## Improving Lateral Contrast using 3D Multi-Perspective Ultrasound of Deep Organs: Applied to the Abdominal Aorta

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### Background, Motivation and Objective

Abdominal aortic aneurysms (AAAs), dilations of the abdominal aorta, can rupture and cause a fatal hemorrhage. Treatment is possible, however, not without risk for the patient. Surgery is decided upon when the diameter exceeds a population based average threshold. However, some aneurysms rupture below this threshold, while others remain stable above. Alternative rupture risk markers, i.e., stress and stiffness of the vessel wall, can be acquired using novel computer models [1]. These models require accurate geometry and dynamic motion of the aorta as input. Ultrasound is widely used to acquire these data. However, low contrast in the lateral direction remains a major challenge. This study proposes 3-D multi-perspective imaging to enhance the lateral contrast.

### Statement of Contribution/Methods

A Philips iU22 system equipped with raw frequency output was used to acquire images of the abdominal aorta in volunteers using an X6-1 curved matrix array probe. The probe was moved from side to side over the abdomen to acquire images from 7 locations. These acquisitions contained multiple heartbeats and ensured insonification angles between -45 and +45 degrees. First, the aorta was detected using image gradient analyses [2]. Second, the spine was detected using a custom Hough transform, designed to identify horseshoe features. The aorta and spine positions were used to register the images and compounding was achieved by averaging the envelope signals. Registration results were compared to ground-truth angles and manual annotation, image improvement was quantified by the contrast-to-noise ratio between wall and lumen.

### Results/Discussion

Automatic detection of the aorta and spine showed a good agreement with manual segmentation (MAD: 1.3 mm). Compounding of multi-perspective ultrasound images presented a large enhancement of lateral contrast of the aortic wall (Figure 1). This increase in contrast is present during the entire heart cycle. Contrast-to-noise ratios increased from 0.18 to 0.47. However, low 3D volume-rates (6-10 fps) caused minor temporal misalignment. Ongoing work focuses on advanced schemes for signal-intensity compounding, as well as combining motion vectors from multiple perspectives for improved motion tracking.

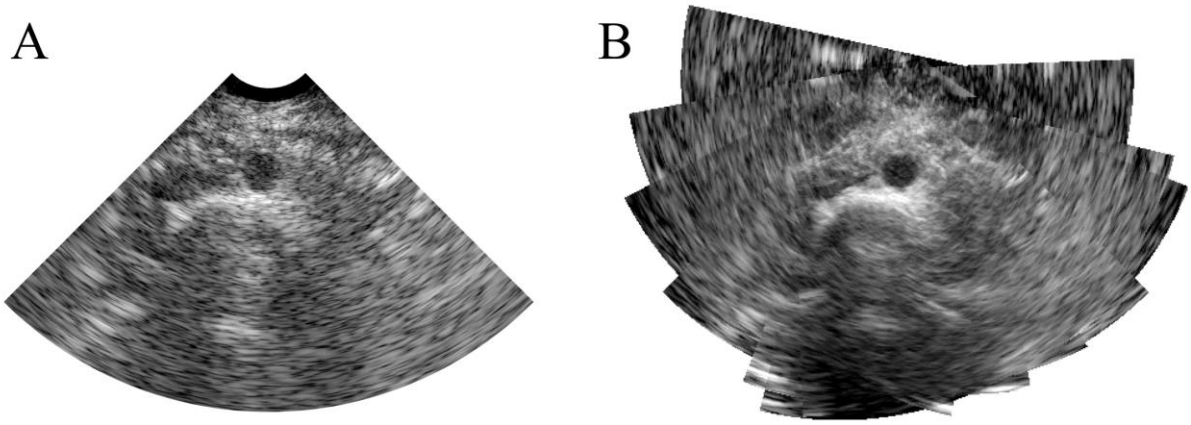


**Figure 1:** A: Single perspective ultrasound recording of the abdominal aorta; B: Multi-perspective ultrasound recording, combining 7 acquisitions taken from angles between -45 and +45 degrees.

*[1] E. M. J. van Disseldorp et al., "Patient Specific Wall Stress Analysis and …" EJVES, vol. 52, no. 5, pp. 635–642, Nov. 2016.*

*[2] E. Smistad and F. Lindseth, "Real-Time Automatic Artery Segmentation…" IEEE Trans on Med Im, vol. 35, no. 3, pp. 752–761, Mar. 2016.*