Full-waveform inversion algorithms with quantified uncertainty for medical shear elastography

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Elastography is a noninvasive medical imaging technique that aims to visualize the elastic properties of soft tissue. The underlying idea is that elastic behavior can distinguish healthy from unhealthy tissue in specific situations. For instance, cancerous tumors and scarred liver tissue will often be stiffer than the surrounding healthy tissue. Elastography based devices emit elastic waves that interact with the tissue under study and record the response received. Using the recorded data, adequate mathematical algorithms provide information on stiffness variations in the explored region. Such devices are already being used for the diagnosis of liver and prostate diseases. However, there is a need for improved methods and algorithms, allowing to resolve for tiny tumors or for little contrast regions with quantified uncertainty. Here, we propose a full wave form inversion scheme for localized inhomogeneities that proceeds as follows. First, we identify the most prominent anomalous regions in the tissue by visualizing topological fields associated to functionals comparing the true recorded data with the data that would be obtained varying the stiffness fields. Then, we improve this information by optimization strategies. Finally, we quantify uncertainty in the outcome resorting to a Bayesian inversion framework [1, 2, 3, 4, 5]. We illustrate the method using data from prostate and liver studies.

References

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