A Projection Space-Filling Criterion and Related Optimality Results

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Abstract

Computer experiments call for space-filling designs. Recently, a minimum aberration type space-filling criterion was proposed to rank and assess a family of space-filling designs including Latin hypercubes and strong orthogonal arrays. It aims at capturing the space-filling properties of a design when projected onto subregions of various sizes. In this paper, we also consider the dimension aside from the sizes of subregions by proposing first an expanded space-filling hierarchy principle and then a projection space-filling criterion as per the new principle. When projected onto subregions of the specific size, the proposed criterion ranks designs via sequentially maximizing the space-filling properties on equally-sized subregions in lower dimensions to higher dimensions, while the minimum aberration type space-filling criterion compares designs by maximizing the aggregate space-filling properties on multidimensional subregions of the same size. We present illustrative examples to demonstrate two criteria and conduct simulations as evidence of the utility of our criterion in terms of selecting efficient space filling designs to build statistical surrogate models. We further consider the construction of the optimal space-filling designs under the proposed criterion. Although many algorithms have been proposed for generating space-filling designs, it is well-known that they often deteriorate rapidly in performance for large designs. In the present paper, we develop some theoretical optimality results and characterize several classes of strong orthogonal arrays of strength three that are the most space-filling.