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Hybrid FEM-RBFNN: A Fusion of Finite Element Method and Radial Basis Function Neural Networks for Solving PDEs

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Abstract

Traditional numerical methods like the Finite Element Method (FEM) have long been relied upon for solving partial differential equations (PDEs) due to their stability and theoretical foundation. However, these methods face significant challenges when applied to problems involving complex geometries, moving boundaries, or high-dimensional spaces, where mesh generation and refinement become computationally demanding. To address these limitations, this research proposes a hybrid FEM-Radial Basis Function Neural Network (FEM-RBFNN) framework, integrating machine learning with classical numerical techniques. By embedding RBFNNs within the FEM structure, the hybrid approach enhances solution accuracy, efficiently captures sharp gradients, and improves adaptability to complex problem domains. Comparative analyses with traditional FEM demonstrate that the FEM-RBFNN method not only improves computational efficiency but also achieves superior accuracy, particularly in scenarios with challenging boundary conditions or incomplete observational data. The research highlights the capability of integrating FEM with neural networks to create more adaptable and efficient PDE solvers, hence advancing scientific computing and engineering simulations.

Keywords: Hybrid FEM-RBFNN, Convergence, FEM, Root Mean Square Error, Radial Basis Function, Neural Networks.

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