WOLFRAM CONSULTING SERVICES

Optimizing the Thermal Performance of Electric Trucks with Neural Networks

Industry: Engineering **Applications:** Neural Networks, System Modeling

ABOUT

Wolfram collaborated with a multinational automotive company to optimize the thermal performance of their electric freight trucks. Wolfram's team used a mixture of real-world data from the truck's components and realistic range estimates and constraints provided by the client's engineers to conduct simulations and generate insights into the thermal behavior of the whole system. This combination of measured and simulation-derived data was then used to train a neural network capable of predicting and optimizing the thermal performance of individual components. The final result is an automated control system that improves energy efficiency, enhances operational reliability and helps maintain a comfortable environment for the driver.

THE CHALLENGE

Ensuring optimal thermal performance of the different components in freight trucks is crucial for efficiency, sustainability and driver comfort. However, thermal profiles are complex systems influenced by many factors—some internal to the truck's engineering and components, and others external, like ambient temperature, road

conditions and weather. To be able to meaningfully predict and control the thermal performance of such a complex system, the most important factors need to be brought together into a single high-fidelity model.

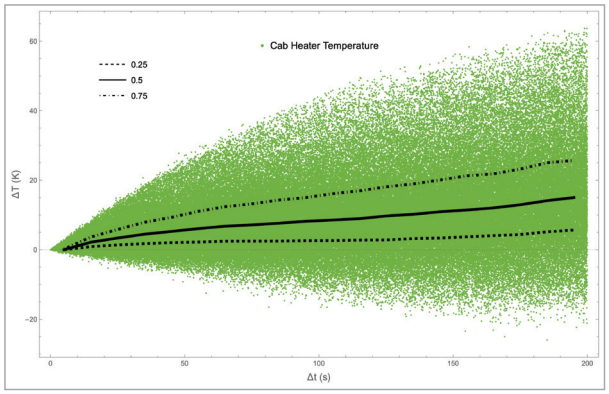
The individual components in this model can then be analyzed for their thermal profiles, while the model as a whole can generate additional data to drive a deeper understanding of the full system. Yet constructing such a model is challenging not only because of the complex behavior of the variables but also because most off-the-shelf tools and software packages aren't built to handle the kind of cross-domain physical modeling, precision and simulation needed at this scale.

THE APPROACH

Wolfram's team used System Modeler to represent the various components that affect thermal performance in the client's electric freight trucks. This enabled a clear identification of input parameters, including factors such as valve fractional openings, compressor speed and radiator mass flow. Wolfram's team worked with the client's engineers to define realistic parameter ranges and used mathematical techniques—such as Latin hypercube sampling—to generate a wide range of simulated operating conditions that reflect real-world scenarios.

The data generated from these simulations was then used to train a neural network model capable of quickly predicting how different configurations affect the truck's thermal behavior. With this model, Wolfram's client can rapidly generate and test component settings that optimize for specific outcomes—whether that's maintaining a target temperature of an individual component, maximizing the energy efficiency of the truck or balancing thermal loads across the system.

By combining cyber-physical system modeling with machine learning techniques and neural networks, Wolfram created a solution that captures both the physical structure of the system and its complex behaviors under real-world conditions. This not only provided actionable insights into the truck's thermal behavior for the client's current route but also created a flexible foundation for future optimization efforts across different routes, conditions and vehicle types.



Results of multiple simulations showing the change in cab heater temperature across a time period of 200 seconds.

ACHIEVEMENTS

Rapid optimization for different outcomes

The resulting neural network is able to suggest optimal configurations for various components—such as valve positions, compressor speeds and flow rates—that lead to specific thermal outcomes. Depending on the operating context, the model can optimize for reduced energy consumption, faster thermal stabilization or minimizing peak component temperatures. This provides engineers with a valuable tool for making informed design and operational decisions quickly.

Full drive cycle simulations

The model and the neural network can be used to simulate a complete drive cycle of over three hours. Using inputs like ambient temperature, the system can predict how each component will behave throughout the cycle to ensure all temperatures remain within safe operating limits. This allows engineers to evaluate thermal performance across realistic, long-duration scenarios.

A base model for continuous improvement

The System Modeler framework and the trained neural network together form a robust foundation for iterative improvement. As more real-world operational data is collected, the model can be refined and retrained, leading to more accurate predictions and expanded functionality. This provides the client with a scalable solution that grows in value over time as part of a continuous engineering optimization pipeline.

LET'S TAKE YOUR PROJECT TO THE NEXT LEVEL

Find out how the Wolfram Consulting Services team can jump-start your project with in-depth troubleshooting, code optimization, custom training or production deployment.

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