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Analysis of High-Order Partial Differential Equations by Using the Generalized Finite Difference Method

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ABSTRACT

The generalized finite difference method (GFDM), which cooperated with the fictitious-nodes technique, is proposed in this study to accurately analyze three-dimensional boundary value problems, governed by high-order partial differential equations. Some physical applications can be mathematically described by boundary value problems governed by high-order partial differential equations, but it is non-trivial to analyze the high-order partial differential equations by adopting conventional mesh-based numerical schemes, such as finite difference method, the finite element method, etc. In this study, the GFDM, a localized meshless method, is proposed to accurately and efficiently solve boundary value problems governed by high-order partial differential equations. The GFDM, truly free from mesh generation and numerical quadrature, adopts the Taylor series expression and the moving-least square approach to derive the expressions of partial derivatives. The partial derivatives are approximated as the linear accumulation of functional values and weighting coefficients at each node and the nearby nodes on computational domain. The resultant system of linear algebraic equations can be yielded by enforcing the satisfaction of the governing equation at interior nodes and the boundary conditions at boundary nodes. Once the sparse system of linear algebraic equations is efficiently solved, the accurate numerical solutions of the GFDM can be stably acquired. Besides, the fictitious-nodes technique is adopted to deal with the multiple boundary conditions in the high-order partial differential equations. Some three-dimensional numerical examples, governed by high-order partial differential equations, will be provided in this study to verify the merits of the proposed combination of the GFDM and the fictitious-nodes technique. In addition, the stability and consistency of proposed novel meshless scheme will be numerically examined by using various parameters.

KEYWORDS

Meshless method; generalized finite difference method; high-order partial differential equation; fictitious-nodes technique; taylor series expression

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.