LINEAR AND NONLINEAR INVERSE SCATTERING IN ULTRASONIC AND ELECTROMAGNETIC NON-DESTRUCTIVE EVALUATION

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Imaging of defects is an important task in ultrasonic non-destructive evaluation. For that purpose, an algorithm acronymed SAFT (Synthetic Aperture Focussing Technique) has been heuristically proposed, and we could prove that this is a time domain backpropagation version of linearized diffraction tomography. Both algorithmic alternatives are presently applied for three-dimensional ultrasonic imaging, and a number of experimental examples will be given. Even though SAFT is essentially a scalar inversion it is applied to both pressure and shear waves neglecting their respective elastodynamic vector and tensor character. Interesting enough, elastodynamic scattered far-fields decouple polarization and wave mode, i.e. pressure waves are longitudinally and shear waves are transversely polarized. Based on that observation an elastodynamic pressure-shear-mode diffraction tomography has been formulated, and its application to simulation as well as experimental data clearly exhibits resolution improvements.

For non-conducting materials, in particular concrete, electromagnetic waves complement ultrasound for non-destructive evaluation of tendon ducts. In principle, standard GPR-techniques and -processing (GPR: Ground Probing Radar) can be applied, but, as in elastodynamics, the polarization information of electromagnetic waves is generally ignored. Hence, we formulated a polarimetric diffraction tomographic inversion scheme, which shows superior performance when compared to standard SAR-processing (Synthetic Aperture Radar).

For quantitative inverse scattering, the inherent linearization of diffraction tomography must be overcome. We implemented various versions of scalar nonlinear optimization algorithms (Modified Conjugate Gradient, Contrast Source Inversion) and applied them to experimental electromagnetic TM and elastodynamic pressure wave data. It turns out that the resulting improvement regarding resolution and suppression of multiple scattering artifacts, even though prominent, does not really justify the tremendous additional effort, at least if standard non-destructive testing problems are considered.