Latin Hypercube Designs for Meta-Model Construction Based on Quasi-Random Sequences

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Abstract

Design of Experiments (DoE) constitutes an essential part in many fields of engineering research. It creates an integral component of Meta-Modeling which is an often used tool for analyses of complex systems usually described by computationally demanding models [Forrester, 2008]. The meta-model is a relatively simple function which replaces the original demanding model and enables multiple evaluations in a fraction of time. It is constructed based on training data: a) the DoE uniformly spread over the solved domain and b) responses of the original model in points selected by the DoE. Then the meta-model is used for an approximation of the original model's response in an arbitrary point of the domain.

Quality of the approximation highly depends on the selected design of experiments. There are many methods for generation of the DoE and many criteria for evaluation of its quality. One of the most efficient ways is employment of the quasi-random sequences [Niederreiter, 1992], where Halton and Sobol sequences are the most popular examples. They ensure two demanded properties, good space-filling as well as low discrepancy.

Another common approach uses the Latin Hypercube Sampling methodology (LHS) which is a method for stratified sampling [McKay, 1979]. Each variable of the problem is divided in advance into the same number of intervals. The LHS rule requires that only one design point lies in each interval of each variable. This condition ensures perfect projection properties needed in cutting out unimportant variables during meta-modeling.

Our recent research suggests that the combination of efficient Halton sequences and the LHS methodology forms a promising method for construction of the DoEs suitable for construction of meta-models.

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