Quantification of reverberation and aberration using lag-one coherence

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Background, Motivation and Objective

Abdominal ultrasound imaging is known to be plagued by the effects of acoustic clutter, a temporally stable haze that reduces target conspicuity by decreasing contrast and obscuring fine details. Clutter is generated by two major sources: near-field reverberation and phase aberration. While both sources have a frequency dependence, its effects on each have not been quantitatively compared in an abdominal model. The aims of this study are: (1) quantitatively separate the contributions of these sources of clutter using lag-one coherence (LOC), a direct estimate of clutter levels, and (2) characterize trends in these contributions with frequency.

Statement of Contribution/Methods

Channel data capturing signal + reverberation + aberration (S+R+A) were obtained from an *ex vivo* setup consisting of a porcine abdominal layer placed over a speckle generating target (n=8) and *in vivo* liver in healthy volunteers (n=3), over a range of transmit frequencies. To capture isolated measurements of reverberation, the speckle generating target and liver were replaced with anechoic rubber and bladder in *ex vivo* and *in vivo* setups, respectively. LOC_{S+R+A} was calculated from fundamental and harmonic channel data. Using measurements of reverberation and signal only, a channel signal-to-clutter ratio (SCR) was calculated by taking the ratio of signal power to reverberation power. This SCR was used to calculate a corrected LOC (LOC_{S+R}), i.e. a measurement of the decorrelation due to reverberation alone, using derivations from Long *et al*, 2018.

Results/Discussion

Initial results show that LOC_{S+R} was appreciably higher than LOC_{S+R+A}, suggesting that at depth, reverberation contributes less to clutter relative to aberration. *In vivo* harmonic imaging yielded higher LOC_{S+R} values than those of fundamental imaging, agreeing with the 10 dB improvement in measured SCR. These findings match the clinical experience: because the harmonic signal is generated at depth, it may be less prone to near-field reverberation. However, the harmonic signal remains susceptible to aberration, which appears to be a larger source of decorrelation as frequency increases, shown by the increasing difference between LOC_{S+R+A} and LOC_{S+R}. The phase shifts caused by aberration become larger with increasing frequency, which may lead to higher-order effects such broadening of the transmit beam.