BME 581 / ECE 493-T28 / ECE 700-T09: Ultrasound in Medicine and Biology
Programming Assignment – Due Mar 27th, 2025

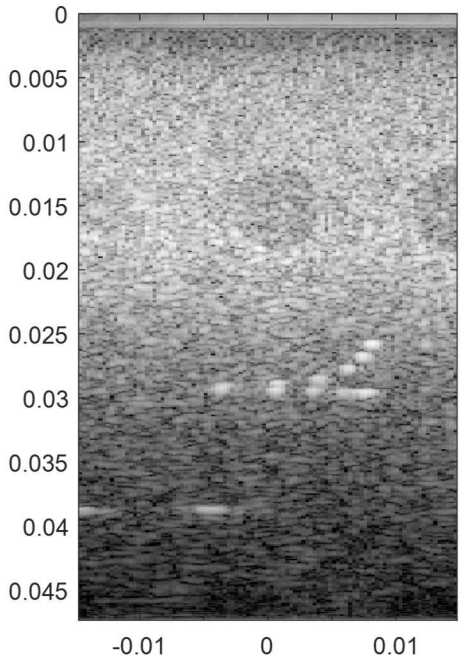
I. BACKGROUND INFORMATION

This programming assignment is designed to provide a hands-on experience for ultrasound image formation. You will be provided with a set of channel radiofrequency (RF) ultrasound data (*PA_data.mat*) and are tasked with forming an ultrasound B-mode image from the data. The assignment can be completed in either the Matlab or Python programming languages. Starter code will be provided for both languages (*PA_starter.m* or *PA_starter.py*).

For Matlab, the University of Waterloo provides access to Matlab for all students at the following webpage:
https://uwaterloo.atlassian.net/wiki/spaces/ISTKB/pages/284525621/MATLAB

For Python, the language is freely distributed. Certain packages and libraries are required to run the code and to have helpful functions available for use. For this programming assignment, we will require the NumPy, SciPy, and Matplotlib packages. One way to obtain Python is by using the Anaconda distribution, then installing the required packages using the "conda install" or "pip install" commands:
https://www.anaconda.com/download

The starter code already performs the data loading. Next, the raw data is visualized (data description is next section) by displaying the log-scaled echoes for each transducer array element. The beamforming function (DASbeamform) must be completed for this assignment and the function in the starter code will output an all-zeros array of the correct dimensions. The beamformed image is then scaled and envelope detected and output to the user. The Matlab functions are found at the end of the starter code and the Python functions are found in the middle of the starter code. The completed programming assignment should output an image that appears similar to the following:



II. DATA DESCRIPTION

The ultrasound data comes from a series of scanline transmissions. In total, the data is compiled from 97 total firings of scanline transmissions at different lateral positions. The lateral position shifts by one pitch-length with every transmission. Each scanline uses a subaperture of 32 transducer array elements for transmission. The echoes are recorded at all array elements, but only the corresponding subaperture of 32 elements should be used for beamforming. The DASbeamform function which must be completed contains all the variables required to form a complete B-mode image.

rfData – the data tensor containing all the ultrasound echoes (samples by array elements by scanlines)

tx_centers – the centered lateral position of each scanline (lateral x coordinate array of scanlines in m)

focus – the position of the axial focus of each scanline (given to be 0.02 m)

pos_z – image axial positions (axial z coordinate array of the image pixels in m)

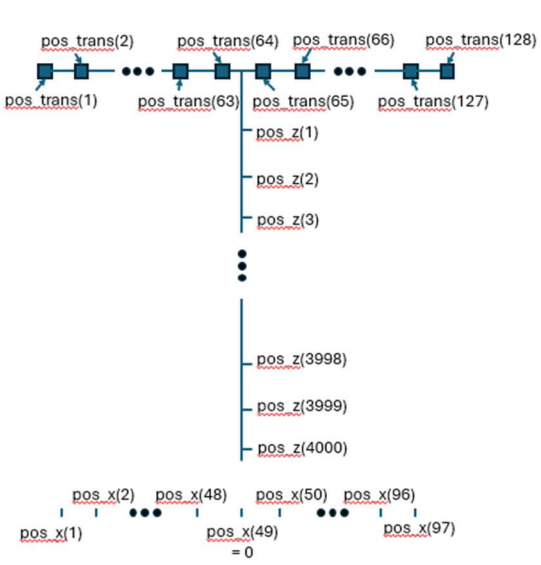
pos_x – image lateral positions (lateral x coordinate array of the image pixels in m)

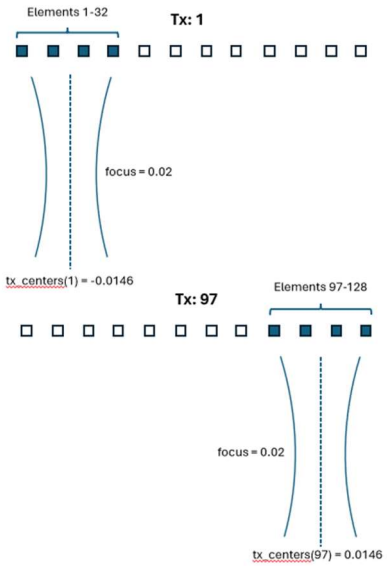
pos_trans – transducer lateral positions (lateral x coordinate array of the elements in m)

fs – sampling frequency (given to be 65 MHz)

sos – speed-of-sound (given to be 1540 m/s)

The following diagrams (1-indexing for arrays in Matlab, equivalent to 0-indexing for arrays in Python) helps to illustrate the role of some variables more clearly. Lastly, the time of the first sample of the data is simultaneous to when the first transmitting element fires for each scanline.





III. GRADING SCHEME

Please submit the completed *PA_starter.m* or *PA_starter.py* files to the LEARN Dropbox. The assignment will be assessed out of 20 marks. Approximate thresholds for the grading are as follows:

20 – completed DASbeamform function with dynamic receive delay calculations and no errors

16+ – completed DASbeamform function with few errors and implemented fixed receive delay only

10+ – incomplete DASbeamform function with right ideas, but failed to form an appropriate image