Portable Ultrasound Imaging

This PhD project investigates hardware strategies and imaging methods for hand-held ultrasound systems. The overall idea is to use a wireless ultrasound probe linked to general-purpose mobile devices for the processing and visualization. The approach has the potential to reduce the upfront costs of the ultrasound system and, consequently, to allow for a wide-scale utilization of diagnostic ultrasound in any medical specialties and out of the radiology department. The first part of the contribution deals with the study of hardware solutions for the reduction of the system complexity. Analog and digital beamforming strategies are simulated from a system-level perspective. The quality of the B-mode image is evaluated and the minimum specifications are derived for the design of a portable probe with integrated electronics in-handle. The system is based on a synthetic aperture sequential beamforming approach that allows to significantly reduce the data rate between the probe and processing unit. The second part investigates the feasibility of vector flow imaging in a hand-held ultrasound system. Vector flow imaging overcomes the limitations of conventional imaging methods in terms of flow angle compensation. Furthermore, high frame rate can be obtained by using synthetic aperture focusing techniques. A method is developed combining synthetic aperture sequential beamforming and directional transverse oscillation to achieve the wireless transmission of the data along with a relatively inexpensive 2-D velocity estimation. The performance of the method is thoroughly assessed through simulations and measurements, and in vivo investigations are carried out to show its potential in presence of complex flow dynamics. A sufficient frame rate is achieved to allow for the visualization of vortices in the carotid bifurcation. Furthermore, the method is implemented on a commercially available tablet to evaluate the real-time processing performance in the built-in GPU with concurrent wireless transmission of the data. Based on the demonstrations in this thesis, a flexible framework can be implemented with performance that can be scaled to the needs of the user and according to the computing resources available. The integration of high-frame-rate vector flow imaging in a hand-held ultrasound scanner, in addition, has the potential to improve the operator’s workflow and opens the way to new possibilities in the clinical practice.

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