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A Multi-stage, Multi-response Bayesian Methodology for Surrogate Modeling in Engineering Design

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Abstract

To design products, engineers often need a mathematical model of the system behavior as a function of a set of design parameters. Systematic use of such models allows the designer to gain knowledge about the influence of different design parameters on the responses of the system and to search for the best solution to the design problem in terms of a suitable set of performance measures. In practice, however, the designer rarely has a model of the system in the initial stages of the design process and, if such a model is available, it is usually expensive to evaluate and thus unsuited for systematic use in preliminary design. A common approach used in practice to circumvent these problems is the use of metamodels, or surrogate models.

In this project, we propose to extend the multi-stage Bayesian surrogate modeling (MBSM) methodology, an existing framework for building surrogate models of systems with a single, deterministic response variable, to applications with multiple response variables that can be deterministic or stochastic. The proposed extensions will increase the range of applicability of the MBSM methodology to multi-criteria design and optimization of systems, with potential applications in emerging fields such as nanotechnology and life sciences. The extensions will be tested with two design problems of interest to industries in the Commonwealth, namely the design of an infrared sensor array for thermal imaging and the design of bone tissue regeneration therapies. By the end of the funded period, a computational implementation of the methodology will be made available to the public as an open-source application in the MatLab programming language, to facilitate dissemination of the results of this research and its adoption by Commonwealth industries and academia.