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BAYESIAN MACHINE LEARNING FOR FASTER DESIGN OF COMPOSITE STRUCTURES

Abstract

The design of composite structures is often a time-consuming and costly process which requires simulations supported by test evidence. The performances of composite materials are always affected by uncertainties present in the bulk properties of the raw material, in the manufacturing process, in the operational environments and in the test execution. All these variables lead to a statistical definition of ultimate structural strength, i.e. material allowables. The accuracy of the estimation of these values is highly important in order to guarantee the integrity of the structure. Moreover, the definition of material allowables is extremely important in the design phase which aims to identify maximum efficiency of the material during a given mission of the structure. Given the statistical nature of material allowables, a high number of experimental tests have to be performed for the full mechanical characterization of a new material. This drastically increases the costs and reduces the efficiency of the design phase of a new structure. Different methodologies have been explored in literature by combining simulation-based solutions with a reduced set of test data. In the recent years, some Machine Learning algorithms have been tested by demonstrating to be powerful alternatives to full testing-based or coupled simulation-based solutions. However, all the proposed approaches aim to estimate the allowables of a material given a known allowables of e.g. a subset of laminates. This paper aims instead to estimate the allowables of a new material starting from the knowledge of other certified materials. The approach translates into a non-linear regression over the physical parameters of composite materials with the advantage to leverage from the effort made in the design and certification of previous materials by allowing for a faster design phase of a new programme. The paper proposes the usage of Bayesian methods applied to Machine Learning, which is particularly suitable for the examined case with input, i.e. material data, and output, i.e. allowables, uncertainties. Different testing cases will be explored and validated on a simulated database.