History and tools of ML

### Case Study: Optimizing F1 Aerodynamic Geometries Exercise 1-1

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In the AWS-F1 case study, machine learning is used to improve aerodynamic design of F1 car wings by combining Design of Experiments (DoE) workflows with regression models to reduce the number of expensive CFD (Computational Fluid Dynamics) simulations. The problem is: how to find the best combination of geometric parameters (like leading edge height, trailing edge height, angles, ground clearance etc.) that maximize downforce (Cz), while keeping the design space feasible and minimizing computational cost.

Traditional DoE methods require many initial CFD runs to sample the entire design space. What’s done here is more efficient: first an initial sample via Latin Hypercube Sampling, then a “greedy inputs” algorithm to select candidate geometries that are far apart in the feature space to maximize coverage. Regression models (OLS, Support Vector Regression, Gaussian Process, XGBoost, and a stacked model) are trained on the sampled data to predict downforce for new geometries.

What ML contributes that humans alone (or standard simulation alone) can’t do (or would take too long): it can predict outcomes for untested geometries, quantify which geometry parameters matter most (feature importance), and guide exploration vs exploitation (choosing when to test high-potential designs vs exploring uncertain regions). Using this workflow, the team converged to an optimal design in 12 iterative CFD runs vs the ~25 that a standard DoE would need.

Source: *https://aws.amazon.com/blogs/machine-learning/optimize-f1-aerodynamic-geometries-via-design-of-experiments-and-machine-learning/*