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A physics-informed approach to resolve third-order differential problems

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Solving third-order differential equations plays a vital role in evolving our understanding of complex phenomena across various scientific and engineering fields where they are applied to model the behavior of dynamic systems. In this research, we focus on the development and application of Physics-Informed Neural Networks (PINN) in resolving third-order differential problems particularly on ordinary differential equations (ODEs) due to the challenges faced when utilizing traditional methods such as the New Iterative Method (NIM) and Adomian Decomposition Method (ADM) in providing efficient and accurate solutions to third-order ODEs. The proposed PINN model presents an alternative for solving these third-order ODEs efficiently and accurately by integrating the residual of ODEs and initial conditions into the training process through the loss function, enabling the neural network to learn the governing equation effectively. PINN comprises input, hidden and output layers, in which the hidden layer captures the complex mathematical computations within the third-order ODEs with the support of Tanh activation function which introduces non-linearity into the systems. The proposed PINN model is also trained using backpropagation to compute the gradients of the loss function with respect to the neural network parameters which are then optimized using Adam and L-BFGS optimizer in order to approximate the solutions to third-order ODEs with high precision and minimal error. Five numerical problems were used in evaluating the effectiveness of the proposed model and the results from these problems demonstrate that the proposed PINN model is superior to the NIM and ADM methods by producing accurate solutions that match the exact solution with very low error. These findings highlight the capabilities of PINN in producing accurate and efficient solutions to third-order ODEs encountered in real-world problems.

Keywords: Physics-informed neural network, third-order differential equations, complex systems, numerical method, computational efficiency.