CoroViz: Visualization of Whole-Heart Coronary MRA Data

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Introduction: Recently, whole-heart coronary MRA using a steady-state free-precession technique has been shown to provide data of the entire coronary tree in a single volume [1]. With this method, long segments of all major vessels can be visualized. Good image quality and excellent discrimination from the background can be achieved. However, a comprehensive tool for proper visualization of the 3D data sets has been lacking. The previously described SoapBubble tool [2] is intended for targeted volume data and relies on in-plane vessels. Furthermore, the SoapBubble tool does not take advantage of the almost isotropic resolution achieved by the whole-heart approach and does not support the 3D nature of the data. Alternatively, a volume rendering approach (VirtualPlace Advance, AZE Ltd, Japan) has recently been reported to be useful in coronary MRA display [3]. Whereas the acquired three-dimensional models and segmented virtual scenes look very natural, the segmentation procedure may involve the risk of either artificially creating or obliterating stenoses. Approaches closer to the source data may be preferable. We therefore developed a comprehensive tool for 2D and 3D visualization and quantification of whole-heart coronary MRA data sets.

Methods: The CoroViz software package was implemented under IDL6.1 (Research Systems, Inc.; Boulder, CO) on a commercial desktop computer (3.0GHz Pentium4) running Windows XP.

The advanced visualization modules described below are based on knowledge of the vessel centerline. Due to large signal contributions originating from outside the vessels, a fully automated tracking procedure was found to perform unsatisfactorily. Semi-automatic tracking based on at least one user defined point on the coronary tree was therefore implemented. The algorithm combines a vessel enhancement filter [4] with a basic wave-front propagation algorithm.

After definition of the vessel centerline, a number of 3D-visualization modes are available. One mode ('GlobeViz') utilizes a maximum intensity projection (MIP) onto a deformed sphere defined by the coronary vessels. The user can freely choose the thickness of the MIP-volume. An alternative mode ('VolumeViz') creates a masked MIP volume rendering. By restricting the MIP-volume to the inside of a tubular structure along the vessel, signal contributions from outside the vessels can effectively be excluded from the MIP. The diameter of the tubular structure can be adjusted by the user for optimal results.

In all views, an interactive user interface allows zooming, panning and rotation of the data space, manual correction of the found centerline, as well as display of all visualization modules. Besides the display of axial, coronal and sagittal viewports, the current vessel cross-section is shown, allowing the identification of vessel branches and stenoses.

Additional modules include a local region-growing segmentation tool as well as planar and curved reformats.

Quantification tools provide measures for vessel length, as well as maximum, minimum and average diameter along the vessel.

Results: Eight datasets were successfully processed. The time required to automatically track the vessel centerline and generate the different visualization was <2 minutes for all datasets; a manual refinement and alignment of the vessel axis for optimal results added between 1 and 10 minutes to the preparation time.

Figure 1 shows a number of visualizations created in the CoroViz tool. The major coronary vessels, along with a number of side branches, are clearly visualized.

Conclusions: A tool for comprehensive processing of whole-heart data sets was developed. Globe visualization and masked MIP volume rendering allow the three-dimensional assessment of the coronary arteries with only marginal concealment by signals originating from outside the vessel. The use for clinical routine image post-processing and for modalities other than coronary MRA (such as coronary computed tomography angiography) remain to be investigated.

References:

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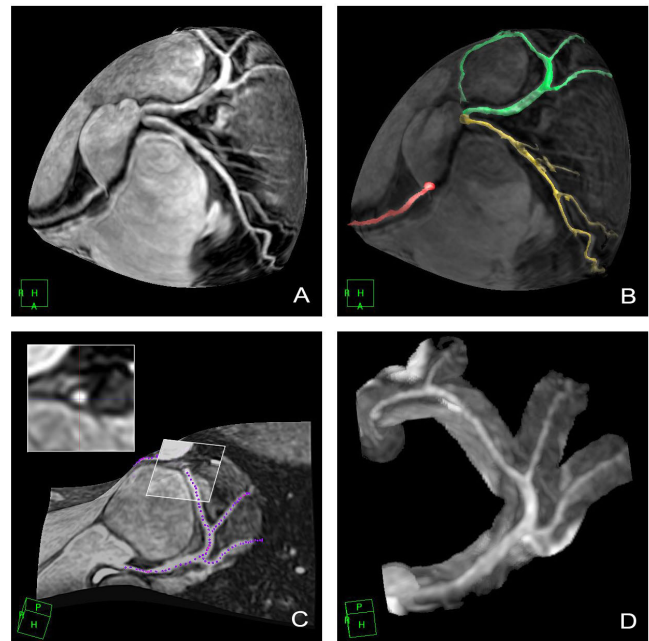
Figure 1: *CoroViz offers various visualization options for whole-heart coronary MRA data. A: Projection onto a deformed sphere (GlobeViz) shows true geometrical features and side branches of the coronary vessels. The deformed sphere can be interactively rotated, zoomed, panned, and windowed. B: Vessel segmentation allows for easier identification of the vessels (RCA, red; LAD, yellow; LCX, green). The GlobeViz background is set to 40% transparency. C: Curved MIP-reformat of the LCX with the vessel centerline found by the tracking algorithm. The cross sectional image can be interactively moved along the vessel. D: Masked volume rendering along the LCX restricts the MIP to a tubular structure around the vessel center line (VolumeViz), allowing for an accurate local assessment of the vessel structure*