Multi-wave Imaging: A solution to image rheological properties of soft tissues

Mathias Fink
Institut Langevin, Ecole Supérieure de Physique et de Chimie Industrielles, 75005, Paris, France

We describe a new concept for imaging soft solids. The idea is that very different waves -- one to provide contrast, another to provide spatial resolution -- can be productively combined to generate something akin to near-field imaging. We will focus specifically on imaging rheological properties of soft biological tissues. Here, the multi-wave approach relies on the simultaneous use of both sonic shear waves and ultrasonic compressional waves. The sonic shear wave has typically centimetric wavelengths and propagates at low velocity in tissues (between 1 and 10 m/s). They are progressively distorted by the viscoelastic inhomogeneities of encountered tissues. When coupled to an ultrafast ultrasound scanner (10.000 images per second), it allows for the follow up of the propagation of these waves with a sub millimetric resolution over a large zone of interest. From the spatio-temporal evolution of the displacement fields, inversion algorithms are used to recover the rheological properties with sub-millimetric resolution. These techniques are no more diffraction limited because, the near field of the shear waves is directly observed. Here, the shear wave gives the contrast (viscoelasticity) while the ultrasonic wave gives the spatial resolution. Various examples of *in vivo* images will presented in breast, liver, eyes, muscles, cardiac applications that show the interest of this quantitative imaging technique in diagnostic and therapy monitoring.