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Two-Level Designs within Three-Level Designs

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Much has been written about augmenting preliminary designs for first-order regression with additional runs to support quadratic models. This is a reasonable approach to practical sequential experimentation, allowing an early stop if the preliminary first-order result does not look promising. Central composite designs are especially well-suited to this (Box and Wilson, 1951), as all or part of the factorial portion can be executed first, and the remainder of the design including axial points can be added if the analysis of the early data warrants. A similar strategy is reasonable in the context of experiments in which factors have qualitative levels, where augmentation focuses on factors that are apparently active in the preliminary analysis. Here it makes more sense to focus on preliminary and final designs that have good properties under a qualitative factorial model, rather than a regression model. The ideal solution would be a two-level orthogonal array nested within a three-level orthogonal array.

Here, we examine three-level orthogonal arrays to find subsets of runs that constitute good two-level designs. The assumption being made here is that the experimenter's tentative plan is to complete a three-level factorial experiment, but would like the option of early termination if a small preliminary experiment using two levels of each factor, perhaps those thought a priori to be most different, does not provide promising results. For this purpose, we use the complete collections of three-level orthogonal arrays generated by Schoen, Eendebak and Nguyen (2009). Each three-level array is systematically examined to find the subsets of runs that constitute a non-singular two-level design. From this collection, we identify designs that are Pareto-admissible with respect to the generalized word length of the three-level array, and the Ds criterion and a bias criterion for the two-level subset.

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