Time-of-Flight based Registration in Bistatic Dual-Probe Ultrasound Imaging

Hans-Martin Schwab[1], Hein de Hoop[1], Frans van de Vosse[1], Richard Lopata[1]
[1]Eindhoven University of Technology, Eindhoven, The Netherlands

Background, Motivation and Objective

The accuracy of ultrasound imaging and motion tracking, e.g. to assess the risk of rupture in aortic aneurysms, strongly suffers from limited angular coverage of the vessel walls. One solution to circumvent this limitation is to compound the images of multiple probes that image the same region from different perspectives. The major challenge in multi-perspective imaging is the registration of the images. We propose to use bistatic measurement data in which one probe transmits and the other probe receives to extract the relative location of two probes automatically. Besides allowing for a coherent registration of monostatic datasets, this automated registration also enables a full bistatic image reconstruction with improved contrast and resolution.

Statement of Contribution/Methods

The registration method was validated in an ex-vivo experiment with a porcine aorta that was embedded into gelatin on top of a 3D printed spine phantom and perfused by a saline solution. Two curved arrays (C5-2v, Verasonics) were connected to a Verasonics Vantage system and 7 transmission angles were acquired with each probe. For each transmission event, both receive datasets were recorded. In the receive datasets of the non-active probe, the time-of-flight (TOF) from was extracted by a cross correlation with an approximated transmit pulse. The relative position of the center of the transmitting curved array was estimated by triangulation based on the TOF information. The relative rotation between the arrays was estimated based on the shift in TOF between both probes along the aperture angle. Finally, a non-reflective rigid transformation matrix was retrieved from the relative translation and rotation and used for the allocation of the apertures in a delay-and-sum reconstruction that allows for arbitrary source and sensor locations.

Results/Discussion

Compared to manual registration, the automated registration only deviated by 1.0% in translation and 0.46 degrees in rotation. This allowed for coherent compounding of the two monostatic images and could significantly improve the angular coverage, contrast and resolution of the vessel walls, especially in shadow regions of the single probe images. Moreover, reconstructing the full bistatic dataset, the ratio between peak power of the lower wall edge and signal power inside the lumen was further increased by 27.4 dB.