Iterative time reversal of electromagnetic wave fields

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Abstract

Time reversal is based on recording the wave field by a set of transducers, time reversing the recorded signal, and retransmitting the result. The retransmitted wave field propagates back in the medium towards its source of origin. Time-reversal in acoustics have been extensively studied. Maxwell's equations have the same type of time symmetry as the linear acoustic equations, thus time-reversal can be used for electromagnetic fields. Applications of time-reversal algorithms include lithotripsy, pulse focusing, medical imaging, inverse scattering, optimal distinguish-ability measurements, and communication.

The time reversal is approach is suitable in inhomogeneous medium supporting mutipath wave propagation. The approach does not require knowledge about the propagation environment and it is known to be statistically stable in broadband regimes. As the time reversal focusing properties is much better in inhomogeneous environments than in homogeneous ones, the approach offers an improved resolution in imaging and concentration of the power in communication.

Here, the time-reversal approach is analyzed from a boundary control perspective in which time reversal is used to steer the wave field towards a desired state, corresponding to the original state. It is shown that the iterative time-reversal algorithm converge to the controllable part of the desired state for electromagnetic fields in lossless medium. The first step of the time-reversal algorithm corresponds to the common version of time reversal.

In this paper, we consider the time reversal approach for multiple antennas and antennas in inhomogeneous environments. In the cases of mutual coupling between antennas as well as near-field scattering of the antennas it is advantageous to remove this near field coupling before the wave field is retransmitted. Numerical examples are used to illustrate the results.

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