A novel 2D speckle tracking method for high frame rate cardiac imaging

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Background, Motivation and Objective

Speckle tracking echocardiography (STE) is a clinical tool to non-invasively assess regional myocardial function through the quantification of regional motion and deformation. However, STE is based on low frame rate (FR) B-mode imaging thus limiting the time resolution of cardiac mechanics' assessment. This issue might be overcome by high frame rate (HFR) imaging. However, typical STE algorithms cannot directly be applied as inter-frame motion becomes too small and spatial resolution and image quality of HFR imaging remains limited. Therefore, the aim of this study was to validate a 2D speckle tracking method purposely developed for HFR cardiac data sets from in-silico and in-vivo recordings.

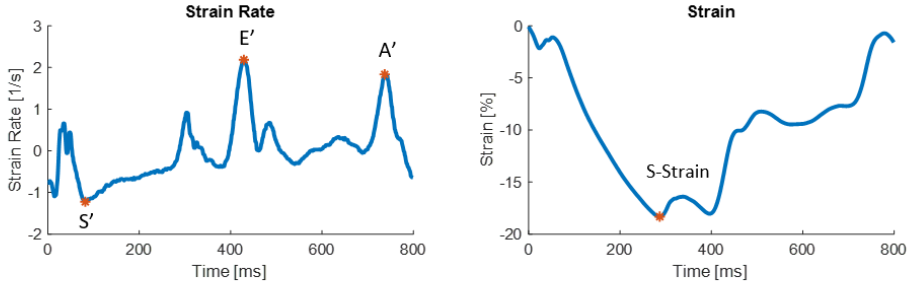
Statement of Contribution/Methods

Field II was used to generate raw data from 5 heart models (1 healthy and 4 diseased). HFR (833 Hz) and wide sectors (90°) were obtained by coherent compounding of 6 diverging waves (6DW).
The healthy model was used to optimize the parameter settings of the proposed 2D speckle tracking algorithm that was based on the cross-correlation with spline interpolation (for subsample motion estimation) and sample-based re-correlation of 2D kernels. The algorithm consists of 2 steps: (1) axial displacement estimation using RF signals; (2) lateral motion estimation using envelope data and a time-gap (T) to obtain enough lateral inter-frame motion.
The position of the cardiac wall was automatically extracted and the accuracy of the method was measured as the average temporal root-mean-square error (RMSE) between the ground truth and the estimated deformation curves for all myocardial points.
In-vivo apical 4-chamber views were recorded with the HD-PULSE scanner from 10 healthy volunteers using the same 6DW sequence. The myocardial contour was placed by an expert cardiologist and tracked throughout the cycle. Strain rate and strain curves and their respective clinical markers (i.e. peak values) were extracted for all segments.

Results/Discussion

The best results were obtained with a 3mm × 7° kernel for axial displacement (RMSE = 3.4±0.7%) and 6.75mm × 21.4° with T=30ms for lateral displacement (RMSE =10.3±1.8%). In-vivo results gave curves with a physiological pattern (Fig. 1a). Moreover, the extracted clinical markers and the feasibility of extracting them were in the same range as those reported with color tissue Doppler-based strain estimation (Fig. 1b).

a)



b)

	Septum			Lateral Wall		
	Basal	Mid	Apical	Apical	Mid	Basal
Feasibility	90%	100%	70%	0%	80%	40%
S' (1/s)	-0.86±0.31	-1.19±0.29	-1.12±0.26	-	-1.18±0.51	-1.44±0.46
E' (1/s)	2.47±0.54	2.24±0.73	1.73±0.52	-	2.57±0.81	3.65±1.29
A' (1/s)	1.35±0.57	1.24±0.4	0.8±0.26	-	0.82±0.32	0.66±0.34
S-Strain (%)	-15.54±7.09	-22.55±3.59	-18.37±5.34	-	-20.09±7.06	-17.99±8.31

Fig 1. a) Example of strain and strain rate curves obtained from an in-vivo recording and measured clinical markers for all 10 recordings. **b)** Extracted clinical markers and extraction feasibility.