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Physics Informed Neural Network for Heat Transfer Problems

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Abstract

Physics-Informed Neural Networks (PINNs) offer a promising approach for solving heat transfer problems by embedding governing physical laws directly into the neural network training process. These methods are particularly valuable for complex thermal-fluid systems where conventional modelling approaches struggle. Turbulent and two-phase flows are ubiquitous across many areas of energy management, yet accurate modelling of these systems remains extremely demanding. From refrigeration system optimisation and oil extraction to renewable technologies such as solar thermal collection, a fundamental understanding of turbulent and multiphase flows is essential for translating models into reliable real-world systems. Traditional numerical methods often rely on complex assumptions and discretisation strategies, which can limit predictive performance and computational efficiency. Machine learning techniques, especially PINNs, provide an alternative pathway by integrating observed data with partial differential equations (PDEs), enabling the network to infer flow regimes and thermal behaviour under complex boundary conditions. This work presents a systematic development of PINNs capable of modelling multiphase and turbulent phenomena. By combining machine learning with physics-based constraints, PINNs can significantly enhance the prediction and understanding of heat and fluid flow, enabling optimised engineering designs, improved thermal systems, and more accurate, scalable solutions for industrial applications.