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# ADVANCES IN TIME-DEPENDENT WAVE-BASED OBSTACLE IDENTIFICATION METHODS

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Obstacle identification problems are an important class of inverse problems, where the goal is to find the location, size and shape of a local "object" (which can be a cavity, a region made of material different from the background material, a geometric irregularity in the boundary, etc.) in an otherwise given medium, based on some measurements of the relevant field. A sub-class of problems in this category is that based on time-dependent waves. Here, a given time-dependent wave source is introduced in the medium, and the response to this source is measured at certain points in space and time. Based on these measurements, some computational method is used to identify the obstacle. Such problems appear (and are important), for example, in bio-medical engineering, Non-Destructing Testing (NDT) of structures, damage evaluation, underwater acoustics and solid earth geophysics (SEG).

The most common, which is also the simplest, method used for obstacle identification is *Arrival Time Imaging (ATI)*, also called Kirchhoff Migration. It is claimed that about 80% of SEG identification problems are solved using ATI. At the other end of the spectrum there is *Full Waveform Inversion (FWI)*, usually with the aid of an efficient *adjoint*-type scheme. Computational methods based on *Time-Reversal (TR)* are also effective for such problems.

In this talk we present various methods to solve time-dependent wave-based obstacle identification problems in acoustics, SEG and structural damage evaluation. This work is partly based on the recent papers [1-3]. In addition, we compare the performance of the various methods. One of our conclusions is that adjoint-based methods are generally more efficient than TR-based methods, but require more data to succeed and are more sensitive to measurement noise, especially in comparison to Augmented TR. We also present an adjoint-based method for the precise identification of the shape of an obstacle.

## REFERENCES

[1] D. Rabinovich, E. Turkel and D. Givoli, An Augmented Time Reversal Method for Source and Scatterer Identification,' *J. Comput. Phys*., Vol. **375**, pp. 99–119, 2018.
[2] T. Levin, E. Turkel and D. Givoli, Obstacle Identification Using the TRAC Algorithm with a Second-Order ABC, *Int. J. for Numer. Meth. in Engng*., Vol. **118**, pp. 61–92, 2019.
[3] A. Sayag and D, Givoli, Shape Identification of Scatterers Using a Time-Dependent Adjoint Method, *Comp. Meth. in Appl. Mech. & Engng*., under review.