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A gradient-enhanced physics-informed neural network (gPINN) scheme for the coupled non-Fickian/non-Fourierian diffusion-thermoelasticity analysis

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This research introduces a modified artificial intelligence (AI) approach using the gradient-enhanced physics-informed neural network (gPINN) with a novel structure for analyzing generalized coupled non-Fickian/non-Fourierian diffusion-thermoelasticity. Building upon the successful application of gPINN in function approximation and single partial differential equation (PDE) problems, we extend its application to solving a system of coupled PDEs. The study formulates governing equations for a copper strip based on the Lord-Shulman theory of generalized coupled thermoelasticity. To showcase the capabilities of the gPINN-based approach, we present three examples involving distinct boundary conditions in a one-dimensional half-space, along with an example in a two-dimensional half-space. The primary objective is to explore the transient behavior of field variables: non-dimensional molar concentration, non-dimensional displacement, and non-dimensional temperature. Additionally, we delve into variations of dimensionless stress. Comparisons between the gPINN-based method and conventional approaches substantiate the effectiveness of the gPINN with its novel structure. Detailed sensitivity analyses investigate the impact of neural network hyperparameters. We also address the influence of relaxation time on mass concentration in a specific scenario. Overall, the proposed gPINN-based method with its novel structure consistently produces encouraging and satisfactory results, with potential for application to more complex problems. Numerical results underscore the significance of appropriately weighting the derivatives of loss terms for achieving accurate predictions. Nonparametric statistical tests further confirm the agreement between gPINN solutions, employing specific weights, and outcomes obtained through commonly used analytical techniques.