOFTWARE DESCRIPTION

MIV is an open-source software written in the C++. It uses a set of open-source libraries such as the Insight Toolkit [4] (http://www.itk.org) for image processing and input/output operations, the Visualization Toolkit [5] (http://www.vtk.org) for image visualization and the QT library (http://www.qtsoftware.com) for the design of the user interface.

After loading the image into the system, the user can apply the segmentation method to isolate the left ventricle. The segmentation is a semi-automatic procedure based on a mathematical morphology approach [6]. At first, we need to set markers over the left ventricle. MIV uses the Hough Transform [4] for finding circles on all short axis (axial)
slices. This information is used to build two different heuristics for automatic marker generation. The user can also use the marker editor to create, delete or update markers. Once markers are set, the Watershed Transform [6] is used to segment the left ventricle. Figure 3 illustrates this procedure.

The polar map can only be generated after the segmentation process. This process is divided into three steps:

1) Axis definition. The program suggests an axis that should pass through the center of the myocardium. Each frame has its own axis that will guide the generation of the polar map. The user can check the suggestion against the axial slices (Figure 4(a)). In case the suggestion is not satisfactory, the user can override it by assigning a new axis with the mouse.

2) Definition of regions. The program makes a suggestion for dividing the slices between the regions: apex, apical, medial and basal. The user can check this suggestion graphically (Figure 4(b)). Optionally, the user can override the suggestion and determine a new start and end slices for the different regions for each frame.

3) Polar map generation. Finally, the Bull’s Eye diagram is generated and shown in the interface (Figure 4(c)). Each frame will have its own polar map.

III. CONCLUSION

We presented MIV, a medical image visualizer targeting gated SPECT studies in cardiology. Although the MIV workflow tries to minimize the amount of user intervention necessary for segmentation, there are still cases where segmenting a whole study might be too time consuming (a total of 23 real cases have been used to test the software). We are experimenting now with methods to reduce further the amount of user interaction by taking more advantage of the inherent redundancy between markers of adjacent slices. We tried to keep the MIV interface fully flexible, allowing the user to override any automatic suggestion made by the software, recognizing that no totally automatic procedure can be accurate in all cases.

The future steps of this work is to validate the platform; firstly with simulated cardiac data and then with annotated real images. The validation is an important step that must be done to make this software tool mature enough for clinical use. Finally, we should note that until validation MIV must be considered of research utility only.

ACKNOWLEDGMENTS

The authors would like to thank support from FAPESP, CNPq and FINEP.

REFERENCES


