MACHINE LEARNING OF PHYSICAL REDUCED ORDER MODELS FOR FAST LIFETIME COMPUTATION OF TURBINE BLADES WITH UNCERTAINTY QUANTIFICATION

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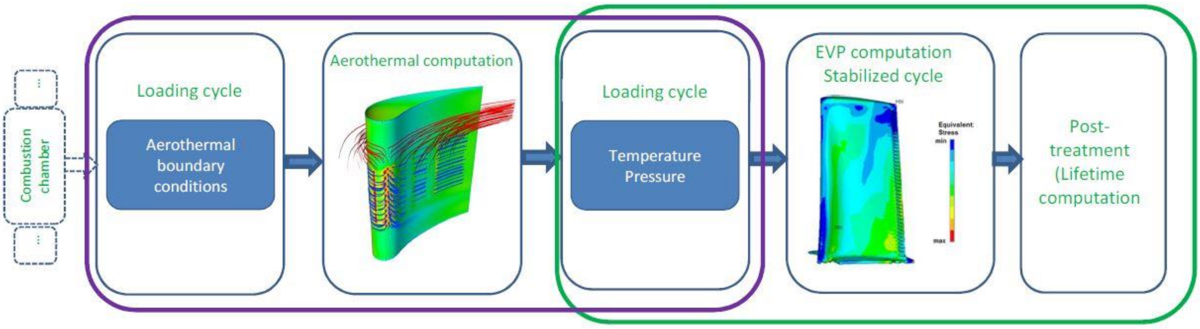

Figure 1: Computation chain for the lifetime prediction of high-pressure turbine blades.

- Reduced-order modelling, hyper-reduction methods
- Machine learning
- Computational mechanics

Abstract:

As in the vast majority of industrial domains, the numerical simulation is a tool used in many stages of Safran's activities. The complexity of the models leads to computation times of several hours (or even days) for a single run, although optimization and uncertainty quantifications require many runs. Hence, new strategies must be found. In this thesis, we are interested in the lifetime prediction of high-pressure turbine blades in aircraft engines. The computation chain contains a coupled aerothermal fluid-solid computation and an ElastoViscoPlastic (EVP) cyclic computation of which the lifetime calculation is a post-treatment (see Figure 1). Boundary conditions for the EVP part are provided by the aerothermal computation.

The objective is to increase the speed of the EVP cyclic part by constructing a dictionary of reduced order models using machine learning tools. The idea is to use neural networks in order to identify a hyper-reduced model which is adapted to the boundary conditions. To do so, a clustering algorithm will be applied to a collection of numerous low-fidelity computations so as to build a dictionary of possible models for lifetime predictions. Then, an efficient criterion based on classification methods taken from data science will be chosen to decide in real time which hyper-reduced model is the best for fast and accurate predictions.

Some theoretical questions will also be addressed, such as the unicity of the stabilized cycle, the conditions for the reduced models to converge towards the stabilized cycle, etc. Finally, the methodology will be applied to an uncertainty quantification study on the lifetime computation of high-pressure turbine blades, for which loading cycles are not accurately known despite having an important influence.