Proceedings of the 10th World Congress on Momentum, Heat and Mass Transfer (MHMT 2025)
Barcelona, Spain - April, 2025
DOI: 10.11159/icmfht25.004

Exploring Applications of Machine Learning For Data Regression in Heat Transfer

Francesco Coletti[1,2]
[1]Hexxcell Ltd., Foundry Building, 77 Fulham Palace Road, London, W6 8AF, UK
[2]Department of Chemical Engineering, Brunel University London, Kingston Ln, Uxbridge UB8 3PH, UK

Extended Abstract

Capturing the phenomenological aspects underlying complex heat transfer processes, such as boiling and condensation, presents significant challenges. Traditional modelling approaches that rely on the detailed description of the physics of these process often fall short in accurately predicting heat transfer quantities, such as convective heat transfer coefficients and pressure drops, even when supplied with reliable experimental data.

Artificial Intelligence (AI) offers a promising solution to these challenges by leveraging advanced algorithms capable of identifying non-obvious correlations in large datasets. AI can also predict key system parameters, even in cases where the underlying physics is not fully understood. For example, machine learning models have been trained on experimental data to predict flow patten maps [1] and heat transfer coefficients in single [2] and two-phase flows [3, 4], often providing a level of accuracy that empirical and semi-empirical models struggle to achieve.

However, while AI presents significant potential, it is not without limitations. In cases where data is scarce or unreliable, AI models may fail to produce reliable predictions. Additionally, as shown in previous work [4], there is a risk of overfitting the training data, making extrapolation beyond experimental data unreliable. Moreover, the black-box nature of many AI algorithms makes it difficult to interpret the results and understand the physical phenomena underlying the predictions.

In this Keynote, we will explore the role of AI in addressing these challenges, with specific examples from pulsating heat pipes, condensation in micro-fin tubes and flow boiling in micro-channels. We will discuss both the current capabilities of AI methods and their limitations, while highlighting their potential to revolutionize the heat transfer industry by enhancing the predictive accuracy and facilitating the development of novel systems.

References

[1] Loyola-Fuentes, J., L .Pietrasanta, M. Marengo and F. Coletti (2022). Machine Learning Algorithms for Flow Pattern Classification in Pulsating Heat Pipes. Energies 2022, 15(6), e1970.

[2] B. Kwon, F. Ejaz, L. Hwang (2020) Machine learning for heat transfer correlations. Int. Commun. Heat Mass Transfer, 116.

[3] B. Souayeh, S. Bhattacharyya, N. Hdhiri, M. Waqas Alam (2021) Heat and fluid flow analysis and ann-based prediction of a novel spring corrugated tape Sustainability, 13 (6), p. 3023.

[4] Loyola-Fuentes, J., N. Nazemzadeh, E. Diaz-Bejarano, S. Mancin, and F. Coletti (2024). A framework for data regression of heat transfer data using machine learning. Applied Thermal Engineering, Volume 248, id.123043.