Geminus

Case Study

Simulating a combined cycle power plant in real-time with machine learning

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Power plants are ripe for digital innovation. According to McKinsey, power plants have the potential to boost earnings by 20 to 30% by applying digital tools. The International Energy Agency (IEA) estimates that digitalization can reduce power plant O&M costs, increase efficiency, reduce downtime, and increase operational lifetime to the tune of $80 billion in savings per year. One pragmatic way to improve process efficiency is to create models that can accurately predict the complex behavior of a plant and optimize design and operations.

For example, the power generation industry heavily uses simulation to evaluate what-if scenarios for process improvement and control logic testing. As in many verticals, simulation typically lives in the design and planning phase; due to computational lag, these insights cannot be produced quickly enough to inform real-time control. To show how high-performance machine learning (ML) models can provide simulation quality insight in real-time, Geminus created a fast, accurate surrogate of a high-fidelity simulation of a natural gas combined cycle (NGCC) power plant.

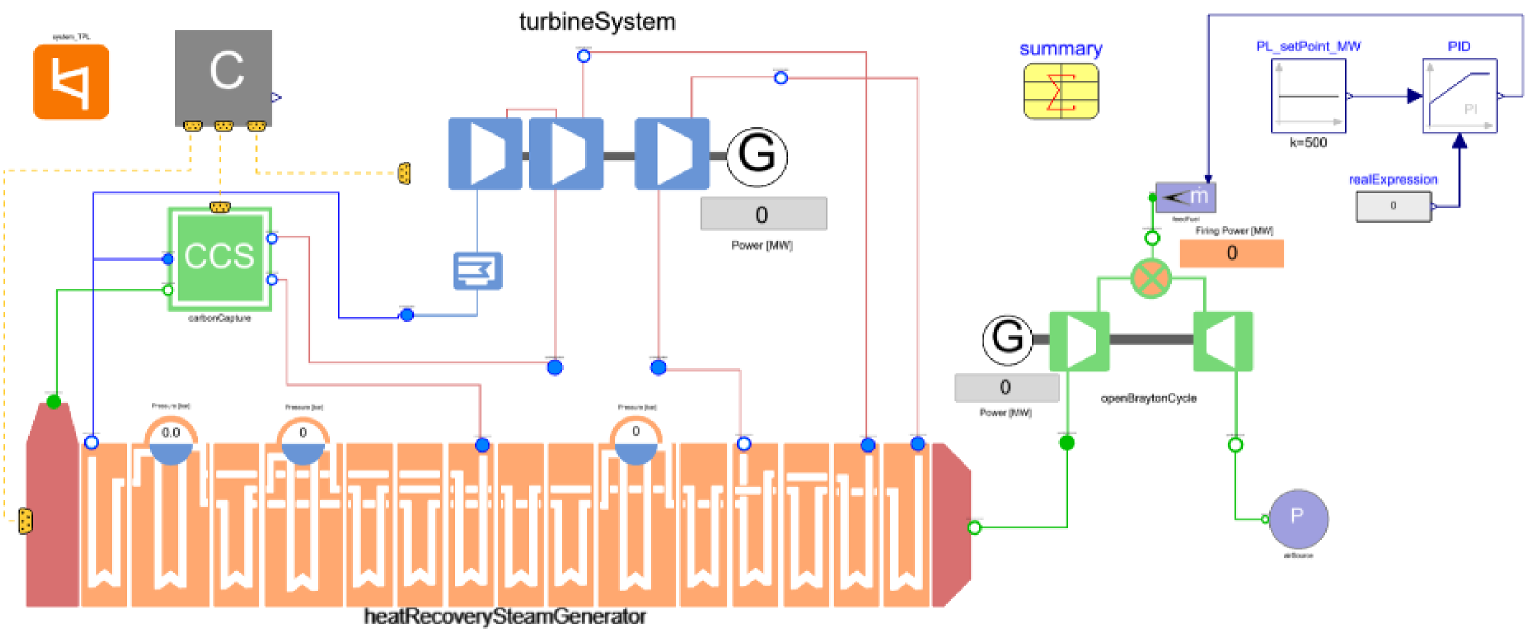


Fig 1. Modelon Impact model of the NGCC power plant

This Geminus AI model was trained using synthetic data from [Modelon Impact](). (A description of the plant can be found [here]().) The system includes a heat recovery steam generator, a steam turbine, and a natural gas combustion turbine. The resulting machine learning model was validated against the performance of the original simulator by evaluating the accuracy of predicted quantities of interest, and the inferencing speed compared to the simulation times. To illustrate the accuracy of the ML model, we can look at overall plant efficiency to compare the performance against the base simulation. Typical accuracies are well under +/- 0.2% on average for all quantities of interest.

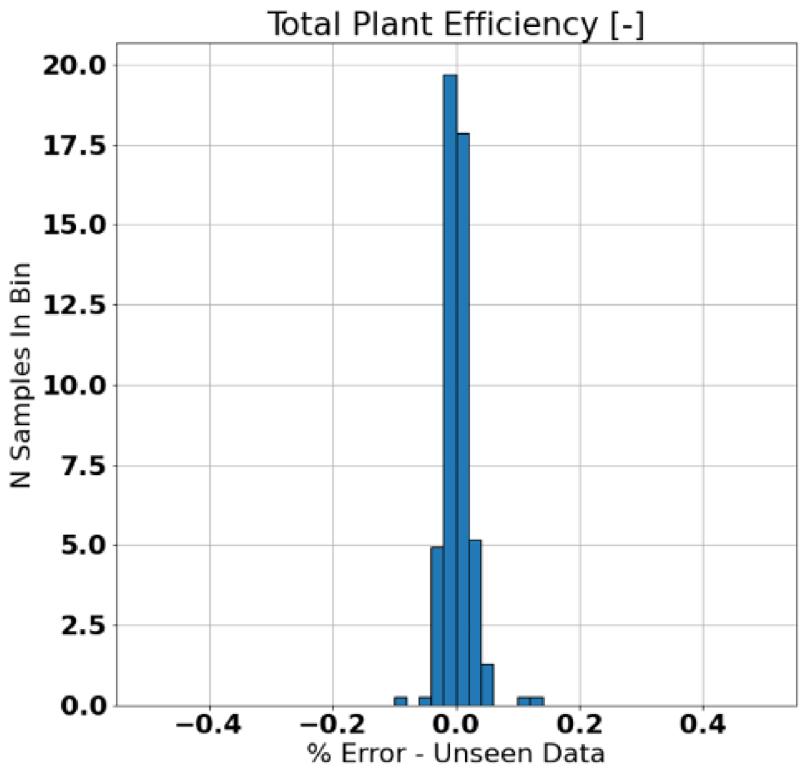


Fig 2. Error distribution for ML model vs. simulator for data points not used in training

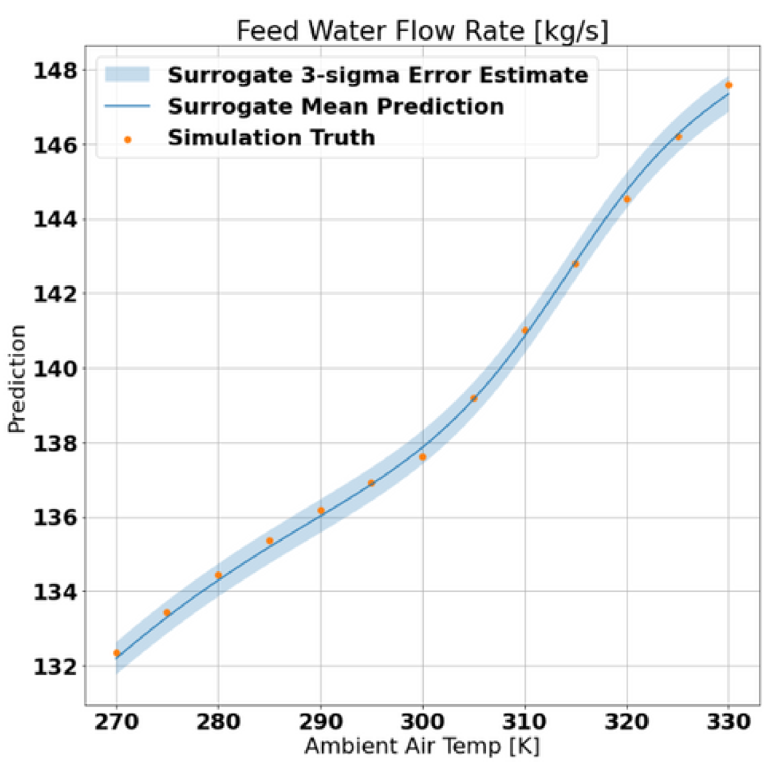
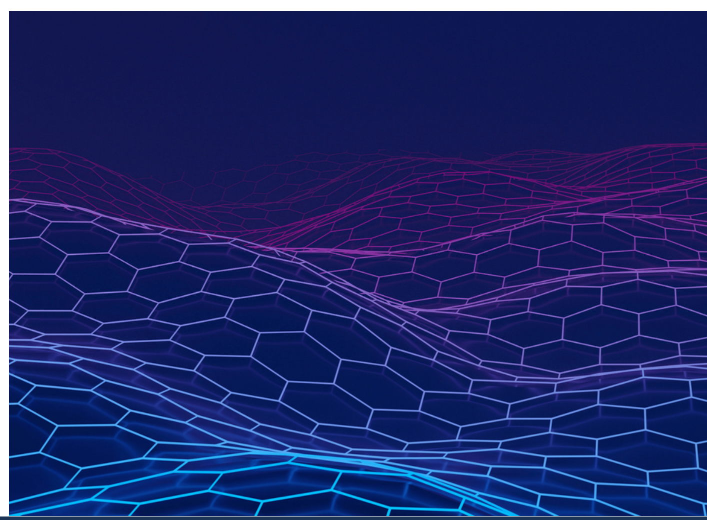


Fig 3. Accuracy of predictions with uncertainty for an input/output pair keeping all other variables fixed.

Furthermore, we can examine accuracy by fixing certain settings and sweeping against a variable of interest, as shown below for feed water flow rate. In addition to high accuracy, Geminus propagates uncertainty throughout the modeling process.



In addition to the high simulation level accuracy, Geminus ML models have the expected fast inferencing time, in this case over 6 orders of magnitude faster than the original simulator. Besides instantaneous what-if-scenario exploration, real-time optimization becomes possible because scanning millions of scenarios is tractable in reasonable time frames. As an example, we can now get recommended power plant settings to reduce fuel use while maintaining power output in a second or less.

Metric	Simulator	Geminus ML Model
Avg Error (for a given output)	-	+/- 0.2%
Query times	300s	150μs

Repeatable production of ML models from high-fidelity simulation changes the digital transformation landscape. Simulation captures the true physics of complex processes in a way that data-only techniques cannot. By capturing those insights while moving them into real-time, it is now possible to optimize operations in motion, rather than stay in the realm of design and planning.

Geminus opens the possibility of real-time optimization and true digital twins to realize the promise of digitalization for power generation.

Geminus

Geminus is an industrial AI optimization platform challenging the AI status quo. Our next-generation predictive intelligence solution fuses measurement data and physics to power resilient and efficient digital twins. This approach enables model creation in hours, rather than months. It's industrial AI, made easy.

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