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Author: Mr. Oier del Rey Rodriguez
ISAE-Supaero University of Toulouse, France, oierdelreyrodriguez@gmail.com

Mr. Pedro Chen
ISAE - Institut Supérieur de l'Aéronautique et de l'Espace, France, pedromschen@gmail.com

SURROGATE MODELS FOR OPTIMAL LAUNCHER TRAJECTORY DESIGN

Abstract

The design and optimization of a launcher requires the construction of its optimized ascent trajectory. This trajectory requires, in addition to the physical characteristics of the launcher, the determination and optimization of many control variables. The large number of variables to be optimized and the complexity of the physical models required to build a precise launcher trajectory make this aspect of the design process very computationally expensive. The objective of the present work is to develop surrogate models for the trajectory optimisation to be included in the framework of an MDAO tool for launcher design. This will permit to substantially reduce the computational cost thus allowing large parametric studies, taking into consideration different constraints among which sustainability and reusability. A six degree of freedom (6DOF) physical model for a rigid launcher has been developed. In line with the current trends of the market, reusability and sustainability concerns were also included within these restrictions, assuming a recoverable first stage. The conventional optimization scheme requires the propagation of the mentioned model in each of its iterations, until the solution is reached. Being the 6 DOF model, a complex, high dimensional, non-linear ODE, each iteration is extremely computationally costly on its own. We have explored different methods that are useful to avoid or substantially reduce the amount of launch trajectory propagations and explore the design space more efficiently. Surrogate models, in particular based on deep learning networks, have been identified as suitable candidates to reduce the computational cost of the process, since they approximate the behaviour of a complex system using a simpler function. These models have been trained by using historical launch data available in open-source or by propagating the existing model a reduced number of times, when compared with the conventional methods. Their computational cost, performance, accuracy, and relevance have been evaluated in the end to identify the most suitable model for the desired application.