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Medical ultrasound tomography: lessons from exploration geophysics

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Abstract

The seismic method is a widely-used imaging tool in the geophysical exploration industry. This has led to the development of powerful imaging methods, in some cases inspired by and akin to those used in medical ultrasound tomography. In both exploration seismology‘ and in medical imaging, the experi-ment involves the propagation of sound waves over distances of a few tens of wavelengths to a few hundred wavelengths. In both cases the transmitters and receiver design is used to control bandwidth and illumination apertures. However, in exploration seismology i) access to the target is unusually restricted, ii) geological targets are often embedded in strongly scattering material, iii) we cannot ignore 3D heterogeneity, elastic wave effects including mode conversions, and anisotropic wave propagation, and iv) we must account for the presence of high amplitude dispersive modes associated with the free surface of the Earth.

In exploration the past decade has seen the emergence of “Full Waveform Inversion” (FWI) as a remarkably successful innovation. Historically, seismic imaging methods have been most successful when applied to back-scattered (aka reflected) waves. FWI, in contrast, has to date been most suc-cessful with transmitted (aka refracted) waves. FWI of reflected data is progressing, but significant problems remain. These include i) handling the significant non-linearity and non-uniquenesses that are inherent in the experiment, and ii) convincing skilled interpreters that FWI yields a new type of image that contributes in significant (but unusual) ways. It is suggested that the field of medical ultrasound tomography shares these problems and that there is much to be learned by cross-fertilization in both fields.

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