Interaction Effects in the Design of Computer Simulation Experiments for Architecting Systems-of-Systems

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ABSTRACT

This paper demonstrates the applicability and benefits of optimal design of experiments (ODOE) for architecting systems-of-systems (SoSs). All experiments depend on appropriate models for their design and analysis. In keeping with the sparsity-of-effects principle, a general linear model with main-effects-plus-two-factor-interactions (MEPTFI) is assumed to realistically characterize the relationship between the SoS elements and the response of interest. The designed experiment requires additional simulations to account for the two-factor interaction effects, and the main effects cannot be interpreted as defining the optimal solution. The optimal performance architecture is determined by optimizing the fitted MEPTFI model. The proposed method is applied to the problem of architecting a SoS to protect against small boat attacks. A statistical analysis confirms that the MEPTFI model has excellent predictive capability. It also proves the fallacy of the applicability of the standard Taguchi method for architecting SoSs by demonstrating that it gives misleading results because of the omission of active interactions. The ODOE method can be implemented using commercially available general-purpose statistics software. Given its mathematical formulation, it can be generalized to solve systems engineering and architecting problems that require complex models beyond the MEPTFI model. © 2014 Wiley Periodicals, Inc. Syst Eng 17: 426–441, 2014

Key words: interaction effects; maritime terrorism; optimal design of experiments; orthogonal array experiment; system-of-systems architecting; Taguchi method

1. INTRODUCTION

Design of experiments (DOE) is a structured approach to designing and analyzing experiments in which purposeful changes are made to multiple input variables (or factors) to efficiently investigate the effects on an output variable (or

response) [Kleijnen et al., 2005]. It has a long and illustrious history since Fisher [1926] founded the underlying principles of design and statistical analysis of designed experiments in the 1920s and early 1930s. Montgomery [2012: 22] notes that "There is not a single area of science and engineering that has not successfully employed statistically designed experiments." The early applications principally used 2-level full factorial and fractional factorial designs (FFDs). Full factorial designs consider all combinations of factors and an experiment with k 2-level factors require 2^k runs. FFDs drop some of the factorial combinations to reduce the number of runs,

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Engineering Offshore Oil and Gas Security and Protection Transportation and Policy Making   <u>Statistical Theory and Method Abstracts</u> ,1968   **The Design and Analysis of Computer Experiments** Thomas J. Santner,Brian J. Williams,William I. Notz,2019-01-08 This book describes methods for designing and analyzing experiments that are conducted using a computer code a computer experiment and when possible a physical experiment Computer experiments continue to increase in popularity as surrogates for and adjuncts to physical experiments Since the publication of the first edition there have been many methodological advances and software developments to implement these new methodologies The computer experiments literature has emphasized the construction of algorithms for various data analysis tasks design construction prediction sensitivity analysis calibration among others and the development of web based repositories of designs for immediate application While it is written at a level that is accessible to readers with Masters level training in Statistics the book is written in sufficient detail to be useful for practitioners and researchers New to this revised and expanded edition An expanded presentation of basic material on computer experiments and Gaussian processes with additional simulations and examples A new comparison of plug in prediction methodologies for real valued simulator output An enlarged discussion of space filling designs including Latin Hypercube designs LHDs near orthogonal designs and nonrectangular regions A chapter length description of process based designs for optimization to improve good overall fit quantile estimation and Pareto optimization A new chapter describing graphical and numerical sensitivity analysis tools Substantial new material on calibration based prediction and inference for calibration parameters Lists of software that can be used to fit models discussed in the book to aid practitioners   *Library of Congress Catalog* Library of Congress,1970 Beginning with 1953 entries for Motion pictures and filmstrips Music and phonorecords form separate parts of the Library of Congress catalogue Entries for Maps and atlases were issued separately 1953 1955   **The National Union Catalogs, 1963-** ,1964   <u>Papers and Reports - International Conference of Agricultural Economists</u> ,1974   **Computer Simulation of Human Behavior** John M. Dutton,William H. Starbuck,1971   *Current Issues in Computer Simulation* Nabil R. Adam,Ali Dogramaci,2014-05-09 Current Issues in Computer Simulation is a collection of papers dealing with computer simulation languages statistical aspects of simulation linkage with optimization and analytical models as well as theory and application of simulation methodology Some papers explain the General Purpose Simulation System GPSS a programming package incorporating a language to simulate discrete systems and the SIMSCRIPT a general purpose simulation language using English commands for example FORTRAN Another simulation language is the General Activity Simulation Program GASP providing for an organizational structure to build models to simulate the dynamic performance of systems on a digital computer Other papers discuss simulation models of real systems including corporate simulation models multistage consumer choice process determination of maximum occupancy for hospital facilities and the juvenile court system Many computer simulations are statistical sampling experiments performed on a model of the system under investigation Other

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