Application of Orthogonal Experimental Design on Reliability and Sensitivity Analysis

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Abstract. In the present paper, the effects of four structural parameters at three levels on the reliability and sensitivity of structure are investigated. Sensitivity of parameters is achieved by the range analysis and the significance of parameters is achieved by the variance analysis. A response surface based on orthogonal experimental design and finite element calculations is elaborated so that the relation between the random input variables and structural responses could be established. The First-Order Reliability Method (FORM) as an approximated method is used here to assess the reliability. Comparing with the results of Monte Carlo simulations by ANSYS for a numerical example, the effect of sensitivity analysis has been proved, while the precision of the reliability and sensitivity should be improved in the future.

Introduction

Although the reliability analysis and sensitivity analysis serve different aims, in practice, the implementation of the reliability analysis and that of the sensitivity analysis are very closely connected on both a conceptual and a computational level [1]. All of the methods used in reliability and sensitivity analysis can be divided into three: analysis methods, such as FORM, which depend on the explicit limit state function; stochastic FE methods, such as Monte Carlo simulations (MCs) [2], which is good precision but time-consuming; Response Surface (RS) method based on quick response model, such as Neural Network (NN)-based RS method, which has good generalization ability and time-saving.

Orthogonal experimental design is formulated in a way that minimizes the number of experiments so that the experimental cost can be saved [3]. Each experiment is conducted with the predefined combination of different levels of variables, and the performance of each individual variable can be calculated separately providing it is independent of the other variables. Because of its advantages, it has been widely used in design optimization [4], sensitivity [5,6] and reliability analysis [7].

In the present paper, Orthogonal Experimental Design (OED), Finite Element Simulations, RS and FORM compose the successive stage of the reliability and sensitivity assessment methodology. Sensitivity of parameters is achieved by the range analysis and the significance of parameters is achieved by the variance analysis. RS function of second order polynomial is obtained using least squares regression method. FORM is used here for the reliability index and the reliability probability. Finally, the feasibility and validity of this methodology are checked by the Monte Carlo simulations (MCs) by ANSYS.

Sensitivity Analysis

Sample Preparation for OED. As shown in Fig. 1, the model consists of two different materials, which is fixed at the bottom and applied the uniform pressure on the upper surface. The elastic modulus and Poisson's ratios of structure E_1, E_2, μ_1, μ_2 are input stochastic variables as Gaussian distribution with $E_1 = (200, 30)$GPa, $E_2 = (242, 37.5)$GPa, $\mu_1 = (0.3, 0.03)$, $\mu_2 = (0.35, 0.035)$. The input samples are designed as four factors with each at three levels, i.e. parameters are sampled only with μ and

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Advances in Mechanical Transmission: Innovations and Applications Shuxin Wang,Datong Qin,Fei Liu,2026-02-10 This book compiles cutting edge research from the 2025 International Conference on Mechanical Transmission ICMT 2025 systematically exploring theoretical breakthroughs and industrial innovations in mechanical transmission The content spans new transmission theories and modeling methods e g digital twin driven lifecycle design smart materials composites polymers green manufacturing technologies and AI integrated optimization strategies for transmission systems The book focuses on addressing core challenges such as fatigue reliability NVH Noise Vibration and Harshness behavior and energy efficiency improvement while showcasing industrial applications of smart gears and bearings predictive maintenance algorithms and sustainable lubrication technologies The content uniquely integrates a precision green intelligent manufacturing paradigm offering interdisciplinary solutions For example it demonstrates closed loop optimization of transmission systems from design to testing via digital twin technology and enhances the reliability of industrial robots and wind turbines through AI driven fault diagnosis Bridging academia and industry this book supports the development of efficient low noise and low carbon next generation transmission systems for aerospace new energy vehicles marine equipment and beyond *Wavelet Analysis And Its Applications, And Active Media Technology - Proceedings Of The International Computer Congress 2004 (In 2 Volumes)* John Daugman,Victor Wickerhauser,Bruno Torresani,John Yen,Ning Zhong,Sankar Kumar Pal,Yuan Yan Tang,Jiming Liu,Xiuwen Yang,2004-05-04 Wavelet analysis and its applications have been one of the fastest growing research areas in the past several years Wavelet theory has been employed in numerous fields and applications such as signal and image processing communication systems biomedical imaging radar and air acoustics Active media technology is concerned with the development of autonomous computational or physical entities capable of perceiving reasoning adapting learning cooperating and delegating in a dynamic environment This book captures the essence of the state of the art in wavelet analysis and its applications and active media technology At the Congress invited talks were delivered by distinguished researchers namely Prof John Daugman of Cambridge University UK Prof Bruno Torresani of INRIA France Prof Victor Wickerhauser of Washington University USA Prof Ning Zhong of the Maebashi Institute of

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integrated model of normal academic and organizational knowledge creation called Nanatsudaki seven waterfalls Model The second part presents computational intelligence tools for knowledge acquisition by machine learning and data mining for debating brainstorming for roadmapping and for integrated support of academic creativity The third part presents the use of statistics for creativity support virtual laboratories gaming and role playing for creativity support methods of knowledge representation and multiple criteria aggregation distance and electronic learning The last part addresses knowledge management and philosophical issues and contains chapters on management of technology and knowledge management for academic R and D on knowledge management and creative holism or systems thinking in the knowledge age on technology and change or the role of technology in knowledge civilisation on the emergence of complex concepts in science and the final chapter on summary and conclusions including a proposal of an integrated episteme of constructive evolutionary objectivism necessary for the knowledge civilization age *Environmental Protection and Sustainable Development* Fauziah Shahul Hamid,Seung Bok Choi,Li Yuan Han,2014-02-06 Selected peer reviewed papers from the 2013 2nd International Conference on Sustainable Energy and Environmental Engineering ICSEEE 2013 28 29 December 2013 Shenzhen China **Quality by Experimental Design** Thomas B. Barker,1985 **APPLIED DESIGN OF EXPERIMENTS AND TAGUCHI METHODS** K. KRISHNAIAH,P. SHAHABUDEEN,2012-01-18 Design of experiments DOE is an off line quality assurance technique used to achieve best performance of products and processes This book covers the basic ideas terminology and the application of techniques necessary to conduct a study using DOE The text is divided into two parts Part I Design of Experiments and Part II Taguchi Methods Part I Chapters 1 8 begins with a discussion on basics of statistics and fundamentals of experimental designs and then it moves on to describe randomized design Latin square design Graeco Latin square design In addition it also deals with statistical model for a two factor and three factor experiments and analyses 2k factorial 2k m fractional factorial design and methodology of surface design Part II Chapters 9 16 discusses Taguchi quality loss function orthogonal design objective functions in robust design Besides the book explains the application of orthogonal arrays data analysis using response graph method analysis of variance methods for multi level factor designs factor analysis and genetic algorithm This book is intended as a text for the undergraduate students of Industrial Engineering and postgraduate students of Mechtronics Engineering Mechanical Engineering and Statistics In addition the book would also be extremely useful for both academicians and practitioners KEY FEATURES Includes six case studies of DOE in the context of different industry sector Provides essential DOE techniques for process improvement Introduces simple graphical methods for reducing time taken to design and develop products Computer Applications in the Automation of Shipyard Operation and Ship Design, V P. Banda,Chengi Kuo,G. Di Filippo,1985

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