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Feasibility of noninvasive temperature estimation using acoustic harmonics

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In this study, the feasibility of obtaining 2D temperature change maps was investigated by estimating the change in backscattered energy of the acoustic harmonics and comparing it with the standard RF echo shift technique. A commercial high-frequency ultrasound scanner (Vevo® 770, Visualsonics Inc., Toronto, ON, Canada) with a 25-MHz center frequency wide-band single-element transducer (RMV-710B, f-number 2.1, 15 mm focal length) was used to transmit signals at 13 MHz.
The experiments were performed on gel phantoms composed of 8% (by weight) gelatin. A 1.6 mm thick stainless steel needle was inserted in the gel phantom and hot water was circulated in the needle in order to increase the temperature of the phantom only locally around the needle. Hot water was circulated in the needle by using a peristaltic pump (Masterflex® L/S®, Cole Parmer, Chicago, IL). The needle was not placed within the imaging plane of the transducer in order to minimize the RF signal distortion. The region of imaging was heated from 26℃ to 46℃. The experiments were performed with and without a water reservoir and a pulse dampener (Masterflex® L/S®, Cole Parmer, Chicago, IL) in the flow circuit in order to study the effect of motion on both thermometry techniques. The water reservoir and the pulse dampener were used to eliminate vibration in the flow caused by the peristaltic pump.
For the proposed method, the backscattered energies of the fundamental frequency (E1), the second (E2) and the third (E3) harmonics were obtained by squaring the envelope of the filtered RF echo signal at each harmonic. The standard echo shift technique was performed by taking cross-correlation between each two frames with a window size of $1\times\tau$ (0.07 µs) and an overlap of 50%.
In the absence of vibration in the sample, we were able to obtain 2D temperature change maps using both techniques. However, in the presence of vibration, noninvasive thermometry was feasible only by using the backscattered energies of the harmonics.

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