Statistica Sinica **35** (2025), 1-17
doi:https://doi.org/10.5705/ss.202023.0046

A NEW CLASS OF ORTHOGONAL DESIGNS WITH GOOD LOW DIMENSIONAL SPACE-FILLING PROPERTIES

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Abstract: The space-filling property and orthogonality are perhaps two most desirable design properties for computer experiments. The space-filling property is appropriate for Gaussian process models, while orthogonality allows the estimated effects to be uncorrelated. This paper presents a general approach for constructing a rich class of orthogonal designs with attractive low-dimensional space-filling properties. This is apparently new in the literature. The construction methods are straightforward to implement. Their theoretical supports are established. Moreover, the resulting designs are flexible in the run sizes.

Key words and phrases: Computer experiment, orthogonal design, orthogonality, space-filling property.

1. Introduction

Computer experiments are widely used in many fields to explore complex systems; whereas space-filling designs are popular for such experiments; see, for examples, Fang, Li and Sudjianto (2006) and Santner, Williams and Note (2018). A space-filling design uniformly spreads its points in the design region. The uniformity can be evaluated by distance or discrepancy criteria; see, for examples, Johnson, Moore and Ylvisaker (1990), Fang et al. (2000), Joseph, Gul and Ba (2015), and Wang, Sun and Xu (2022). Many fruitful approaches have been proposed for constructing designs with good space-filling properties. The Latin hypercube design was first introduced by McKay, Beckman and Conover (1979). Owen (1992) and Tang (1993) proposed randomized orthogonal arrays and orthogonal array-based Latin hypercube designs, respectively. More recently, He and Tang (2013) introduced strong orthogonal arrays, and such arrays have been further developed in He and Tang (2014), Liu and Liu (2015), He, Cheng and Tang (2018), Zhou and Tang (2019), Shi and Tang (2020), Tian and Xu (2022), and Wang, Yang and Liu (2022). Mukerjee, Sun and Tang (2014) proposed mappable nearly orthogonal arrays. Note that both strong orthogonal arrays and mappable nearly orthogonal arrays have better space-filling properties than ordinary orthogonal arrays.

Orthogonality is another desirable property for designs of computer experiments. It guarantees that the estimated effects are uncorrelated with each other.

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