Scilight

24 October 2019

Enabling optimization under uncertainty in aerospace design

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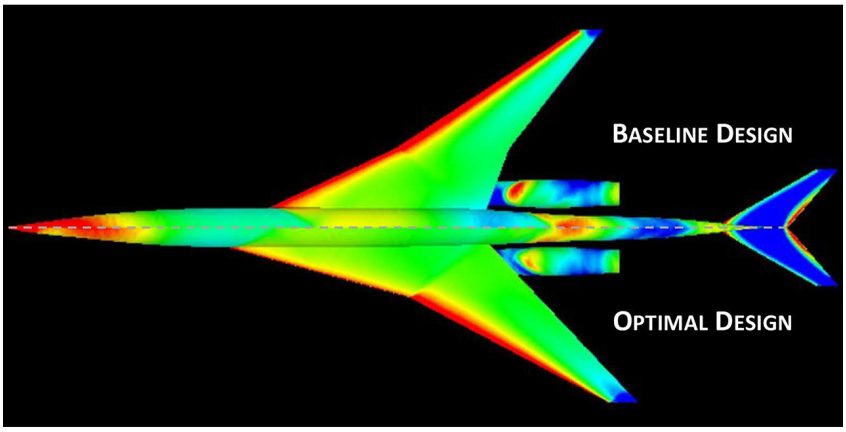
Researchers address a longstanding problem in optimizing aerospace designs under errors and uncertainty.



With an ever-present demand for lighter, faster, more efficient spacecraft, the aerospace industry is in need of optimal design methods. Unfortunately, traditional methodologies are deterministic and don't account for uncertainties in the final product. Such uncertainties – stemming from many sources including operating conditions, manufacturing, and simulation models – may lead to significant differences in expectation versus actual performance, which may lead to catastrophes, such as the Patriot Missile Failure at Dharan, and the Hypersonic Technology Vehicle II accidents.

One major source of such uncertainties stems from the difficulty for existing turbulence models to capture turbulence physics. Specifically, a design optimized using one turbulence model may have sub-optimal performance using a different turbulence model and in reality. In a new study, Cook et al. introduce a design methodology that is robust to turbulence model uncertainty.

The researchers used eigenspace perturbations to determine the uncertainty introduced by turbulence models, then apply robust regularization to find optimal designs that are robust to the uncertainties in different turbulence models. They applied their method to several aerospace design problems and showed that their newly optimized designs were superior to traditional optimal designs in both performance and robustness to turbulence model form uncertainty.

“Aerospace design has an inherent schism at the edge, balanced between optimality versus sensitivity to the slightest variability in operating conditions, simulation results, etc. Too close to this edge and you're not robust. Too far and you're not optimal,” said author Aashwin Mishra. “In essence, our methodology finds the Goldilocks solution. Not too close, not too far, but just right.”

Currently, the authors are working with aerospace industry partners to test this method in industrial design optimization.

Source: “Optimization under turbulence model uncertainty for aerospace design,” by L.W. Cook, A. A. Mishra, J. P. Jarrett, K. E. Willcox, and G. Iaccarino, *Physics of Fluids* (2019). The article can be accessed at https://doi.org/10.1063/1.5118785.