

BAYESIAN OPTIMIZATION OF A LIGHTWEIGHT AND ACCURATE NEURAL NETWORK FOR AERODYNAMIC PERFORMANCE PREDICTION

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Abstract

Ensuring high accuracy and efficiency of predictive models is paramount in the aerospace industry, particularly in the context of multidisciplinary design and optimization processes. These processes often require numerous evaluations of complex objective functions, which can be computationally expensive and time-consuming. To build efficient and accurate predictive models with limited high-fidelity data, we propose a new approach that leverages Bayesian Optimization (BO) to optimize the hyper-parameters of a lightweight and accurate Neural Network (NN) for aerodynamic performance prediction. To clearly describe the interplay between design variables, hierarchical and categorical kernels are used in the BO formulation. We demonstrate the efficiency of our approach through two comprehensive case studies, where the optimized NN significantly outperforms baseline models and other publicly available NNs in terms of accuracy and parameter efficiency. For the drag coefficient prediction task, the Mean Absolute Percentage Error (MAPE) of our optimized model drops from 0.1433% to 0.0163%, which is nearly an order of magnitude improvement over the baseline model. Additionally, our model achieves a MAPE of 0.82% on a benchmark aircraft self-noise prediction problem, significantly outperforming existing models (where their MAPE values are around 2 to 3%) while requiring less computational resources. The results highlight the potential of our framework to enhance the scalability and performance of NNs in large-scale multidisciplinary design optimization problems, offering a promising solution for the aerospace industry.