Fundamental Strategies to Handle Noise In Experimental Situations

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Introduction

Experimentation is the manipulation of controllable factors (independent variables) at different levels to see their effect on responses (dependent variables) in the face of noise (noise is referred to as unit structure in this paper). In the context of this paper, experimentation is done with the intent of understanding causality represented by the symbolic model Y=*f*(x). Some experimental designs, such as randomized complete block designs, are more effective in understanding both design factor effects **and** noise effects. The efficiency and effectiveness of an experimental design is a function of how noise is handled during the experiment. Noise is the set of factors one is unwilling to manage or control. This may be for reasons of convenience, difficulty or cost. Robustness is the consistent performance of products or processes in the face of changing noise. In order to understand robustness, noise must be included *and* must vary in the experimental studies (i.e., not held constant). The identification and understanding of noise is an opportunity to increase the robustness of products and processes.

There are a number of ways to estimate or *manage* noise during the execution of an experiment. Tests of significance (e.g., F-test) are comparisons between the factors explicitly manipulated in an experiment (herein referred to as design factors) and the factors that change during the experiment but are NOT explicitly manipulated (herein referred to as unit structure). The recommended strategy is to partition the unit structure in some sensible way to allow for better precision in detecting design factor effects and also to allow for estimation of the noise effects. This needs to be done while not compromising the ability to extrapolate the results (i.e., negatively affecting the inference space of the study). A host of techniques such as blocking, efficiency split-plots, cross-product arrays and nesting are effective at accomplishing this. Selection of which technique to use is dependent on the situation.

The focus of this paper will be on two fundamental strategies to handle noise in a designed experiment, repeats and replicates. These approaches will be illustrated with a hypothetical situation where two variables (X1 and X2) are the factors manipulated in a designed experiment.

The intent is to:

- clarify the differences in strategies,
- describe the mechanics of using each strategy,
- explain how each strategy estimates the effect of noise,
- provide guidance as to when each strategy is applicable, and
- demonstrate the differences with a data set.

The target audience for this paper is individuals applying experimentation to the fields of science and

engineering.