

HAAR WAVELET AND MESHFREE METHODS FOR SOLVING TWO AND THREE DIMENSIONAL TELEGRAPH INTERFACE MODELS

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Abstract

In this dissertation, Haar wavelet and meshfree methods are developed and applied for the numerical solution of two- and three-dimensional telegraph interface models. The telegraph equation governs various physical phenomena such as electrical signal propagation, electromagnetic waves, and transient processes in transmission lines. When extended to multidimensional domains with discontinuous coefficients or interfaces, these models present significant challenges in terms of accuracy and computational efficiency.

The proposed numerical techniques are based on the Haar wavelet collocation method and meshfree radial basis function based methods. The Haar wavelet collocation method utilizes a piecewise constant basis, providing computational efficiency and accuracy in capturing sharp transitions across interfaces, while the meshfree radial basis function approach avoids the complexity of meshing in higher dimensions and exhibits strong adaptability for irregular geometries. The temporal discretization of the problems is carried out using established time-marching schemes.

Both linear and nonlinear forms of the telegraph interface equation in two and three dimensions are addressed. For nonlinear problems, the method of quasi-linearization is employed, wherein nonlinear terms are approximated by linear terms, enabling the use of techniques originally developed for linear equations. Iterative updates allow the extension of these methods to nonlinear problems effectively.

To evaluate the accuracy, robustness, and efficiency of the proposed approaches, extensive numerical experiments are performed on two dimensional and three dimensional telegraph interface problems. Error analysis using the L_∞ -norm, root mean square error and efficiency tests through CPU time measurements are conducted to assess the comparative performance of the methods. The results confirm that the developed schemes outperform several traditional approaches in terms of computational cost and accuracy.

This research provides effective numerical strategies for solving multidimensional hyperbolic telegraph equations in complex geometries with discontinuities and interfaces, contributing to the advancement of computational methods in applied mathematics and engineering.