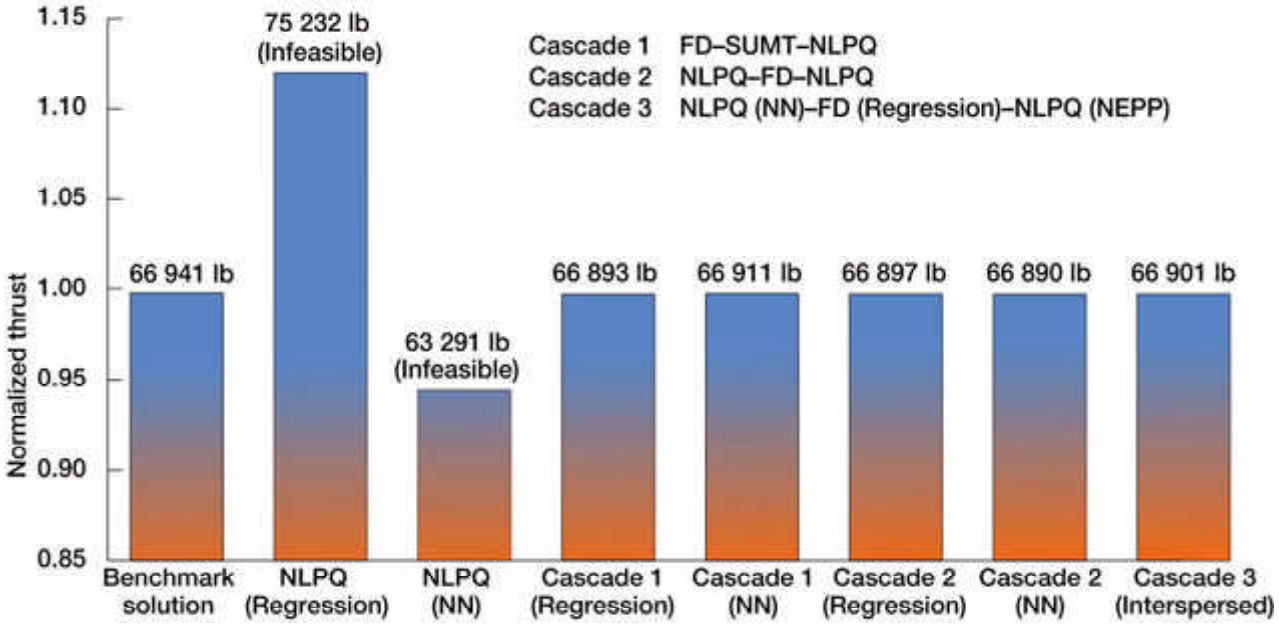
Cascade Optimization Strategy With Neural Network and Regression Approximations Demonstrated on a Preliminary Aircraft Engine Design

A preliminary aircraft engine design methodology is being developed that utilizes a cascade optimization strategy together with neural network and regression approximation methods. The cascade strategy employs different optimization algorithms in a specified sequence. The neural network and regression methods are used to approximate solutions obtained from the NASA Engine Performance Program (NEPP), which implements engine thermodynamic cycle and performance analysis models. The new methodology is proving to be more robust and computationally efficient than the conventional optimization approach of using a single optimization algorithm with direct reanalysis. The methodology has been demonstrated on a preliminary design problem for a novel subsonic turbofan engine concept that incorporates a wave rotor as a cycle-topping device. Computations of maximum thrust were obtained for a specific design point in the engine mission profile. The results (depicted in the figure) show a significant improvement in the maximum thrust obtained using the new methodology in comparison to benchmark solutions obtained using NEPP in a manual design mode.



Optimum thrust for a subsonic wave-rotor-topped engine for the sixth operating point.

Optimization method	Description
Benchmark solution	Average thrust obtained using 10 different initial designs.

NLPQ (Regression)	Thrust obtained using NLPQ and regression approximation.
NLPQ (NN)	Thrust obtained using the quadratic programming algorithm (NLPQ) and the neural network (NN) approximation.
Cascade 1[a] (Regression)	Thrust obtained using the Cascade 1 strategy and the regression approximation.
Cascade 1[a] (NN)	Thrust obtained using the Cascade 1 strategy and the neural network approximation.
Cascade 2 (Regression)	Thrust obtained using the Cascade 2 strategy and the regression approximation.
Cascade 2 (NN)	Thrust obtained using the Cascade 2 strategy (NLPQ-FD-NLPQ) and the neural network approximation.
Cascade 3 (Interspersed)	Thrust obtained using the interspersed cascade strategy (NLPQ with NN, FD with regression, and NLPQ with the NASA Engine Performance Program (NEPP) reanalysis).
[a]The Cascade 1 strategy uses three algorithms: the Method of Feasible Directions (FD) followed by the Sequential Unconstrained Minimization Technique (SUMT) and the quadratic programming algorithm (NLPQ).	

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