Machine Learning Techniques for Inverse Heat Transfer Problems: Opportunities and Challenges

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Abstract:

Inverse problems are encountered when required information about a physically unreachable domain needs to be obtained from the data collected at the accessible domain. Due to its frequent occurrence in heat transfer and many other fields, a family of methods has been developed over decades to tackle such problems. Recently, physics-constrained neural networks have shown great promisein providing fast, elegant solutions for inverse problems. In this work, a physics-informed neural network was developed to solve several unsteady inverse heat transfer problems. Using physics-constrained deep neural network model, we were able to predict the temperature profiles across the whole domain and estimate the unknown thermophysical parameters such as the material's thermal diffusivity and boundary conditions at the inaccessible side (i.e., heat flux) with high accuracy. Furthermore, the method was extended to estimate the time dependent heat flux on the inaccessible side. The predicted temperatures and estimated parameters obtained from our inverse technique are in good agreement with their corresponding exact or true values. However, the physics-informed neural network was not able to predict the heat flux accurately if the boundary temperatures were not used for training the artificial neural network. To overcome this challenge, we have developed a hybrid method coupling the artificial neural network technique with a finite volume method. This hybrid method is capable of predicting the unknown heat flux within 1% of their true values. We also used the hybrid method for a thermal ablation problem with a moving boundary and obtained highly accurate heat flux at the inaccessible side for the thermal ablation problem.

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1st Floor, R. A. Fisher Bhavan, Indian Statistical Institute, Kolkata

Everyone is invited to attend