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Direct Fully Discrete Energy Estimates for Solutions of Finite Difference Schemes for Quasilinear Symmetric Hyperbolic Systems

Abstract

We introduce the time-reversed absorbing conditions (TRAC) in time-reversal methods. They enable one to ``recreate the past'' without knowing the source which has emitted the signals that are back-propagated. We present two applications in inverse problems: the reduction of the size of the computational domain and the determination, from boundary measurements, of the location and volume of an unknown inclusion. The method does not rely on any a priori knowledge of the physical properties of the inclusion. Numerical tests with the wave and Helmholtz equations illustrate the efficiency of the method. This technique is fairly insensitive with respect to noise in the data.

Nonlinear hyperbolic symmetric partial differential equations occur in many fields of applied mathematics.
In particular the Euler equations, describing the flow of inviscid fluids, are important in the aerospace industry. The existence and uniqueness of the solution of these PDE's have been proven in the past. Approximation for their solution can be obtained by numerically solving appropriate nonlinear finite difference schemes. Existence and uniqueness of solutions for those schemes have been proven in the past but always with the assumption that the continuous PDE's solutions are very smooth and the finite difference schemes solutions are estimated in a space which has fewer derivatives.

Our aim is to prove a stronger theorem of existence and uniqueness of discrete solutions for the finite difference schemes without assuming higher smoothness of the continuous solution. As in the continuous case, the crucial part of the proof is obtaining the appropriate energy estimates for the schemes. We successfully prove the existence and uniqueness of solutions in a discrete Sobolev space of the same order as in the continuous case, for a semi implicit scheme. In addition, we proved convergence of the interpolation of the discrete solution to the continuous solution in this smooth space.

מתאמים: פרופ' י. גולדמן, ד"ר ש. מיברג, פרופ' י. סטאנצ'סקו
ופרופ' ד. פישלוב

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