History and Latest Advances in Flow Estimation Technology: From 1D in 2D to 3D in 4D

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Ultrasound imaging of flow has seen a tremendous development over the last sixty years from the early crude investigations of the heart using continuous wave Doppler by Satomura in 1959 to todays advanced digital 3D systems. This talk will give an overview of the latest development in the field from current commercial vector flow systems to the latest advances in fast 4D volumetric visualizations. The early systems measured velocities in the axial direction (1D), and showed it as a function of time and depth (2D). This is inadequate to perceive the full complexity of flow in the human circulation. The last decade has therefore seen the introduction of commercial systems for vector flow imaging using transverse oscillation and other methods, where the velocity vector is visualized in real time. This benefits studies of complex flow with vortices and can reliably estimate quantitative flow indices for peak velocities, volume flow, and pressure gradients, which are presented in a number of clinical examples.

The most exciting development has been the radical break with the current sequential data acquisition by the introduction of synthetic aperture imaging, where the whole region of interest is insonified using either spherical or plane waves. This has made it possible to track the flow continuously in all directions at frame rates of thousands of images per second. The flow vector can be determined with a very high precision, and both very low velocities as well as high velocities can be estimated from the same data. The latest research tries to translate this to full volumetric imaging by employing matrix arrays and possibly row-column arrays, which can reduce the channel count by nearly a factor of 100. This enables full 3D vector velocity estimation at all spatial points visualized at very high volume rates (4D). The talk will give a number of examples of this development, and present the latest research results on 3D vector flow in 4D using row-column arrays.

Biography

Jørgen Arendt Jensen is professor of Biomedical Imaging at the Department of Health Technology, Technical University of Denmark. He has conducted research within medical ultrasound since1985 and is the founder and head of Center for Fast Ultrasound Imaging in 1998. CFU has graduated more than 40 PhD students, and the group has contributed with the Field II simulation program, transverse oscillation vector flow in 2D and 3D, synthetic aperture flow imaging, the RASMUS and SARUS research scanner, dual stage beamforming as well as innovations in coded imaging, acoustic models, minimum variance beamforming, and row-column beamforming. JAJ has published more than 450 conference and journal papers and is a Fellow of the IEEE.