Fast Plane Wave 2-D Vector Flow Imaging Using Transverse Oscillation and Directional Beamforming - DTU Orbit (13/12/2018)

Several techniques can estimate the 2-D velocity vector in ultrasound. Directional beamforming (DB) estimates blood flow velocities with a higher precision and accuracy than transverse oscillation (TO), but at the cost of a high beamforming load when estimating the flow angle. In this paper, it is proposed to use TO to estimate an initial flow angle, which is then refined in a DB step. Velocity magnitude is estimated along the flow direction using cross-correlation. It is shown that the suggested TO-DB method can improve the performance of velocity estimates compared to TO, and with a beamforming load, which is 4.6 times larger than for TO and seven times smaller than for conventional DB. Steered plane wave transmissions are employed for high frame rate imaging, and parabolic flow with a peak velocity of 0.5 m/s is simulated in straight vessels at beam-to-flow angles from 45 to 90. The TO-DB method estimates the angle with a bias and standard deviation (SD) less than 2, and the SD of the velocity magnitude is less than 2%. When using only TO, the SD of the angle ranges from 2 to 17 and for the velocity magnitude up to 7%. Bias of the velocity magnitude is within 2% for TO and slightly larger but within 4% for TO-DB. The same trends are observed in measurements although with a slightly larger bias. Simulations of realistic flow in a carotid bifurcation model provide visualization of complex flow, and the spread of velocity magnitude estimates is 7.1 cm/s for TO-DB, while it is 11.8 cm/s using only TO. However, velocities for TO-DB are underestimated at peak systole as indicated by a regression value of 0.97 for TO and 0.85 for TO-DB. An in vivo scanning of the carotid bifurcation is used for vector velocity estimations using TO and TO-DB. The SD of the velocity profile over a cardiac cycle is 4.2% for TO and 3.2% for TO-DB.

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