

Simulation Modeling for Better Decision-Making, II: Cutting-Edge Techniques

Overview

This course will discuss practical and easy-to-understand statistical techniques for comparing alternative system designs, the use of AI/machine learning (ML) to develop and analyze simulation models, experimental design techniques for determining important system factors, agent-based simulation, simulation-based optimization, and digital twins. The course can have two formats: (1) A two-day continuation of the “Fundamental Principles” course or (2) a stand-alone three-day course that presents a comprehensive treatment of all advanced simulation techniques. The prerequisite for this seminar is the “Fundamental Principles” course or equivalent knowledge, particularly, for the topic “Designing and Analyzing Simulation Experiments.” This course has also been presented hundreds of times worldwide.

Outline

1. Advanced Techniques for Output-Data Analysis

- Analyzing steady-state simulations
- Estimating probabilities and percentiles
- Dealing with multiple measures of performance

2. Comparing Alternative System Designs

- Confidence intervals for comparing two or more system designs
- Using the variance-reduction technique common random numbers to obtain more precise comparisons

3. Impact of AI/ML on Simulation Modeling and Vice Versa

- Using large language models (LLMs) such as ChatGPT to assist in model building
- Using ML to create “entities” whose latency depends on the entities’ attributes
- Using a ML algorithm in a simulation model as a surrogate for a set of complex rule-based logic
- Using reinforcement learning and simulation-generated data to make a set of sequential decisions in an optimal way

4. Design of Experiments for Simulation Modeling

- Identifying the simulation input factors that have the largest impact on performance measures of interest
- Developing a fast-executing surrogate model (metamodel) for making on-the-fly predictions of system performance

5. Agent-Based Simulation

- What is agent-based simulation and for what applications is it ideally suited
- Fundamental relationship to discrete-event simulation
- Available simulation software and toolkits
- Demonstration and analysis of an agent-based simulation model

6. Simulation-Based Optimization

- How the integration of optimization modules into simulation software has added a whole new dimension to simulation modeling
- Live optimization of a model with seven decision variables

7. Detailed Discussion of Digital Twins

- A digital representation of an existing process or system that is fed with system data on a regular basis using software systems [e.g., Manufacturing Execution System (MES) and Engineering Resource Planning (ERP)] and the Internet of Things (IoT) (containing, for example, sensor data)
- Can monitor the operation of the real system to determine when a problem occurs
- Can simulate into the future to see the effect of changes to the system
- Validation of a digital twin
- Applications to manufacturing systems, hospitals, supply chains, military scenarios, and more