COMPUTER SIMULATIONS IN PARAMETRIC ULTRASONIC IMAGING

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Computer simulations are very important tools in the study of both conventional and parametric ultrasound imaging. A linear imaging model based on a frequency domain approximation is used to simulate ultrasound echo signals. The simulation program models important physical and technical factors relevant to a typical ultrasound machine. These include dynamic focusing, dynamic aperture, frequency dependent attenuation, frequency dependent backscattering, etc. The model can produce images for different scan formats, including linear and sectored array scanning and IVUS scanning. The accuracy of the simulation program is demonstrated in several studies, including one on the effects of medium sound speed on lateral resolution of ultrasound images.

Parametric imaging is a category of imaging modalities for which a specific meaningful quantity is extracted and displayed instead of the signal amplitude. Simulation schemes for parametric imaging modalities such as scatterer size imaging, attenuation imaging, and elastography are presented.

The ultrasound echo signal has a stochastic nature because it is formed by summation of signals from scatterers located randomly inside the medium. This stochastic nature causes noise in parametric ultrasonic images. Different compounding schemes have been proposed to overcome this noise. In this dissertation, we focus on angular compounding, which achieves optimal noise suppression with minimum loss of resolution. Several examples using the simulation program are presented. A theory describing the correlation of angular RF signals is developed so that an optimal angular compounding scheme can be designed.

Other examples on how computer modeling may be used in parametric imaging include applications in contrast agent imaging, where bubbles oscillate nonlinearly in the acoustic field, and harmonic rather than fundamental frequency echoes are used to construct images.