

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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The Design of Computer Simulation Experiments Design of Computer Simulation Experiments Symposiu, *The Design of Computer Simulation Experiments* Thomas H. Naylor,1969 **PAPERS PRESENTED AT A SYMPOSIUM ON THE DESIGN OF COMPUTER SIMULATION EXPERIMENTS.** , *The Design of Computer Simulation Experiments* Institute of Management Sciences. College on Simulation and Gaming,Duke University,1969 Compilation of conference papers on methodology for designing computer simulation experiments defines a number of specific design problems describes several techniques for data analysis of data generated by the experiments and includes applications etc Graphs and references Conference held in durham 1968 October 14 to 16 Computer Simulation Dragan Cvetković,2017-06-07 The first chapter provides an overview of the development of a novel agent based simulation model of socio environmental innovation diffusion The second chapter shows the study about rendering of colours with three rendering engines The third and fourth chapters are devoted to modelling clothes at different levels The fifth chapter describes the modelling of computer simulation in the optimization of bioprocess technology Chapters 6 and 7 formulate a physical model of deformation of steel and idea of constructing a scientific workshop focused on high temperature processes Chapter 8 formulates surrogate models Chapter 9 shows computer simulation of high frequency electromagnetic fields Chapter 10 proposes the modelling of the task allocation problem by the use of Petri Nets Chapter 11 presents various scenarios whose ranking is done according to defined criteria and weight coefficients **NBS Special Publication** ,1968 Hypothesis-Driven Simulation Studies Fabian Lorig,2019-08-16 Fabian Lorig develops a procedure model for hypothesis driven simulation studies which supports the design conducting and analysis of simulation experiments It is aimed at facilitating the execution of simulation studies with regard to the replicability and reproducibility of the results In comparison to existing models this approach is based on a formally specified hypothesis Each step of the simulation study can be adapted to the central hypothesis and performed in such a way that it can optimally contribute to the verification and thus to the confirmation or rejection of the hypothesis **Biomedical Index to PHS-supported Research** ,1990 *Operations Research Using Personal Computers* University of Michigan. Engineering Summer Conferences,1984 Health Care Evaluation Using Computer Simulation Boris Sobolev,Victor Sanchez,Lisa Kuramoto,2012-07-12 The purpose of this book is to place computer simulation studies within the paradigm of intervention research that is concerned with comparing the outcomes of health care delivered under different policies This book presents computer simulation as a tool for testing various policy alternatives that have been developed by decision makers within health care systems This approach differs from the use of computer simulation in operations research where simulation helps determine the configurations of a system that will allow it to function optimally Although simulation of health care processes is not new few health care systems have used simulations as a basis for re engineering the delivery of health services There is growing appreciation that the complexity of health care processes

exceeds the capacity of individual disciplines health services research health economics or operations research to guide health care reform In this book the authors focus on bringing the methodological rigor of evaluative research to the design and analysis of such simulation studies The book is intended as a reference for health services researchers It offers a comprehensive description of the methodology of conducting simulation studies in evaluation of service alternatives in surgical care using discrete event models including the steps for identifying the clinical and managerial activities of the perioperative process determining the model requirements implementing simulation models designing simulation experiments and analyzing the experimental data and interpreting and reporting results The book also offers examples of specific aspects of conducting simulation experiments how to determine the number of runs needed to estimate the effect of implementing a health care policy how to allocate the number of runs to study groups in simulation experiments aiming to evaluate policy or management alternatives and how to use statistical analysis to estimate interpret and report effect sizes

Design and Analysis of Simulation Experiments Jack P.C. Kleijnen, 2007-11-15 Simulation is a widely used methodology in all Applied Science disciplines This textbook focuses on this crucial phase in the overall process of applying simulation and includes the best of both classic and modern methods of simulation experimentation This book will be the standard reference book on the topic for both researchers and sophisticated practitioners and it will be used as a textbook in courses or seminars focusing on this topic *The Design and Analysis of Computer Experiments* Thomas J. Santner, Brian J. Williams, William I. Notz, 2013-03-09 In the past 15 to 20 years the computer has become a popular tool for exploring the relationship between a measured response and factors thought to affect the response In many cases scientific theories exist that implicitly relate the response to the factors by means of systems of mathematical equations There also exist numerical methods for accurately solving such equations and appropriate computer hardware and software to implement these methods In many engineering applications for example the relationship is described by a dynamical system and the numerical method is a finite element code In such situations these numerical methods allow one to produce computer code that can generate the response corresponding to any given set of values of the factors This allows one to conduct an experiment called a computer experiment to explore the relationship between the response and the factors using the code Indeed in some cases computer experimentation is feasible when a properly designed physical experiment the gold standard for establishing cause and effect is impossible For example the number of input variables may be too large to consider performing a physical experiment or it may simply be economically prohibitive to run an experiment on the scale required to gather sufficient information to answer a particular research question This book describes methods for designing and analyzing experiments conducted using computer code in lieu of a physical experiment It discusses how to select the values of the factors at which to run the code the design of the computer experiment in light of the research objectives of the experimenter It also provides techniques for analyzing the resulting data so as to achieve these research goals **Off-road Mobility Research** Cornell

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web jun 15 2018 bee venom is a very complex mixture of natural products extracted from honey bee which contains various pharmaceutical properties such as peptides enzymes biologically active amines and nonpeptide components the use of bee

venom into the specific points is so called bee venom therapy which is widely used as a [bee venom overview of main compounds and bioactivities for](#) - Apr 11 2023

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web aug 18 2022 if you ve had a reaction to bee stings that suggests you might be allergic to bee venom your doctor may suggest one or both of the following tests skin test during skin testing a small amount of allergen extract in this case bee venom is injected into the skin of your arm or upper back

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web a bee sting is the wound and pain caused by the stinger of a female bee puncturing skin bee stings differ from insect bites with the venom of stinging insects having considerable chemical variation the reaction of a person to a bee sting may vary according to

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web aug 18 2022 to sting a bee jabs a barbed stinger into the skin bee sting venom contains proteins that affect skin cells and the immune system causing pain and swelling around the sting area in people with a bee sting allergy bee venom can trigger a more serious immune system reaction risk factors you re at increased risk of bee stings if

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web apitoxin or bee venom is the venom produced by the honey bee it is a cytotoxic and hemotoxic bitter colorless liquid containing proteins which may produce local inflammation it may have similarities to sea nettle toxin 1 components bee venom is a complex mixture of proteins and smaller molecules