The Volumetric Bull's Eye Plot

M.A. Termeer[1], J. Oliván Bescós[2], M. Breeuwer[2], A. Vilanova[3], F.A. Gerritsen[2], E. Gröller[1]

[1]Vienna University of Technology – Institute of Computer Graphics and Algorithms, Favoritenstrasse 9-11 / E186, A-1040 Vienna, Austria
[2]Philips Healthcare, Healthcare Informatics – Clinical Science & Advanced Development, P.O. Box 10.000, 5680 DA Best, The Netherlands
[3]Eindhoven University of Technology, Biomedical Engineering – Image Analysis and Interpretation, P.O. Box 513, 5600 MB Eindhoven, The Netherlands

Introduction

The bull's eye plot is a commonly used schematic for the visualization of quantitative late enhancement cardiac MRI data. It gives an intuitive overview of the viability of the entire left ventricular myocardium in a single diagram. However, common implementations do not provide a continuous transition between slices and provide poor or no information about the exact location and transmurality of non-viable tissue.

Purpose

We propose a novel visualization technique that relieves the drawbacks of the bull's eye plot but maintains its advantages. Our hypothesis is that our technique will enable a more accurate assessment of the relation between viable and non-viable myocardial tissue (scar).

Methods

Short-axis late enhancement cardiac MRI acquisitions consist of 10-20 slices. We segment the leftventricular myocardium in all slices using manually drawn contours on both the epicardium and the endocardium. The segmented myocardium is subsequently unfolded along the long axis and reformatted to form a thin cylinder (Figure 1). In this process myocardial cross-sections are mapped to equidistant rings within this cylinder. The volumetric nature of the myocardium is preserved during the unfolding.
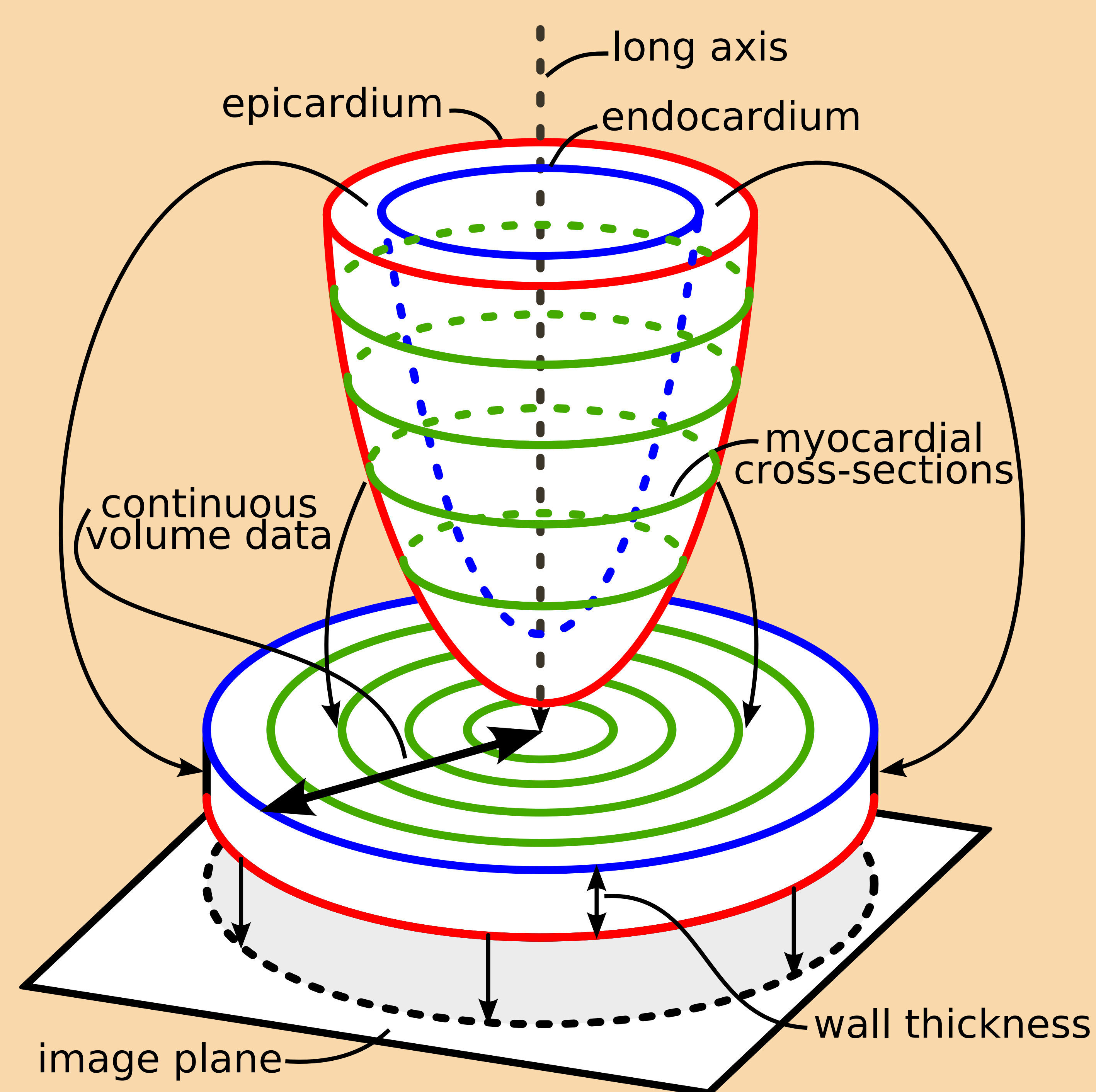

Figure 1: Schematic of the long-axis unfolding.

A projection of the cylinder is generated using the technique of volume rendering (Figure 2). The viewing direction in this projection is oriented from the apex towards the base of the ventricle. This makes the viewer perceive the endocardium to be behind the epicardium. This view is further augmented with the main coronary arteries extracted from a whole heart MRI scan (150 slices, SSFP). Furthermore, two dots indicating the points where the left and right-ventricular myocardial connect are added. A thin slab perpendicular to the long axis within the cylinder can be selected for exclusive rendering, providing a method of visualizing only epicardial or endocardial viability.
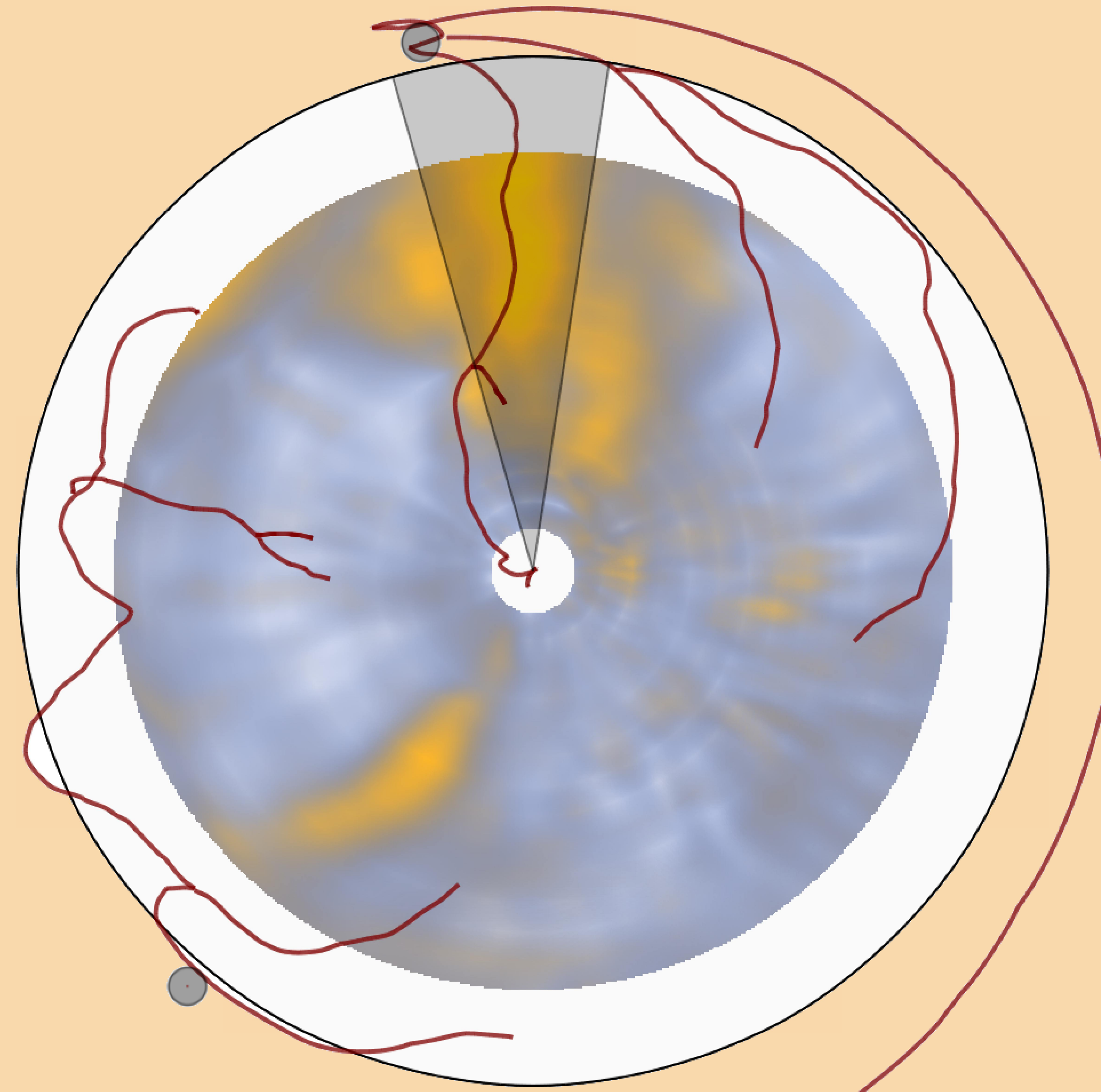

Figure 2: Long-axis projection of the unfolded myocardium showing scar (yellow areas), coronary arteries (red lines) and the location of the right ventricle (gray dots).

To investigate scar transmurality, the user can select a wedge-shaped region of interest. Figure 3 shows the transmurality of the selection region of Figure 2 by projecting it from its side. The unfolding method is modified for this projection to compensate for distortions due to the shape of the selected region. Since the wall thickness may vary within the region of interest, lines indicating the minimum and maximum wall thickness in the selected region are displayed.
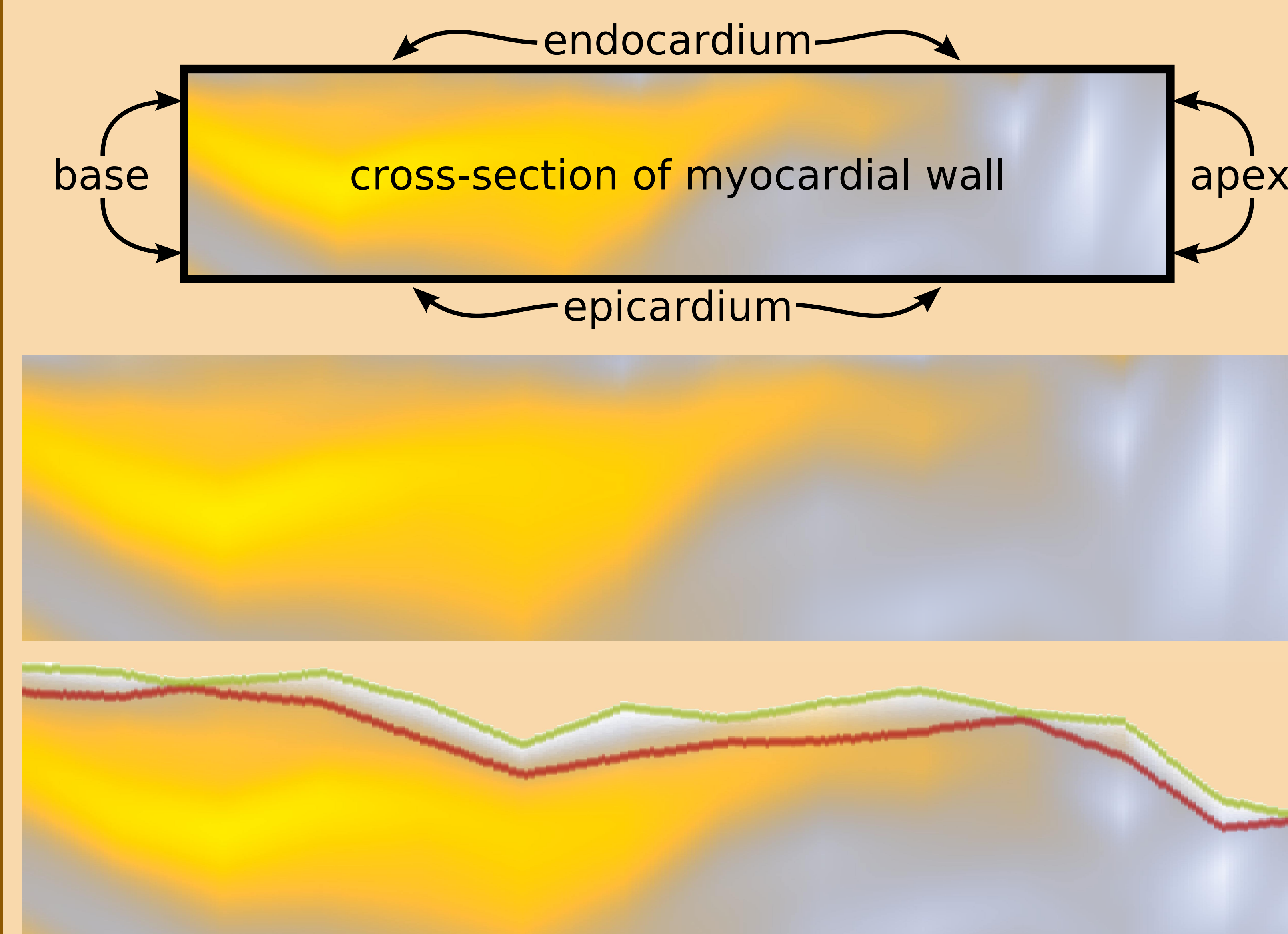

Figure 3: Transmurality view of the selected region focusing on relative (middle) and absolute (bottom) transmurality. The top figure shows the orientation of the cross-section with respect to the ventricle. The green and red lines show the maximum and minimum wall thickness of the selected region, respectively.
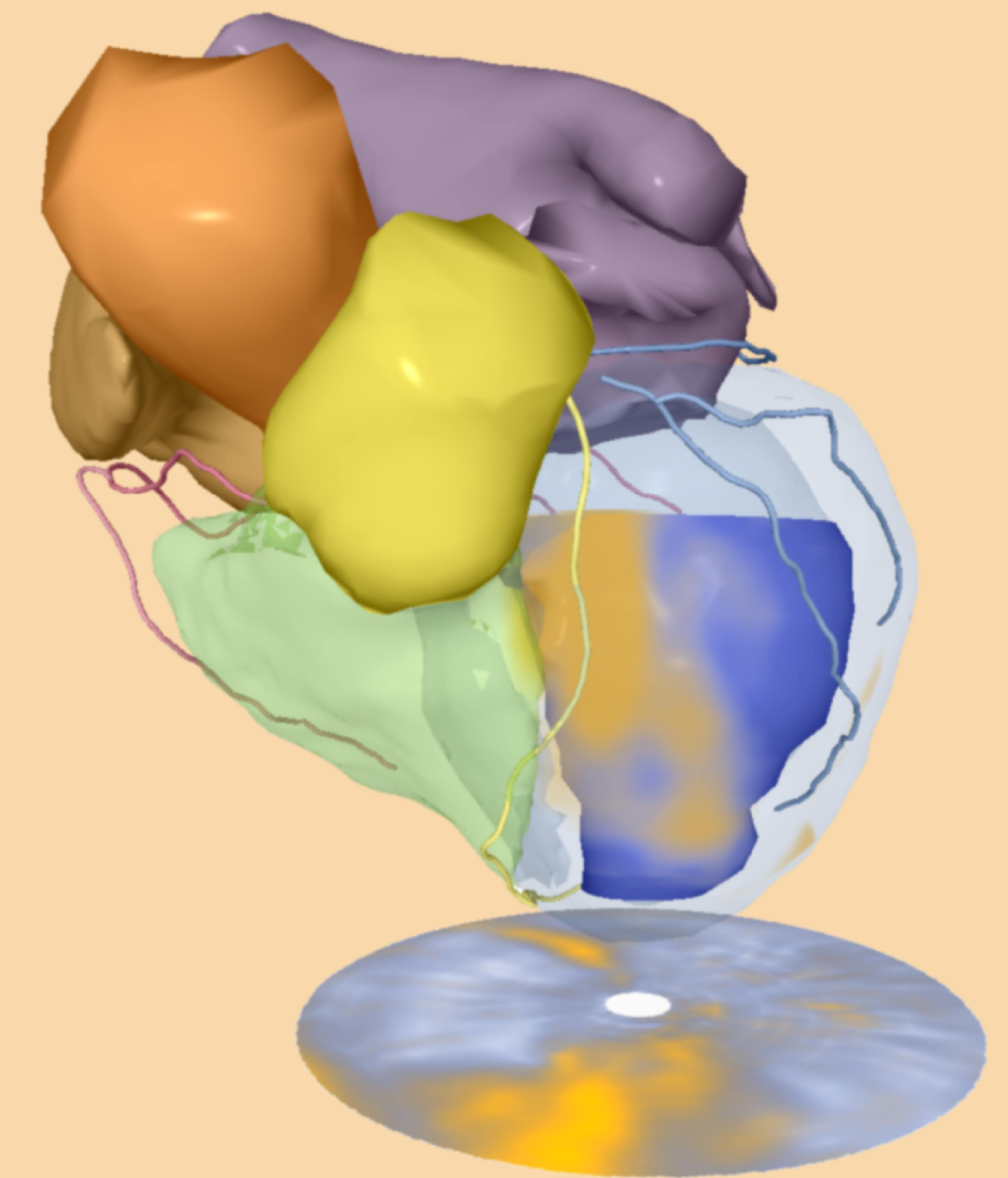

Figure 4: Three dimensional view showing the segmented heart annotated with scar (orange spots), coronary arteries and a volumetric bull's eye plot.

Results

The long-axis projection provides a smooth overview of the viability due to the unfolding method that preserves the continuous, volumetric nature of the myocardium. This also causes the resolution of the diagram to increase when more slices are acquired. The additional context information (i.e., coronary arteries) allows for easier interpretation of the location of any scar. Due to the close relation to the bull's eye plot, we believe that clinical adoption will be easy. The transmurality view provides detailed information on the distribution of scar within the myocardium. The preservation of wall thickness allows for judgment of the location and extent of the scar in relation to healthy tissue.

Conclusion

Our novel volumetric bull's eye plot allows for a comprehensive assessment of viability and scar transmurality thanks to its continuous nature and the additional context information provided.

References

[1] M. Termeer, J. Oliván Bescós, M. Breeuwer, A. Vilanova, F. Gerritsen, E. Gröller, CoViCAD: Comprehensive Visualization of Coronary Artery Disease, Proc. IEEE Visualization, 2007

Acknowledgments

More Information

Maurice Termeer <maurice@cg.tuwien.ac.at>