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Predictive Modelling to Support Design and Manufacturing in Aerospace Engineering

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Abstract

A crucial issue in the design of aircraft components is the evaluation of a large number of potential design alternatives. This evaluation involves too expensive procedures, consequently, it slows down the search for optimal design samples. As a result, a scarce or small number of design samples with high dimensional parameter space will pose issues in the learning of surrogate models. These issues bring the need to investigate methods for surrogate modelling for the most effective use of available data. Furthermore, during the manufacturing of components, it is crucial to monitor (in-situ process monitoring) the welding process for quality assurance. A large amount of process data is generated from these in-situ monitoring methods, which can be used to build prediction models for defects classification. However, the process data are unstructured, and defects are unknown, which brings the need for investigations to address these issues to build defect classification models.

The thesis goal is to support engineers in the early design and manufacturing phases of aircraft engine components via (1) surrogate modelling for the purpose of exploration of larger search spaces and for speeding up the evaluation of design configurations, and (2) defects classification to support in-situ process monitoring to speed up defects' analysis.

The first part of the thesis focuses on addressing challenges in design data when building surrogate models. For this, the thesis explores, evaluates, and improves tree models for design space exploration. The second part of the thesis focuses on addressing challenges in process data when building defect classification models. For this, the thesis (1) investigates the performance of selected handcrafted feature extraction techniques, (2) proposes an oversampling technique to balance process datasets, and (3) proposes an active learning approach for labelling data.

Keywords: surrogate modelling, defects classification, machine learning, aerospace, additive manufacturing