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Incorporating Uncertainty and Multi-Criteria into Surrogate Models for Use in Preliminary Design

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Abstract

The design process often determines the total development cost of a product or service. This has motivated intensive research in the early design stages in order to decrease development time and cost and, at the same time, increase product quality. To this end, surrogate models are being used to help reduce modeling costs, but they are used infrequently in the early stages of the design process because the commonly used modeling methodologies cannot accommodate changes in the design space. Therefore, we propose the development of surrogate models that can adapt to changes in the design space for use in the early design stages to help reduce the cost and increase the accuracy of modeling associated with product development. Multi-stage, multi-criteria surrogate models will provide an understanding of the interactions of parameters and their influence on system performance. They increase the value of the information gained through experimentation and reduce the number of experiments needed. These models are constructed and refined based on *a priori* knowledge, numerical simulations, and experimental data. The goal is to provide designers with a robust, flexible, and general framework in which to acquire better models and deeper understanding of the underlying phenomena. This framework enables the construction of multi-stage, multi-criteria Bayesian surrogate models that synergistically integrate knowledge from non-deterministic physical experiments, deterministic numerical simulations, and heuristics. This project focuses on the development of a Bayesian statistical framework for generating surrogate models for engineering design. The proposed Bayesian framework has the potential to benefit a wide community of researchers and practitioners in academia and industry and to contribute to the design and analysis of a broad span of a complex engineered systems ranging from aging infrastructure to emerging fields like bioengineering.