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Research Advances on the Collocation Methods Based on the Physical-Informed Kernel Functions

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ABSTRACT

In the past few decades, although traditional computational methods such as finite element have been successfully used in many scientific and engineering fields, they still face several challenging problems such as expensive computational cost, low computational efficiency, and difficulty in mesh generation in the numerical simulation of wave propagation under infinite domain, large-scale-ratio structures, engineering inverse problems and moving boundary problems. This paper introduces a class of collocation discretization techniques based on physical-informed kernel function (PIKF) to efficiently solve the above-mentioned problems. The key issue in the physical-informed kernel function collocation methods (PIKFCMs) is to construct the related basis functions, which includes the physical information of the considered differential governing equation. Based on these physical-informed kernel functions (PIKFs), these methods do not need/only need a few collocation nodes to discretize the considered differential governing equations, which may effectively improve the computational efficiency. In this paper, several typical physical-informed kernel functions (PIKFs) that satisfy common-used homogeneous differential equations, such as the fundamental solutions, the harmonic functions, the radial Trefftz functions and the T-complete functions and so on, are firstly introduced. After that, the ways to construct the physical-informed kernel functions (PIKFs) for nonhomogeneous differential equations, inhomogeneous differential equations, unsteady-state differential equations and implicit differential equations are introduced in turn. Then according to the characteristics of the considered problems, the global collocation scheme or the localized collocation scheme is selected to establish the corresponding physical-informed kernel function collocation method (PIKFCM). Finally, four typical examples are given to verify the effectiveness of the physical-informed kernel function collocation methods (PIKFCMs) proposed in this paper.

KEYWORDS

Collocation methods; physical-informed kernel functions; fundamental solutions; T-complete function; harmonic function

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