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Recent Innovations in Medical Ultrasound Instrumentation

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This presentation will describe recent developments in instrumentation and in signal processing in medical ultrasound scanners. Although ultrasound imaging still is done using pulse-echo techniques, capabilities of machines have been greatly expanded by applying modern transducers, digital processing, and computer display methods. In current practice, imaging is done almost exclusively with array transducers. Methods used for transmit-receive beam forming using arrays will be reviewed. New transducer materials, such as PZN-PT ceramics and Capacitive Micromachined Ultrasound Transducers (CMUTs) are also becoming utilized, and the advantages of these will be discussed.

An array element and its pulser-receiver system in the machine commonly is referred to as a “channel.” Channel counts as high as 128 and 192 are in common usage in scanners because of the control provided during receive beam forming and because they allow larger apertures for imaging at greater depths. Except for some continuous wave Doppler modes, receive beam forming is done by digitizing echo signal data from each active element and using ether application specific integrated circuits or field programmable gated arrays to introduce focusing time delays prior to coherent summation of signals from all channels. Following this, all further processing, image formatting, and post processing can be done using the system computer. There is a trend to move a larger share of the beam forming hardware into the transducer handle, so we anticipate smaller, more compact scanners in the future.

Important trends in signal processing are application of harmonic imaging, which can reduce artifacts from reverberations as well as enhance signals from ultrasound contrast agents, use of codes and chirps to improve sensitivity to weak reflectors and scatterers, and spatial compounding to improve image quality and reduce speckle. Post processing done on image data can further reduce speckle by applying various adaptive filters to the image data.

Manufacturers are designing equipment that hopefully can reduce the dependence of images and image quality on the operator. Two important trends here are greater emphasis on scanning using 3 and 4-Dimensional transducers and adaptive, patient specific imaging techniques. The latter includes speed of sound correction schemes to improve beam focusing as well as automatic gain control to establish proper echo signal levels and pre and post processing functions.