Principles of Biomedical Ultrasound and Photoacoustics
hw01: Displacement and Strain

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1 Introduction

For **Focused Ultrasound Thermal Therapy**, an important technique is to estimate the temperature change before and after applying it. The estimation can be derived by the echo-time shift before and after heating. Moreover, the temperature change can be formula as:

$$\Delta T(z) = \frac{C_0}{2} \cdot K \cdot \frac{\partial \Delta t(z)}{\partial z} \tag{1}$$

where $\Delta T(z)$ is the temperature change, C_0 is the speed of sound, K is a constant, $\frac{\partial \Delta t(z)}{\partial z}$ is the **thermal strain**.
In this homework, we need to finish the following requirements:

1. Estimate echo time shift in μs as a function of depth
2. Estimate thermal strain in % as a function of depth

2 Source Code

In this zip archive, there are two matlab source code files:

1. **EE6265_HW1_106061531.m**
2. **Windows.m**

"EE6265_HW1_106061531.m" is the main flow of this homework. It will use the class **Windows** in "Windows.m" to create an object, which can manage each window and makes our code more elegant, and plot figures with our given parameters.

3 Problems

In Equation 1, the term $\Delta t(z)$ is the echo-time shift before and after ultrasound heating. Because $\Delta t(z)$ is a function of z, which means $\Delta t(z)$ will vary at different depth. As a result, we can divide the pre-signal and post-signal into several frames with certain window size and apply cross-correlation for each pre/post window pair. By this way, we can estimate the time shift for each window. For more accurate result, we can upsample the origin signal to get more sample points and higher sample rate. In this homework, I upsample the signal to triple origin sample rate $3 \times f_s$ and use a moving average filter with size 5 to denoise the echo-time shift.
In the following section, I will show and explain several results.

3.1 Echo-Time Shift