3-D Vector Flow Imaging - DTU Orbit (06/05/2018)

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For the last decade, the field of ultrasonic vector flow imaging has gotten an increasingly attention, as the technique offers a variety of new applications for screening and diagnostics of cardiovascular pathologies. The main purpose of this PhD project was therefore to advance the field of 3-D ultrasonic vector flow estimation and bring it a step closer to a clinical application. A method for high frame rate 3-D vector flow estimation in a plane using the transverse oscillation method combined with a 1024 channel 2-D matrix array is presented. The proposed method is validated both through phantom studies and in vivo. Phantom measurements are compared with their corresponding reference value, whereas the in vivo measurement is validated against the current golden standard for non-invasive blood velocity estimates, based on magnetic resonance imaging (MRI). The study concludes, that a high precision was achieved and that estimates were comparable with MRI derived results. However, the large channel count of the applied transducer hinders a commercial implementation of the 3-D method for two main reasons: The large and heavy connection cable is impractical for clinical use, and the high channel count hampers the task of real-time processing. In a second study, some of the issue with the 2-D matrix array are solved by introducing a 2-D row-column (RC) addressing array with only 62 + 62 elements. It is investigated both through simulations and via experimental setups in various flow conditions, if this significant reduction in the element count can still provide precise and robust 3-D vector flow estimates in a plane. The study concludes that the RC array is capable of estimating precise 3-D vector flow both in a plane and in a volume, despite the low channel count. However, some inherent new challenges are introduced with the array. The major disadvantage with an RC transducer, is the limited field-of-view, which is restricted to the forward looking array. It is discussed, that this drawback may be solved with a diverging lens, providing a larger field-of-view, due the the dispersion of the energy. Based on the presented results it is concluded that 3-D vector flow using TO is a feasible method for obtaining angle-independent estimates of e.g. peak velocities and flow rates at a high frame rate for clinical applications. Moreover, the RC array offers a setup allowing for real-time processing.

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