Chirp-coded ultrasound for localization of linear and nonlinear scatterers in isotropic media

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Chirp-coded ultrasound has been under active research for reciprocal Time Reversal with Nonlinear Elastic Wave Spectroscopy for ultrasonic wave focusing and additionally detection and analysis of nonlinear defects. Localisation and imaging of defects under these principles, without scanning or use of other complicated methods, is an open problem. Frequency Modulated Constant Wave technology is widely known in radar applications where the distance to multiple reflecting targets, their velocities and angles of return are found from the chirp signal. These principles are not yet widely used in ultrasound technology. Chirp-coded ultrasound is common between the two methods and enable to maximise total power on target due to longer transmitted signals (as opposed to pulsed operation). This work proposes to unite the Frequency-Modulated Constant-Wave scatterer localization with reciprocal Time Reversal – Nonlinear Elastic Wave Spectroscopy principles to enable the localization of scatterers distant from the transducers and the analysis of their nonclassical nonlinearity which often can be caused by microdamage or cracking. In this paper only the first part (localization of scatterers using frequency-modulated constant wave ultrasound) of the problem is investigated. The main goal is to verify the feasibility of the method for ultrasound in solids and identify the main problems to be solved. Physical experiments and simulations are used to ascertain the detectability of linear and nonlinear scatterers in an isotropic solid medium (acrylic) using ultrasound. Potential problems with this approach are identified, to be solved in future work. In the future, this approach could enable to spatially filter the return signals, enabling to use reciprocal time reversal for focusing the wave energy in space directly onto selected scatterers, using the simplest of test setups: one transmitting and two receiving transducers.