Real-time Left Ventricular Volume Measurements in 3D Echocardiograms

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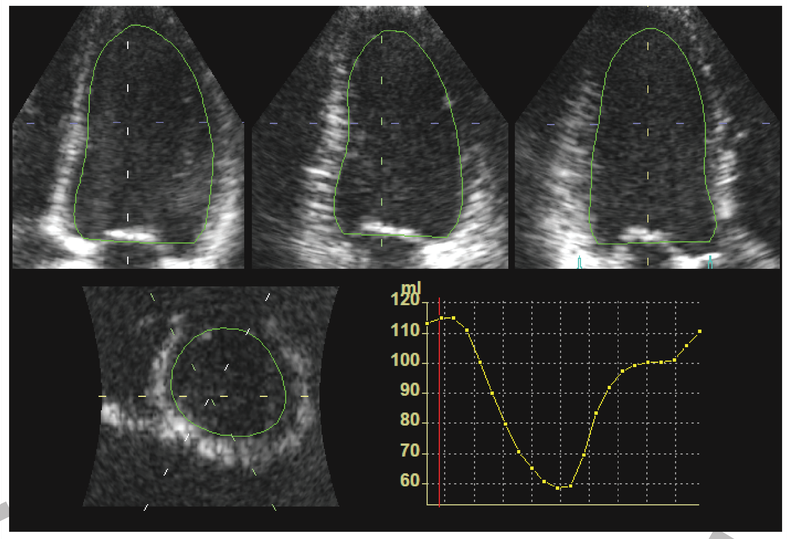
Purpose

- Left ventricular (LV) volumes and ejection fraction (EF) are among the most important parameters in diagnosis and prognosis of heart diseases.
- Semi-automatic tools for measurements of these parameters in 3D echocardiograms (RT3DE) have recently been introduced.
- However, real-time monitoring of chamber volumes has not been achievable due to the processing requirements of current 3D segmentation methods.

- Availability of technology for real-time edge-detection and tracking in volumetric datasets would open up possibilities for instant feedback and diagnosis during data acquisition.

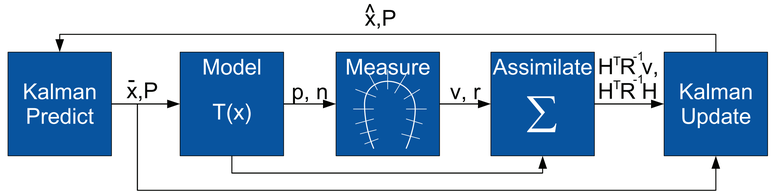
Example



Example of fully automated LV segmentation performed in real-time, along with the corresponding volume curve

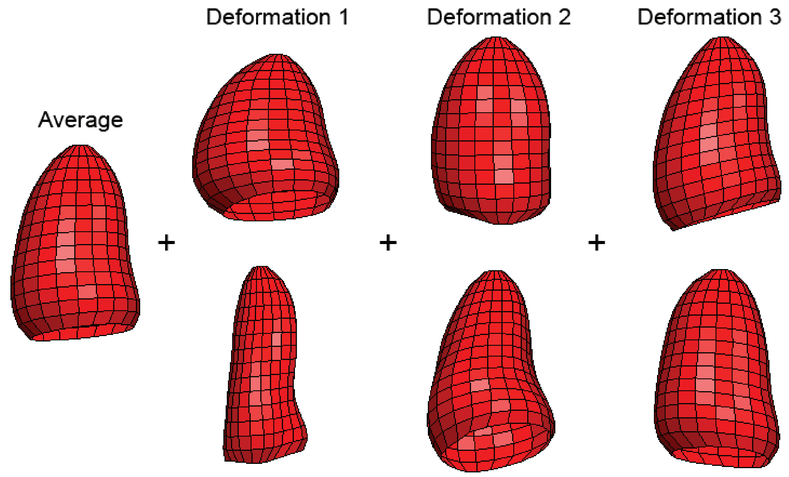
Methods

- A computationally efficient method for real-time detection using an extended Kalman filter has been developed.



Block diagram over the stages in the edge-detection framework

- This method was used with a 3D active shape model to track changes in LV shape, position, and orientation during RT3D acquisition.



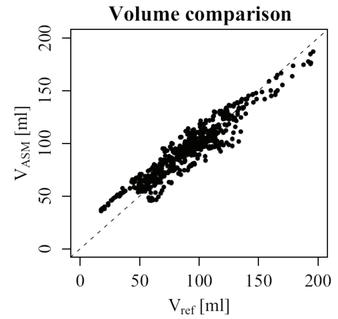
Visualization of the first three deformation modes of the active-shape model

- Edge-detection, performed in the surface normal direction, was used to detect the endicardial boundary.

- Volume curves were derived from the detected LV surface in real-time, giving instantaneous measurements of end-diastolic volume (EDV), end-systolic volume (ESV), and EF.

Results

- The feasibility of the method was evaluated in 21 unselected RT3DE recordings (half with heart diseases), acquired by a Vivid 7 scanner (GE Healthcare).
- Automatic real-time detection without manual initialization was performed in all of the recordings
- Volume curves, EDV, ESV, and EF were compared to a reference detection tool (GE Healthcare)



Volume correspondence throughout the cardiac cycle for all frames in all recordings.

	Volume [ml]	EDV [ml]	ESV [ml]	EF [%]
Difference (mean±1.96SD)	3.4*±20	-5.9*±21	6.2*±19	-7.7*±12
Correlation coeff. (r)	0.95	0.91	0.91	0.74

* Significantly different from 0, $p<0.05$.

Bland-Altman analysis of the volume correspondence throughout the cardiac cycle, at end-diastole, at end-systole and for ejection-fraction.

- The edge-detection was successful in all of the recordings.

Conclusion

This study shows that fully automated real-time monitoring of LV function by RT3D is feasible.