# AbstractID: 7951 Title: Noninvasive Temperature Imaging Using Diagnostic Pulse-Echo Ultrasound

Several ultrasonic parameters are known to have temperature dependence including the speed of sound, attenuation, nonlinearity parameter, etc. Local changes in tissue temperature can be estimated noninvasively using diagnostic pulse-echo ultrasound. A number of temperature estimation methods have been proposed since the early 1990s with varying levels of success. One method that was investigated by numerous groups is based on minute changes in echo locations due to temperature-dependent changes in the speed of sound and thermal expansion. Both *in vitro* and *in vivo* results have been obtained to demonstrate the feasibility of the method. However, several limitations have been shown to limit the use of this method in practice. In this paper, we describe a true two-dimensional displacement tracking algorithm with robust temperature estimation from real-time 2D pulse-echo ultrasound. The method employs a physics-based Kalman filter derived from the transient bioheat transfer equation (BHTE). The filter is shown to be effective in rejecting displacement artifacts from tissue motion as well as those resulting from the thermal lens effects.

This lecture will provide a description of the BHTE and the system approach leading to the design of the Kalman filter for tracking the temperature data based on the observed displacements in echo location in the region of interest. The tracking properties of the filter and its ability to reject artifacts from the observed displacements will be illustrated. One-dimensional and two-dimensional versions of the filter will be presented and contrasted in terms of their ability to reject displacement artifacts. Comparisons with previously published algorithms will be given using *in vivo* and *in vitro* data.

We will also present results on using the Kamlan filter methodology in tracking changes in tissue absorption associated with lesion formation using high intensity focused ultrasound (HIFU). This technique may lead to quantitative parameter imaging for monitoring and control of HIFU treatments under ultrasound image guidance.

The educational objectives:

1. Understand the origin of temperature-dependence of relevant acoustic parameter and their effects on observed pulse-echo data.
2. Understand the limitations of noninvasive temperature estimation using pulse-echo data.
3. Understand the connection between the physical model for temperature evolution and robust temperature and parameter tracking in tissue media.