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Making Experimental Designs Robust Against Time Trend

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Abstract

In numerous experimental settings, engineers and scientists might be obliged to run their experiments in sequence and so the run order of the experimental units must be taken into account. This paper describes an approach to construct experimental designs such that the main effects, 2-factor interactions and quadratic effects are orthogonal or near-orthogonal to the linear and quadratic trends. Some constructed designs will then be compared with those of John (1990). Some trend-free Box-Behnken designs will also be given.

Keywords: Box-Behnken designs; computer-aided designs; A-optimality; D-optimality; optimality; fractional factorial designs; interchange algorithm; response surface designs; trend-free designs.

1 Introduction

Certain experimenal materials such as food may deteriorate over time and therefore, there is a need for designs which are robust against time trend (or trend-free designs). Consider an experiment to study the effects of processing time, temperature and shear stress caused by pumping on the quality of skim milk powder. The milk for this entire experiment is blended and stored at 4^0C in milk cans. It is used over a week for a series of experimental runs. Because the milk quality will deteriorate over the week, the scientist is keen to have a design whose runs are in a particular order such that its main effects, interactions and quadratic effects are orthogonal or near-orthogonal to the time trend.

Daniel & Wilcoxon (1966) constructed plans for 2^n factorial designs whose main effects are orthogonal to the time trend. Noting the connection between these designs and fold-over designs, John (1990) developed trend-free sequences for both 2^n and 3^n factorials. Atkinson & Donev (1996) developed the first determinant-based algorithm, called BT, to construct

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