2019 U.S. DRIVE Highlight

Machine Learning Based Tools Reduce Combustion Chamber Optimization Cycle from Months to Days

Optimization technique combining machine learning and computational simulations shows that it can significantly shrink industrial design cycles for developing advanced automotive engines.

Argonne National Laboratory

The traditional approach to co-designing piston bowl with injection strategy for engines involves multiple iterations of experimental prototyping and testing. More recently, high-fidelity computational simulations together with high performance computing have assumed a much greater significance in engine design optimization. However, traditional virtual optimization approaches combining algorithms, such as design of experiments (DoE) and genetic algorithms (GA) remain time-consuming, due to long simulation runtimes.

Researchers at Argonne National Laboratory developed a novel optimization technique, known as Machine Learning – Genetic Algorithm (ML-GA), which leverages machine learning to speed-up virtual engine design. In this approach, rigorously validated computational fluid dynamics (CFD) simulations are employed to generate the requisite engine data from which Machine Learning (ML)-based surrogate models are developed to predict engine performance as a function of the design parameters. These faster surrogate models are coupled with GA to rapidly optimize the engine design parameters, in terms of maximizing efficiency while satisfying constraints associated with emissions, engine mechanical limits, etc. The surrogate model development methodology utilizes the advanced “Superlearner” technique, which uses multiple ML algorithms (such as Random Forest, Neural Networks, etc.) to obtain better predictive accuracy than any of the constituent learning algorithms alone. In addition, an efficient active learning strategy is used to minimize the simulation data required for training the surrogate model. Argonne researchers demonstrated the novel ML-GA approach for engine design, considering various parameters related to piston bowl geometry, fuel injection, etc. ML-GA reduced time-to-design by 80% (from a few months to a few days) compared to traditional methods. This demonstration was done in collaboration with Aramco researchers on Argonne’s Mira supercomputer.

Argonne researchers, in collaboration with industry partners *Parallel Works* and *Convergent Science*, have now implemented their copyrighted ML-GA software technology in an end-to-end ML workflow (Figure 1). The new workflow, developed under the DOE Technology Commercialization Fund (TCF), can be leveraged by piston engine community.

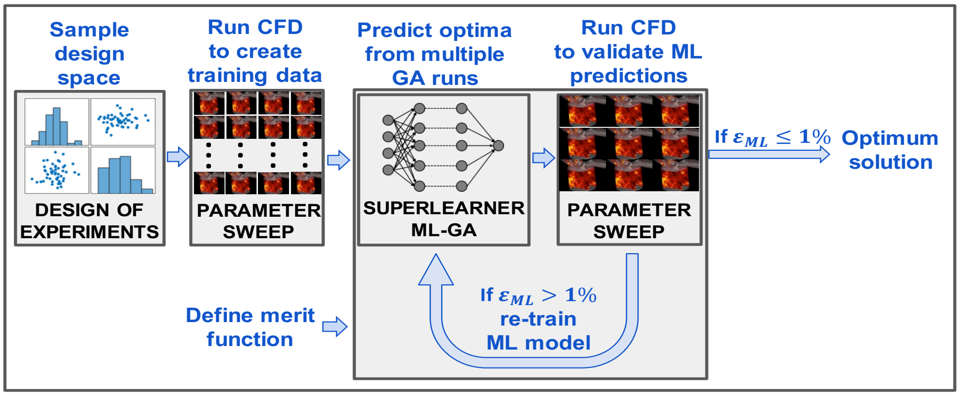

Figure 1: A schematic of the ML-GA workflow for design optimization