Abstract:
One goal of non-destructive testing procedures is the identification of changes of interior details of a structure over time. More general, the deviation of the present state of a structure from a measured or simulated model state has to be identified. These and similar problems occur in different areas of natural sciences, engineering and technology, where geophysics, biomechanical engineering and Structural Health Monitoring are only a few examples. Over the last decade newly developed numerical methods in geophysics allow to identify the interior of the earth in much more detail than ever before [1]. Their dramatic progress is based on smart combinations of detailed seismic measurements, advanced mathematical approaches and efficient algorithms for high performance computing [2]. We present our attempts to transfer and further develop these methods to problems in biomechanics with the goal to monitor healing processes of fractured bone. To this end we investigate the so-called adjoint method, using a numerical bone model which stems from a CT scan of the damaged bone, an acoustic simulation based on this model and synthetic measurements obtained during the healing process. Because the wave equation is symmetric in time, the propagation of sound is time-reversible [3]. Therefore, the
differences of simulated and generated signals at the receiver locations can be time-reversed and played backward into the model. Within the backward simulation sensors become sources and the wave fronts focus on the location of differences in the bone density, being the origin of the difference in the signals. Using the results of this simulation, we construct a sensitivity kernel highlighting the regions of maximal change of material parameters. We illustrate the potential of this approach on numerical experiments with a synthetic model and show that it could open the possibility to reduce cost and radiation exposure by reducing the number of necessary CT scans without compromising the quality of monitoring of the healing process.

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entries: