Locating Multiple Candidate Designs with Surrogate-Based Optimization

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In the initial stages of engineering design, optimization problems are formulated to find a candidate design that meets requirements with the best performance. However, even experienced hands often overlook important objective functions and constraints. This paper seeks to ameliorate this problem by exploring methodology to produce multiple local optima providing some insurance against a discovery late in the design process that the supposed optimum design is seriously flawed because of a missed constraint or objective.

With increases in computer power, engineers have been able to shift the focus from finding locally optimum designs to a single global optimum. This usually requires search in multiple regions of design space, expending most of the computation needed to define multiple alternate designs. Thus, focusing solely on locating the best design may be wasteful.

In previous work, we presented a method to locate multiple optima by dynamically partitioning the design space into sub-regions. Optimization was performed in each sub-region using local surrogates (metamodels) to reduce the number of expensive function evaluations. The sub-regions were geometrically formed based on the distance to the nearest center, where the center was the locally best solution. The partitioning of the design space was updated through this movement of the centers, the merging of sub-regions that converged to the same basin of attraction, and the creation of sub-regions in promising regions or to explore the design space. We have previously demonstrated the capabilities of this method at locating multiple candidate designs in a two-dimensional design space with small disjoint regions of feasibility, a six-dimensional analytical function, and a five-dimensional engineering design problem.

In this paper, we consider different methods that take different approaches to locate optima that have in common the use of surrogate predictions to reduce the number of expensive functions. The method that we developed is compared to optimization with a global surrogate that adds multiple points at a time and the Efficient Global Optimization algorithm. It was observed that existing global optimization algorithms have potential to be adapted to locate multiple candidate designs, but the key to efficiency lies in parallelization of optimization processes.