

PROCEEDINGS

An Improved Interpolating Dimension Splitting Element-Free Galerkin Method for 3D Nonlinear Richards' Equation

Ning Peng¹ and Zhi-juan Meng^{1,*}

¹School of Applied Science, Taiyuan University of Science and Technology, No. 66 Waliu Road, Wanbailin District, Taiyuan, 030024, China

*Corresponding Author: Zhi-juan Meng. Email: mengzj@tyust.edu.cn

ABSTRACT

This paper presents an improved interpolating dimension splitting element-free Galerkin (IIDSEFG) method for solving the three-dimensional (3D) nonlinear Richards equation. In order to improve computational efficiency, using the Kirchhoff transform, the linearized 3D Richards equation is obtained. By coupling the improved interpolating element-free Galerkin (IIEFG) method with non-singular weight function and the dimension splitting method, the corresponding 3D equations are solved. First, the acquired 3D linear space is converted into a series of two-dimensional (2D) subdomains along the selected segmentation direction. Subsequently, the corresponding 2D problem is solved using the IIEFG method. The finite difference method (FDM) is employed in the splitting direction and time domain. Consequently, the initial-boundary value problem for the partial differential equations was discretized into a set of algebraic equations. Thus, the numerical solutions for the distribution nodes of the linear differential equation are obtained. Finally, they are converted into a numerical solutions in the form of a nonlinear differential equation. In order to verify the superiority presented by the IIDSEFG method in solving the 3D nonlinear Richards' equation, examples can be selected and the error analyses are carried out for them by selecting the IIEFG method and the IIDSEFG method, respectively. The systematic

analysis yields the effects of node distribution, influence domain parameter $d_{\max}$, time step, splitting direction, time interval and number of split layers on the numerical results and convergence. The results show that the IIDSEFG method is significantly better than the IIEFG method in terms of computational accuracy and efficiency.

KEYWORDS

Richards' equation; nonlinear; improved interpolating dimension splitting element-free Galerkin method; improved element-free Galerkin method

Funding Statement: The authors received no specific funding for this study.

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

