Master's Thesis Defense Announcement
Mechanical and Aerospace Engineering Department
University of Texas at Arlington

DEEP NEURAL NETWORK MODELS FOR HEATSINK PERFORMANCE PREDICTION AND OPTIMIZATION IN SINGLE PHASE IMMERSION COOLING:
Framework for Future Design Tools and Digital Twin Integration

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Abstract

The rapidly rising computational power of modern computing components combined with the advanced packaging techniques being implemented has resulted in exponentially increasing thermal design powers (TDP) from CPUs and GPUs. Traditional air-cooling methods are approaching their effective cooling limits for many of these components, requiring lower supply air temperatures, higher supply air flowrates, and much larger heatsinks to remain feasible.

Transitioning from air-cooling to single-phase immersion cooling offers numerous benefits in thermal performance, data-center size reduction, and energy efficiency. To leverage the merits of immersion cooling, the performance of a given heatsink must be predicted and optimized for best performance for a given condition. This study presents the use of deep learning (DL) and deep neural networks (DNN) to construct a design tool that can predict the performance characteristics of heatsinks in single-phase immersion cooling. Utilizing a validated synthetic dataset of 15,552 data points generated by parametric CFD simulation, multiple DNN models are trained to predict the thermal-hydraulic performance of a heatsink based on the choice of immersion fluid, flowrate, temperature, component power, and heatsink geometry. When deployed for inferencing, the DNN models show that they are generally capable of making accurate predictions (<15% error) when exposed to input parameter combinations outside of the training or validation datasets. The developed DNN models are additionally applied in a modular neural network architecture, which is an architecture where multiple independent, smaller DNNs are connected together to model an overall larger, more complex system. This investigation shows that the DNN models developed can be successfully expanded to this application and still yield mostly accurate predictions (<30% compounded error) even though this application is beyond the training range. The developed DNN models are also implemented into a multi-objective, multi-variable optimization framework demonstrating their ability to be used for rapid optimization studies. The development of this design tool results in a system that can be utilized to replace or augment traditional CFD studies, reducing lead time and cost in development of effective heatsinks for a given single-phase immersion cooling application. The methodology developed additionally serves as a starting framework for further expansion into the development of rapid design tools and digital twins for data centers.