High resolution real-time elastography

Assistant Research Professor Emad Boctor, Associate Research Professor Gabor Fichtinger, and Professor Gregory Hager and their colleagues at the Engineering Research Center for Computer-Integrated Surgical Systems and Technology (ERC-CISST) have developed new methods for computing tissue stiffness from ultrasound data.

The process of computing tissue stiffness with ultrasound, referred to as “elastography” involves the computation of the motion of tissue as an external force is applied. The stiffer the tissue (formally, the higher the Young’s modulus), the less it is displaced for a given applied force. As a result, it is possible to resolve isoechoic anatomical structures that differ in stiffness from surrounding tissue (e.g. tumors) that would otherwise be invisible in a traditional ultrasound image (Figure 1, left). The major challenge in elastography stems from the fact that it is not the tissue displacements themselves that are used in the computation, but rather the *change* in displacement as a function of depth within the tissue. In order to reliably recover change in displacement, the tissue displacements themselves must be computed with extremely high accuracy.

The Hopkins team has developed a new method to achieve high quality elastography by efficiently computing very high resolution and high accuracy displacement maps. Traditional methods compute displacement by matching “blocks” within ultrasound images acquired while tissue is compressed. As a result, the resolution of the elastography is limited by the size of the block used. Further, each block is handled independently, not taking advantage of that fact that displacements usually vary smoothly throughout the tissue. The Hopkins approach makes use of an efficient global optimization technique known as dynamic programming. With this method, it is possible to compute displacements for each sample of the raw ultrasound data (RF data) without the artifacts introduced by the block structures of traditional methods. Further, it is possible to compute displacements to subsample precision and to include a constraint that enforces smoothness between samples. Figure 1 (center and right) show results comparing the two methods. Finally, the method is quite efficient and can be computed to operate in near real-time.

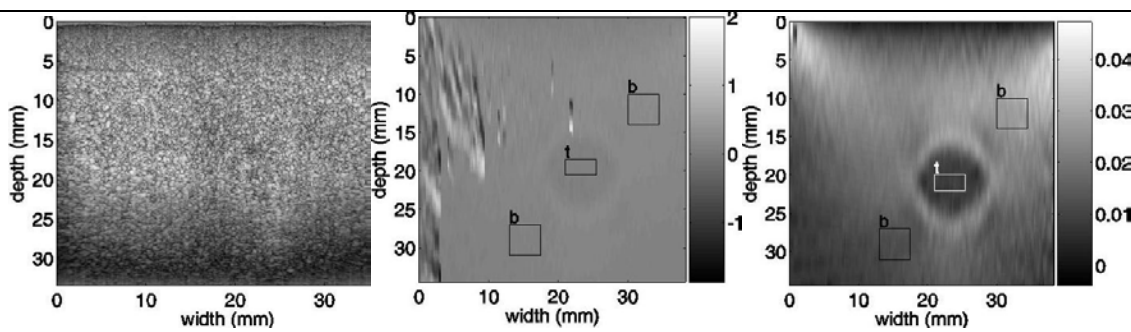

Figure 1: Freehand strain images of elasticity breast phantom (using RF data). Our novel DP method, developed by investigators at the CISST ERC, shows robustness to noise and high-res definition (right.) Traditional NCC method shows substantial degradation of strain quality and low-res capability (middle). Note the isoechoic appearance of the lesion in the B-mode image (left.)

The new method shows great promise as both a diagnostic and an interventional imaging modality. Figure 2 shows the results of computing elastography on an elasticity phantom made by CIRS Inc., locating lesions that would be invisible in normal CT images.

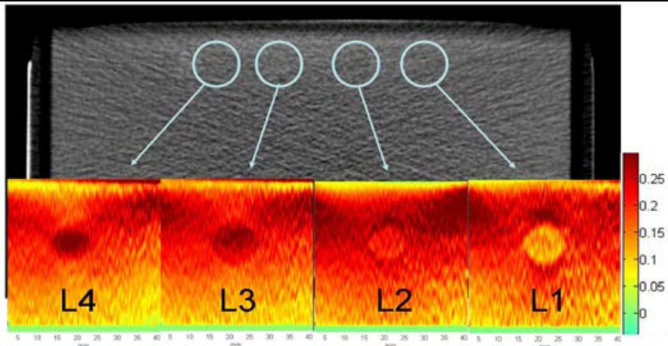

Figure 2: CT (above) vs. US elastography (below) in elasticity phantom (CIRS Inc.). While CT shows the contours only, elasticity imaging is capable of better delineation and identification of relative stiffness of the four lesions. L1 is the hardest and L4 is the softest.