The 2D Fullwave code

For this assignment you will use a program that solves the 2D nonlinear wave equation on an unbounded domain. Refer to [1] for details on the equation and the finite differences used to solve it.

Download the `Fullwave` package from Sakai (`http://goo.gl/d7Y02q`). Create a directory, move the file into it, `cd` there, and use the Linux command `tar xvzf fullwave.tgz` to extract the files. In the following exercises, label and title all Figures appropriately.

1 Focused wave and a single scatterer

In MATLAB execute the script `launch_script.m`. Modify the script so that both the scatterer and the focus of the wave are at $(y, z) = (\mathrm{nY}/3, \mathrm{nZ}/1.3)$. Plot the field at $t = 21\mu$s. Turn this in as `fig1_yourname.jpg`.

2 Propagation in human tissue

a) Modify the script `launch_script_psf.m` so that the speed of sound of the scatterer has an impedance mismatch causing a reflection coefficient of 50%. Does the homogeneous point spread function change? Does the point spread function in the human abdomen change? Why or why not? Turn in the two point spread function plots as `fig2a_1_yourname.jpg` and `fig2a_2_yourname.jpg`.

b) Run the script `launch_script_imaging.m` as given, then increase the transmit frequency to 1.5 MHz. Compare the run-time of the 1 MHz and 1.5 MHz simulations (keep the points per wavelength unchanged). Is the run-time difference what you would expect? Turn in a plot of the B-mode image as `fig2b_yourname.jpg`. How does the image of the lesion compare to the original 1 MHz case in terms of resolution, penetration, etc.?

3 Harmonic imaging in human tissue

a) Plot the energy in the fundamental and harmonic bands of the propagating wave through the human tissue-mimicking layer phantom. Use Gaussian bandpass filters centered at the fundamental and second-harmonic frequencies. Turn in a plot of harmonic and fundamental energy versus depth as `fig3a_yourname.jpg`.

b) Find the contrast-to-noise (CNR) of the lesion phantom with fundamental and harmonic imaging.

Please upload your MATLAB files with your name appended i.e. `fullwavehw_yourname.m`, all figures as jpeg's or png's, e.g. `fig1_yourname.jpg`, and an informal report with the answers to the questions.

David Bradway will be out of town until Tuesday. Your regular TA's can help you get Fullwave set up in Linux. David will hold office hours on Tuesday or Wednesday upon request `david.bradway@duke.edu`.

References

[1] G.F. Pinton, J. Dahl, S. Rosenzweig, and G.E. Trahey. A heterogeneous nonlinear attenuating full-wave model of ultrasound. *Ultrasonics, Ferroelectrics, and Frequency Control, IEEE Transactions on*, 56(3):474–488, March 2009.