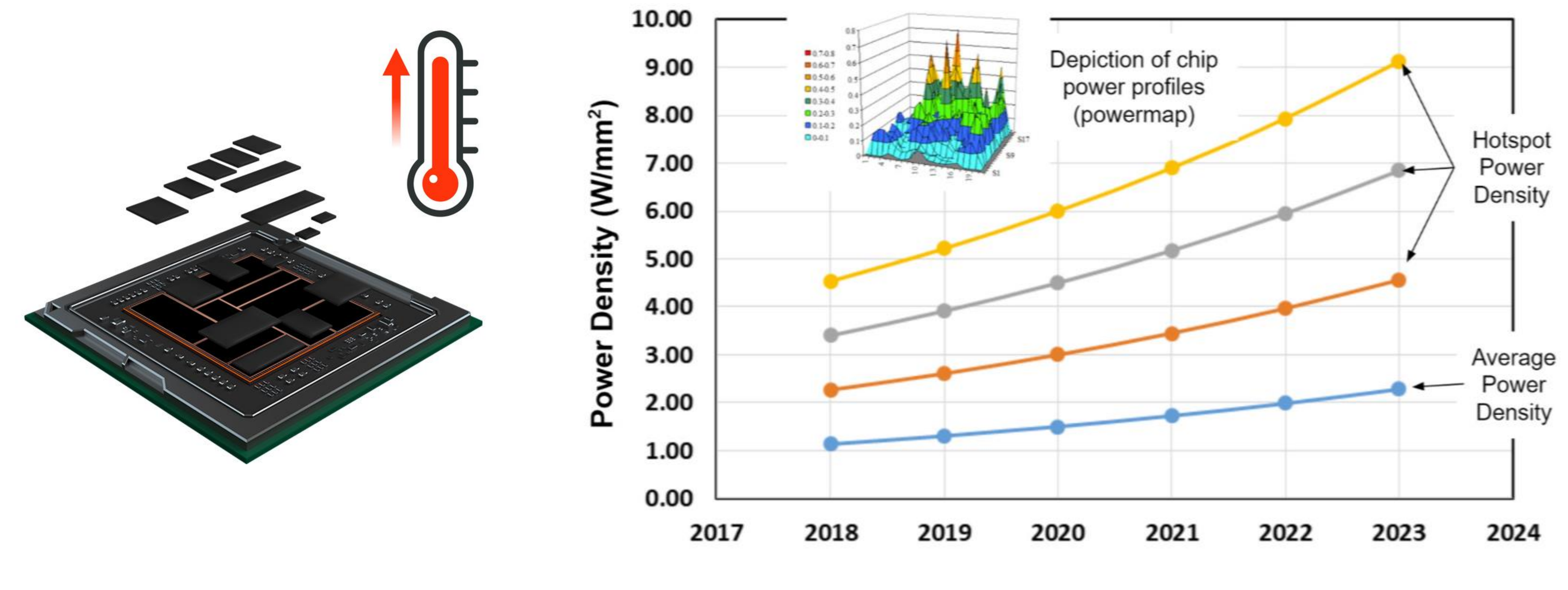
Fast Machine Learning Based Prediction for Temperature Simulation Using Compact Models

Mohammadamin Hajikhodaverdian[1], Sherief Reda[2], Ayse K. Coskun[1]
[1]Boston University, Boston, MA, [2]Brown University, Providence, RI
Contact: aminhaji@bu.edu

Motivation

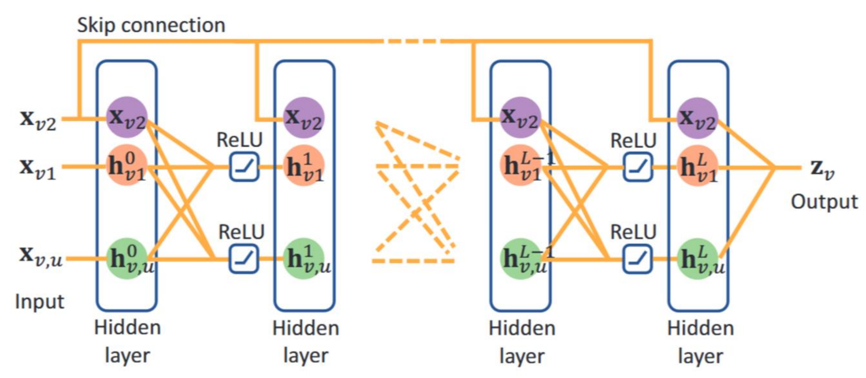


[IEEE. "Chapter 20: Thermal."]

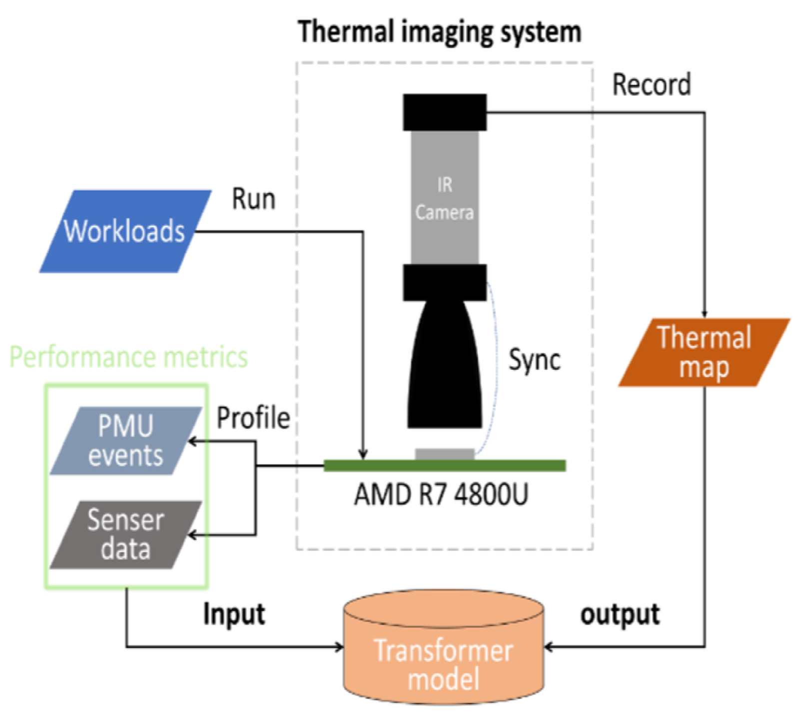
- Power density rises with the technology node, increasing temperature.
- Increased temperatures degrade chip performance and reliability, making thermal simulation essential.

Background

- Conventional methods, like FEM-based tools and compact thermal models, are time-consuming and computationally expensive.
- Machine learning models that use an infrared camera are limited to post-silicon designs.
- Simulation-based ML models typically require many simulation samples for accurate training.

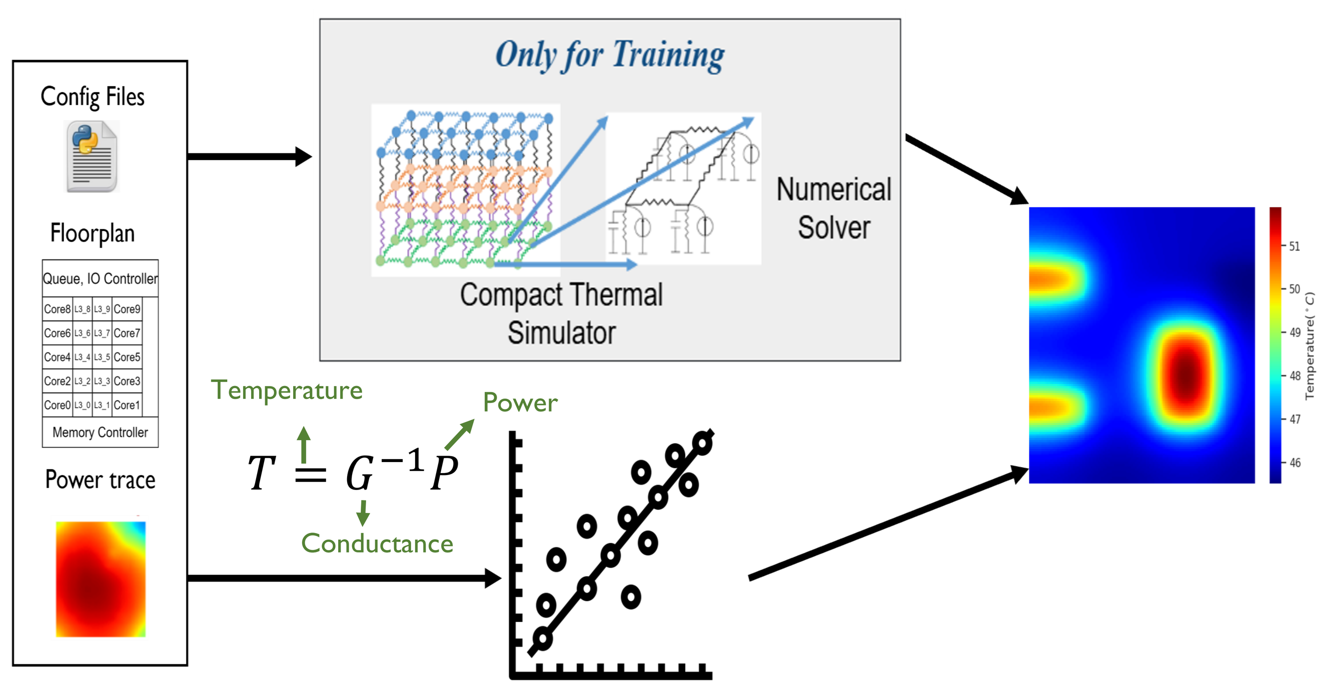


[L. Chen et al., ASP-DAC'22]

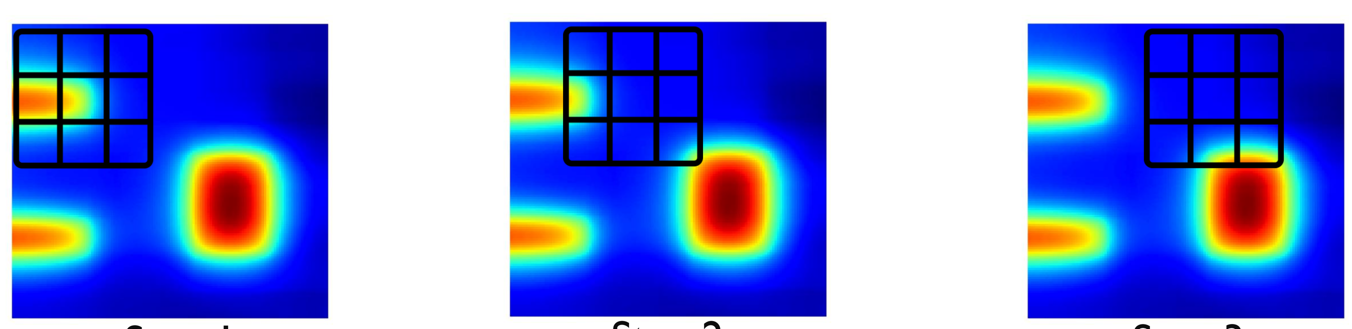


[J. Lu et al., ICCAD'23]

Temperature Prediction Using Machine Learning and CTMs



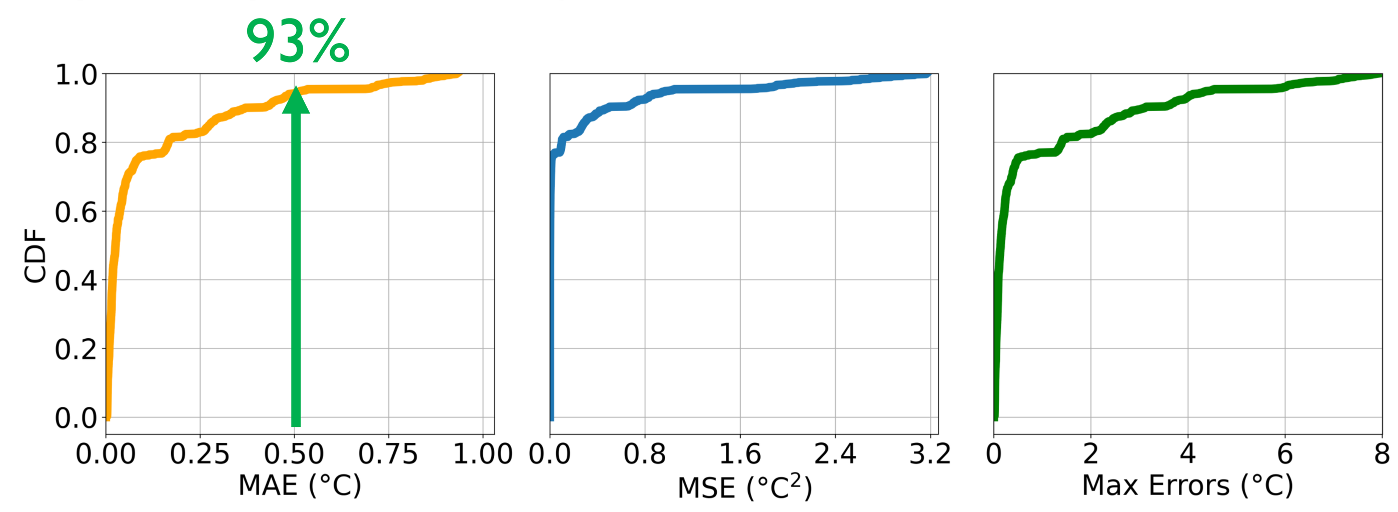
- High-resolution simulations need larger models as the number of parameters increases polynomially with resolution.
- Our model uses overlapping windows to preserve dependency.



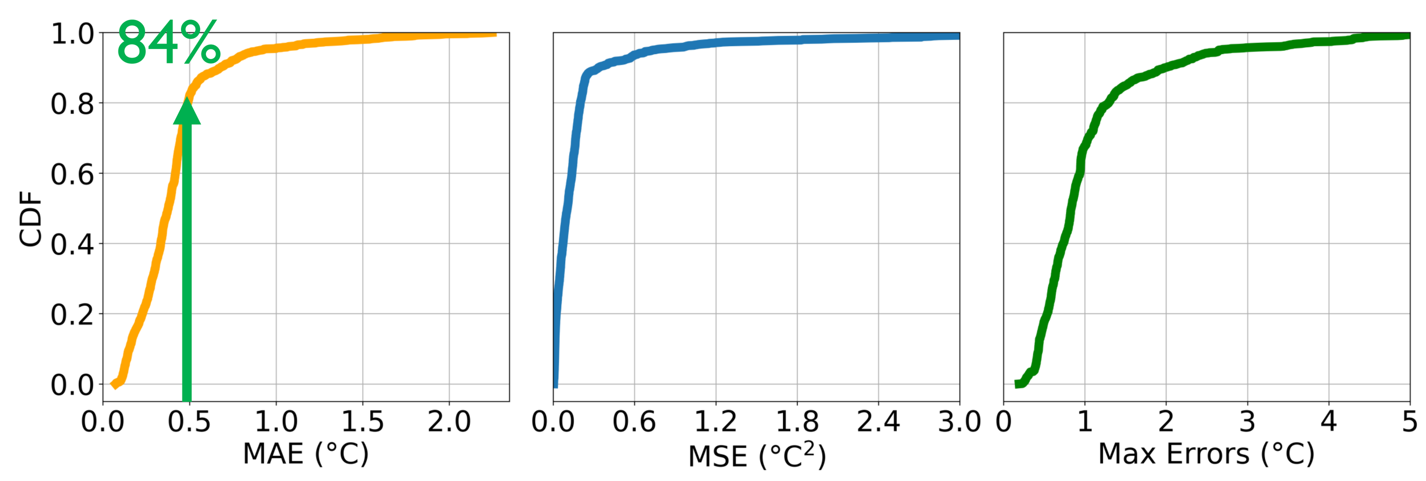
Step 1 Step 2 Step 3

Standard vs. Window-based Results

- We reduce the model's parameters by a factor of 256 without significant accuracy loss by transitioning to window-based.



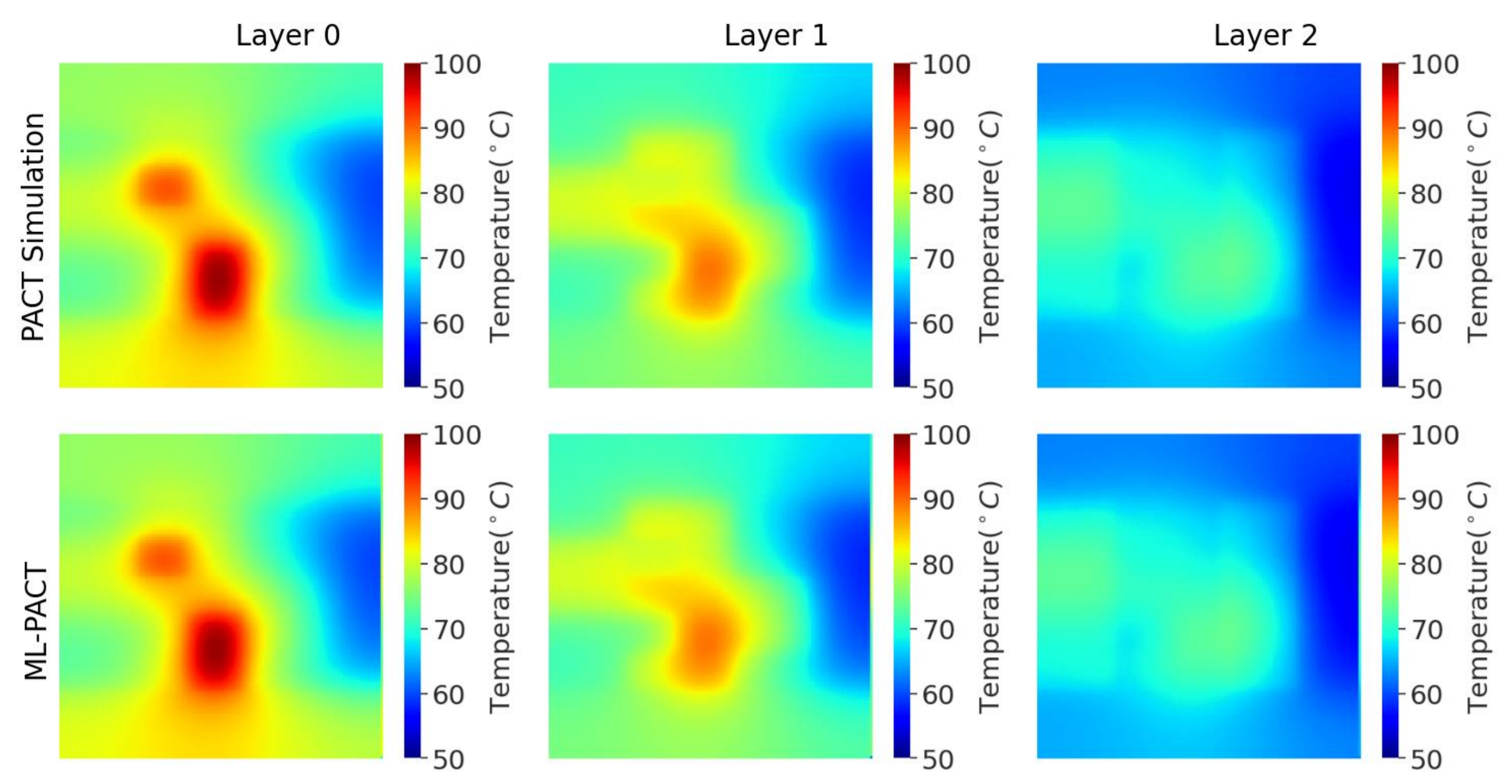
*MSE, MAE, and Max temperature error comparison of Intel i7 with a grid size of 64×64, 128×128, and 256×256 for **standard** method*



*MSE, MAE, and Max temperature error comparison of Intel i7 with a grid size of 64×64, 128×128, and 256×256 for **window-based** method*

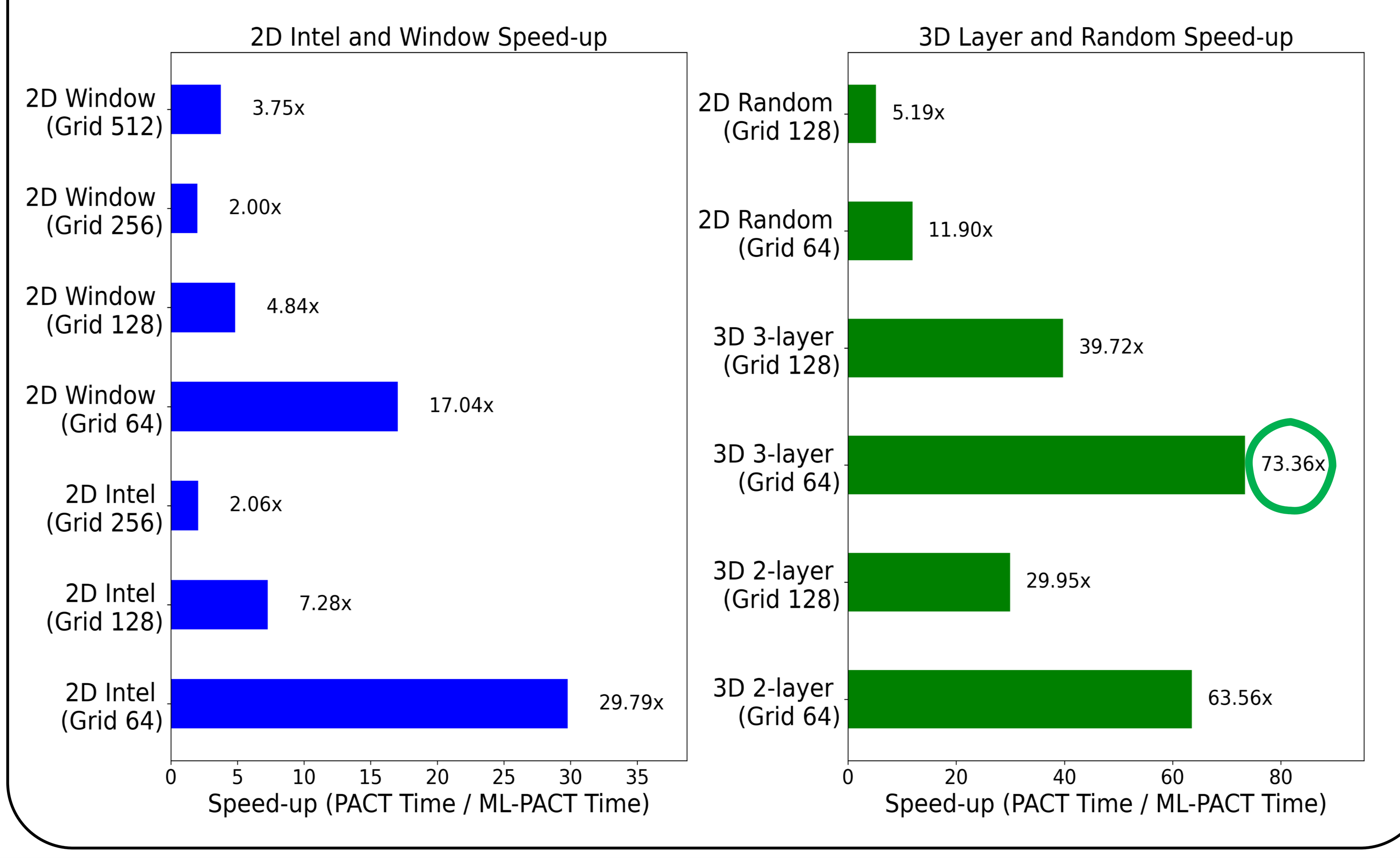
Temperature Prediction vs. PACT

- We compare the output of our framework with PACT for a monolithic 3D design with one computation layer + two storage layers.



Simulation Time Comparison

- We achieve over 73× speed up in comparison with PACT.



[1] IEEE. "Heterogeneous Integration Roadmap, Chapter 20: Thermal." [Online]. Available: http://eps.ieee.org/hir. [Accessed: Oct. 10, 2023]
[2] Z. Yuan et al., "PACT: An Extensible Parallel Thermal Simulator for Emerging Integration and Cooling Technologies," in *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (TCAD).*
[3] L. Chen, W. Jin and S. X. . -D. Tan, "Fast Thermal Analysis for Chiplet Design based on Graph Convolution Networks," 2022 27th *Asia and South Pacific Design Automation Conference (ASP-DAC).*
[4] J. Lu, J. Zhang and S. X. . -D. Tan, "Real-time Thermal Map Estimation for AMD Multi-Core CPUs Using Transformer," *2023 IEEE/ACM International Conference on Computer Aided Design (ICCAD).*