生醫光聲原理

Computer Homework #1: Displacement and Strain – Applications in Thermal Imaging

Due 24:00, 11/02/2017

One of the techniques for monitoring focused ultrasound (FUS) thermal therapy is ultrasonic temperature estimation based on echo-time shift of ultrasound radio-frequency (RF) signals before and after FUS heating. The echo-time shift mainly results from changes in speed of sound induced by FUS heating. It is found that the echo-time shift variation (analogy to displacement variation), named as thermal strain, between the two RF signals is linearly proportional to the temperature change δT in tissue, as defined in the following:

$$\delta T(z) = \frac{C_0}{2} \cdot K \cdot \frac{\partial}{\partial z} \Delta t(z)$$

where C_0 is the initial speed of sound, K is the lumped constant that describes the relationship between temperature and thermal strain $\frac{\partial}{\partial z} \Delta t(z)$ and $T(z)$ is the temperature of the medium at the depth z.

From the equation shown above, the cross-correlation processing can be simply used to estimate the echo-time shift for the estimation of temperature change. In this homework, from the provided RF signals in the "FUS_RFData.mat", please try to

(1) Estimate echo time shift in μs as a function of depth (analogy to "displacement" lectured in Topic 2) with the cross-correlation processing
(2) Estimate thermal strain in % as a function of depth from the echo time shift obtained in (1).

When performing the cross-correlation processing, please compare the results in (1) and (2) obtained with different window size M (M = 2, 6, and 10 wavelengths relative to the center frequency) and different overlapping ratio N (N = 0%, 50%, 75%), and justify the results.

Notice:

1. Name your solution word file as "EE6265_HW1_StudentID.doc" and your Matlab codes as "EE6265_HW1_StudentID.m", and archive all the files into a zip or rar file.
2. Please upload your zip/rar file to the LMS elearning system
3. The first line of your word or Matlab file should include your name and some

brief description, e.g., % EE 6265 王小明 u9512345 HW1 11/02/2017

4. Don’t just show me the results. Please justify the results you’ve obtained.
5. In the provided FUS_RFData.mat,

   FUS_pre: RF signal before FUS heating

   FUS_post: RF signal during FUS heating

   c0: initial speed of sound in mm/μs

   fc: center frequency of the imaging transducer in MHz

   fs: sampling rate in MHz
6. <HINT>

   (a) Useful matlab functions: xcorr() for cross-correlation, conv() for smoothing or filtering, interp() or resample() for interpolation.

   (b) If the estimated echo time shift is too noisy, you may try to smooth it by moving average filtering (e.g., conv(echo time shift, ones(1,N)/N) where N is the filter tap) before the thermal strain estimation.

   (c) To obtain more accurate estimation of echo time shift, you may need to interpolate the provided RF signals (e.g., increase the sampling rate)