MODELING SHEAR WAVES THROUGH A HETEROGENEOUS VISCOELASTIC MEDIUM RESULTING FROM ACOUSTIC RADIATION FORCE EXCITATION

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ABSTRACT

This thesis report presents a finite element model of a simulated viscoelastic phantom with a stiffer cylindrical inclusion, and the resulting shear waves through the heterogeneous media after an ultrasonic acoustic radiation force is applied. The MATLAB-based program, FIELD II Simulator for Ultrasound Systems, was used to calculate the radiation intensity, which is proportional to the applied body force, and the finite element software ABAQUS FEA was used to simulate the response to the acoustic radiation push through the soft tissue and stiff inclusion. Dynamic explicit simulations were performed in ABAQUS and the resulting nodal displacement was observed for several case studies. Each study used the same finite element model but applied a 1) full radiation push, 2) focal region push, 3) single element focal point source, or 4) various thresholds of the full radiation push. For each case, nodal displacements along the lateral direction of the model at both the focal depth and through the inclusion were captured and compared to experimental data. Experiments were performed by Professor Kevin Parker's research group at the University of Rochester, in which a phantom containing a stiffer cylindrical inclusion was imaged using a GE ultrasound system. The finite element simulation results matched well with the experimental data with respect to replicating the shear wave speed through the background medium but did not illustrate comparable attenuation and peak displacements. The shear wave speed through the inclusion was also not as high as expected, but the attenuation was appropriate. As a result of this study, it was shown that a focal region or point source push is not adequate to accurately model the effects of the full radiation push, but thresholding the full push can produce comparable results and reduce computation time. In this report, a historical review of various elastographic imaging methods and prior modeling efforts are presented along with the theoretical background for the problem. The ABAQUS finite element model parameters, use of Field II, and simulation details are provided. Finally, the results of the ABAQUS simulations are presented, compared with experimental data, and discussed.