

Design of Experiments for Simulation Modeling

Overview

Simulation models often have many input factors and determining which ones have a significant impact on performance measures (responses) of interest can be a truly daunting task. The common approach of changing one factor at a time is very often incorrect, because for many models factors interact to impact on the responses. In this 3.5-day course we give a comprehensive presentation of design of experiments (DOE) specifically for simulation modeling, whose major goal is to determine which factors have the greatest effect on the responses. Another important use of DOE is to develop a metamodel (a simplified model of the simulation model) based on the important factors to predict the model response for factor-level combinations that were not actually simulated because a prediction is needed in real time or because of execution-time constraints. A metamodel can also be used to find the factor combination that optimizes a simulation response.

We discuss a simple and widely applicable approach for determining significant factors in the context of simulation modeling. Methods designed for physical experiments, which are discussed in university courses and implemented in statistical software, make assumptions (monotonic responses, normal errors, lack of higher-way interactions, etc.) that are rarely satisfied in practice. Students will analyze simulation-response data in class using a leading DOE software package, and be prepared to apply their knowledge the following week at work.

Each attendee will receive a copy of the book *Simulation Modeling and Analysis* (6th Edition, McGraw-Hill, 2024) by Dr. Averill M. Law as part of their registration fee – this book is widely considered to be the “bible” of simulation with more than 171,000 copies sold and 25,650 citations. Versions of this seminar have been presented to Australian Department of Defence (2 times), Lockheed Martin, Middle East Technical University / Roketsan (Turkey), Military Operations Research Society (4 times), Sasol Technology (South Africa), and the U.S. Navy (2 times).

Outline

1. Factorial Designs

- Determining which factors have the largest impact on the simulation responses (factor screening or sensitivity analysis)
- Main effects and interaction effects and their correct interpretation
- Why the ubiquitous one-factor-at-a-time approach can provide misleading results
- Failure of classical statistical assumptions and how to circumvent this in simulation modeling

2. Fractional Factorial Designs

- Finding the important factors with less computational effort
- Confounding of effects
- Resolution III, IV, V, and higher-level designs
- Minimum-run designs
- Difficulties when three or higher-way interactions are present

3. Metamodels and Response Surfaces

- Central composite designs
- Metamodels based on quadratic or cubic regression models
- Predicting model responses for factor combinations that were not simulated
- Finding the factor-level combination that optimizes a simulation response

4. Metamodels for Simulation Modeling

- Latin hypercube designs
- Metamodels based on Kriging (Gaussian process models) or neural networks
- Recommendations on best designs and metamodels

5. Critical Dangers of Using Standard Designs and Analyses for Simulation Modeling

6. Commercial Statistics/DOE Software Appropriate for Simulation

7. Numerous Examples to Illustrate the Calculations for and Applications of DOE