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Metamodel-Based Parameter Design of Static Systems

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Abstract: *When attempting to achieve an improved design of some physical system, the important variables, the "design variables", are manipulated to find the combination that results in the best system performance. Most research deals with cases where design variables are deterministic thus ignoring possible uncertainties present due to manufacturing or environmental conditions. When uncertainty is considered, the design variables follow a particular distribution whose parameters are defined. Parameter design aims to reduce the probability of failure of a system by moving the distribution parameters of the design variables. In this paper, we focus on moving the means of the design variables to search for a reduced failure probability. The most popular method to estimate the probability of failure is a Monte Carlo Simulation where, using the distribution parameters, many design variable combinations are generated and the number of times the corresponding response does not meet specifications is counted. This method, however, can become time-consuming as mechanistic models become increasingly complex. From structural reliability theory, the First Order Reliability Method (FORM) is an efficient method to estimate probability and to search for the parameters that reduce the failure probability. However, if the mechanistic model is too complex or implicit, FORM becomes difficult to use. This paper presents a methodology that uses approximating functions, called 'metamodels', with FORM to search for the design parameters that minimises the probability of failure. The method will be applied to three examples and the accuracy, along with the speed, of the methodology will be discussed.*

Keywords: *Metamodel, Response Surface Model, Kriging, First-Order Reliability Method*