Computational Model For "Native Tissue Harmonic Imaging"

"Tissue Harmonic Imaging" is a new echo signal processing and display modality on ultrasound scanners. It detects 2nd harmonic echo signals that result from nonlinear distortion of ultrasound waves propagating through tissue. We are implementing a computational model to simulate finite amplitude pulse transmission and harmonic echo signal production from pulse-echo transducers. The goal is to more fully understand the information content of tissue harmonic images and the dependence of echo intensity on transmit beam forming parameters as well as on the acoustical properties of the insonified region.

A frequency-domain numerical method described by Aanonsen was applied to solve the nonlinear model KZK equation for pulsed ultrasonic transmission by a circular disk transducer. This combines effects of diffraction, nonlinear propagation and attenuation. Linear theory is used during echo reception since the amplitudes of backscattered waves are weak compared to transmitted waves. Echoes from both discrete reflectors and randomly positioned scatterers are integrated over the surface of the transducer to obtain the fundamental and the harmonic signals. Pulse-echo responses at different field positions exhibit the details of harmonic build-up and dissipation with depth shown by previous authors. Harmonic images obtained for 2 MHz transmission and 4 MHz reception exhibit improved visualization of spherical voids over images obtained with fundamental 2 MHz beams, also similar to results with clinical imagers. Migrating the model to array transducers requires large increases in computational capabilities, and is being explored.