The biomechanical properties of tissues are widely considered to be important parameters for tissue characterization, as with age and disease many of the pathological and physiological changes involve the alteration of tissue composition, structure, and function. A careful evaluation and assessment of the changes in biomechanical properties can provide a way for early diagnosis and improved treatment of various diseases and lead to a better understanding of different physiological conditions of tissues, and organs. Ultrasound imaging is able to provide information about anatomy, blood flow, and material properties of many types of tissues. Ultrasound-based shear wave elastography (SWE) methods continue to become increasingly used in the clinic for objective assessing of biomechanical properties of tissues. Currently, most commercially available two-dimensional (2D) SWE techniques rely on applying acoustic radiation force (ARF) push beams to generate shear waves that propagate in the medium. Clinical SWE implementations have different configurations for generating the ARF push beams and also different ultrasound imaging methods used for motion detection. There are also differences in filtering the motion and estimating shear wave velocity using time-of-flight reconstruction algorithms. **As a result of this wide variability among different manufacturer implementations, variation in measured velocity and stiffness values within phantom targets and patient populations has been demonstrated.** For wider standardization and improved consistency of 2D SWE for diagnostic purposes across a wide range of applications, it is desirable to have methods that are more independent of the machine and the underlying acquisition and data processing schemes.

The project is about understanding physical phenomena that take into consideration uncertainty in acquisition, machine, modeling, etc. such that mechanical property estimates are produced with reduced uncertainty. We propose to utilize approaches in the frequency-domain that measure shear wave phase velocity (velocity at a particular frequency) and attenuation with expanded usable bandwidth. Numerical models and phantoms will be used to study clinically relevant cases of liver fibrosis and steatosis as well as lesions found in the breast, which will make the overall research more impactful and translatable. We will use commercial and custom-made phantoms to provide increased degrees of complexity for realism for clinical translation.

Successful completion of this research program will result in understanding how inexpensive, noninvasive ultrasound-based techniques can be optimally used for assessing the mechanical properties of soft tissues for characterization of different health states. Because ultrasound is routinely used for clinical assessment it is an excellent modality for quickly and comprehensively assessing mechanical properties of soft tissues. This research focuses on developing and testing robust frequency-domain-based methods for applications in homogeneous and heterogeneous soft tissues. The theory developed in this project will be suited for future utilization on the huge existing installed base of modern ultrasound scanners, for widespread clinical application including imaging in liver, breast, and thyroid throughout the nation and the world.