A framework for managing models in nonlinear optimization of computationally expensive functions

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Abstract
One of the most significant problems in the application of standard optimization methods to real-world engineering design problems is that the computation of the objective function often takes so much computer time (sometimes hours) that traditional optimization techniques are not practical. A solution that has long been used in this situation has been to approximate the objective function with something much cheaper to compute, called a "model" (or surrogate), and optimize the model instead of the actual objective function. This simple approach succeeds some of the time, but sometimes it fails because there is not sufficient a priori knowledge to build an adequate model. One way to address this problem is to build the model with whatever a priori knowledge is available, and during the optimization process sample the true objective at selected points and use the results to monitor the progress of the optimization and to adapt the model in the region of interest. We call this approach "model management". This thesis will build on the fundamental ideas and theory of pattern search optimization methods to develop a rigorous methodology for model management. A general framework for model management algorithms will be presented along with a convergence analysis. A software implementation of the framework, which allows for the reuse of existing modeling and optimization software, has been developed and results for several test problems will be presented. The model management methodology and potential applications in aerospace engineering are the subject of an ongoing collaboration between researchers at Boeing, IBM, Rice and College of William & Mary.

Keyword
Mathematics; Computer science

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Bayesian optimization employs the Bayesian technique of setting a prior over the objective function and combining it with evidence to get a posterior function. This permits a utility-based selection of the next observation to make on the objective function, which must take into account both exploration (sampling from areas of high uncertainty) and exploitation (sampling areas likely to offer improvement over the current best observation). We also present two detailed extensions of Bayesian optimization, with experiments—active user modelling with preferences, and hierarchical reinforcement learning. A nonlinear ensemble predictive control algorithm in an artificial pancreas for people with type 1 diabetes. In: European Control Conference (ECC), pp. 2115–2120 (2016). 18. Nezhadali, V., Eriksson, L.: A framework for modeling and optimal control of automatic transmission systems. IFAC-PapersOnLine 48 (15), 285–291 (2015). Article Google Scholar. Generated expressions are encapsulated in function objects that can be evaluated, numerically or symbolically, in virtual machines (VMs). Compared to similar frameworks, CasADi scales well to higher dimensions, and offers a rich set of differentiable operations.