Literature Survey

Date	21 September 2022
Team ID	PNT2022TMID34417
Project title	Project-Skill/job Recommender Application

Using Machine Learning to Predict Core Sizes of High-Effi ciency Turbofan Engines- Michael T. Tong Year: 2019

With the rise in big data and analytics, machine learning is transforming many industries. It is being increasingly employed to solve a wide range of complex problems, producing autonomous systems that support human decisionmaking. For the aircraft engine industry, machine learning of historical and existing engine data could provide insights that help drive for better engine design. This work explored the application of machine learning to engine preliminary design. Engine coresize prediction was chosen for the first study because of its relative simplicity in terms of number of input variables required (only three). Specifically, machine-learning predictive tools were developed for turbofan engine core-size prediction, using publicly available data of two hundred manufactured engines and engines that were studied previously in NASA aeronautics projects. The prediction results of these models show that, by bringing together big data, robust machinelearning algorithms and data science, a machine learning-based predictive model can be an effective tool for turbofan engine core-size prediction. The promising results of this first study paves the way for further exploration of the use of machine learning for aircraft engine preliminary design.

Multi-Objective Optimization of a Turbofan for an Advanced, Single-Aisle Transport- Jeffrey J. Berton and Mark D. Guynn

Single- and multi-objective optimized solutions are presented for the multidisciplinary design of ultrahigh bypass ratio engines applied to an advanced, notional, single-aisle airplane. NASA’s Subsonic Fixed Wing Project goals serve as optimization objectives. This study is intended to provide independent information to NASA program management to help guide its technology development efforts. Identifying a “best” engine design depends entirely on the metric (s) of interest. The engine design for minimum ramp weight, a traditional aircraft optimization objective, is found to be a high-FPR, high-OPR, direct-drive turbofan. Although its turbomachinery, material selection, cooling, and construction technologies are assumed to be advanced, it may yet be said to be of a conventional architecture. Block fuel, however, is minimized by a strikingly different engine design: a low-FPR, high-OPR, geared UHB turbofan with a variable geometry bypass nozzle. And between these two extremes, an excellent "compromise" engine design exists: a moderate-FPR, high-OPR, geared turbofan that nicely balances the ramp weight and block fuel metrics. This engine also has relatively low community noise and NOX emissions.

Characteristics of the Specific Fuel Consumption for Jet Engines- Artur Bensel

Purpose of this project is a) the evaluation of the Thrust Specific Fuel Consumption (TSFC) of jet engines in cruise as a function of flight altitude, speed and thrust and b) the determina tion of the optimum cruise speed for maximum range of jet airplanes based on TSFC charac teristics from a). Related to a) a literature review shows different models for the influence of altitude and speed on TSFC. A simple model describing the influence of thrust on TSFC seems not to exist in the literature. Here, openly available data was collected and evaluated. TSFC versus thrust is described by the so-called bucket curve with lowest TSFC at the bucket point at a certain thrust setting. A new simple equation was devised approximating the influ ence of thrust on TSFC. It was found that the influence of thrust as well as of altitude on TSFC is small and can be neglected in cruise conditions in many cases. However, TSFC is roughly a linear function of speed. This follows already from first principles. Related to b) it was found that the academically taught optimum flight speed (1.316 times minimum drag speed) for maximum range of jet airplanes is inaccurate, because the derivation is based on the unrealistic assumption of TSFC being constant with speed. Taking account of the influ ence of speed on TSFC and on drag, the optimum flight speed is only about 1.05 to 1.11 the minimum drag speed depending on aircraft weight. The amount of actual engine data was ex tremely limited in this project and the results will, therefore, only be as accurate as the input data. Results may only have a limited universal validity, because only four jet engine types were analyzed. One of the project's original value is the new simple polynomial function to estimate variations in TSFC from variations in thrust while maintaining constant speed and altitude.

ENVIRONMENTALLY RESPONSIBLE AVIATION – REAL SOLUTIONS FOR ENVIRONMENTAL CHALLENGES FACING AVIATION- Fayette Collier, Russell Thomas, Casey Burley, Craig Nickol, Chi-Ming Lee, and Michael Tong

The combined reality of persistently strong growth in air traffic and the vital economic role of the air transport system result in continued demand for the progress of technology for the reduction of aircraft noise, emissions of oxides of nitrogen, and fuel burn. NASA's Environmentally Responsible Aviation (ERA) project has set aggressive goals in these three areas including a noise goal of 42 dB cumulative below the Stage 4 certification level. The goal for the reduction of oxides of nitrogen is 75% below the current standard. The fuel burn reduction goal is 50% below that of a current state-of-the-art aircraft. Furthermore, the overall goal of ERA is to mature technologies that will meet these goals simultaneously and with a timeframe of 2020 for technical readiness. This paper outlines the key technologies and the progress achieved to date toward the goals.

ADAM: A METHOD FOR STOCHASTIC OPTIMIZATION- Diederik P. Kingma , Jimmy Lei Ba

Adam, an algorithm for first-order gradient-based optimization of stochastic objective functions, based on adaptive estimates of lower-order moments. The method is straightforward to implement, is computationally efficient, has little memory requirements, is invariant to diagonal rescaling of the gradients, and is well suited for problems that are large in terms of data and/or parameters. The method is also appropriate for non-stationary objectives and problems with very noisy and/or sparse gradients. The hyper-parameters have intuitive interpret tations and typically require little tuning. Some connections to related algorithms, on which Adam was inspired, are discussed. We also analyze the theoretical convergence properties of the algorithm and provide a regret bound on the convergence rate that is comparable to the best known results under the online convex optimization framework. Empirical results demonstrate that Adam works well in practice and compares favorably to other stochastic optimization methods. Finally, we discuss AdaMax, a variant of Adam based on the infinity norm.