Improving 3D image quality and functional measurements using multi-perspective ultrasound

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Background, Motivation and Objective

3D ultrasound (US) better captures the complex cardiac shape and contraction pattern. However, US quality is limited by low lateral resolution, the angle between the US beam and anatomical structure normal, near-field clutter, and a limited field-of-view. These drawbacks accumulate in 3D, due to lower spatial and temporal resolution.

Multi-perspective US improves image contrast and field-of-view. This study proposes a widely applicable image fusion method, improving spatial resolution, preserving structure, reducing near-field clutter, and enhancing functional measurements, without image border artifacts.

Statement of Contribution/Methods

3D images were obtained by a Philips Epiq system using an X5-1 phased array probe in the apical, parasternal and subcostal view in 6 *ex vivo* beating hearts and in 10 healthy volunteers. Cardiac output (CO) was measured *ex vivo* by a flow sensor and *in vivo* using Pulsed-Wave Doppler.

Oriented complex-wavelet analysis was used to divide the images into several frequency sub-bands, from which phase and amplitude information were extracted. Maximum phase was selected for every sub-band, whilst taking the maximum intensity, thus preserving image structure. Only information parallel to the US beam direction is kept in the highest sub-bands to prevent noise enhancement, whilst enabling speckle-tracking. Near-field clutter was removed automatically by elimination of the perpendicular signal from the frequency sub-bands, whilst conserving edges. Image border artifacts were removed automatically. In addition, an algorithm for fusion strain was developed based on block-matching.

Results/Discussion

The proposed fusion scheme improved the field-of-view, and the lateral and elevation resolution by a factor 3.6. In addition, the *in vivo* image quality was enhanced (ΔCNR = 82%) (Fig. 1 A-C). This method is optimized for fusion strain imaging, resulting in improved lateral strain (Fig. 1 D-G). Fusion CO was more precise, due to augmented image quality. Hence, functional measurements in fused images are more accurate and reproducible compared to conventional US.

Our method depicts a maximum amount of anatomical structure (Δstructure = 16%), whilst requiring a minimal amount of acquisitions (1 per view), thus ideal for clinical implementation. It is applicable and promising for other applications (e.g. aortic aneurysm elastography).

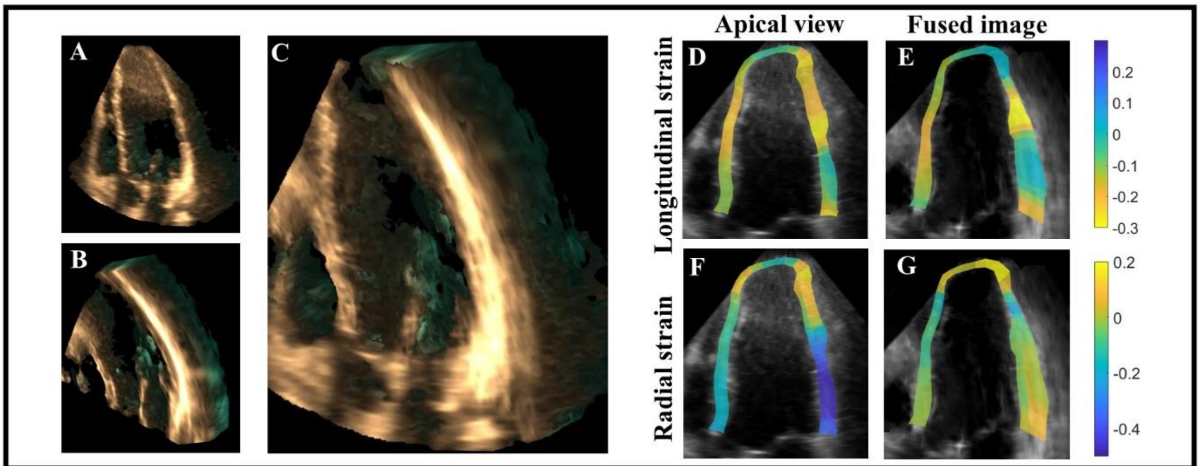

Fig. 1. 3D *in vivo* fusion results, created by fusing 3D volumes obtained from different views. A. Apical 3D volume, B. parasternal volume, and C. the resulting fused volume, showing enhanced field-of-view and image contrast, without image border artefacts. D-G display preliminary fusion strain results at end-systole. D. The longitudinal strain of the apical, and E. the fused image. F. The radial strain of the apical, and G. the fused image. Fusion strain improved speckle-tracking in general due to improved lateral resolution, and provided more accurate radial strain compared to a single view.