

A new reliability based optimization of tuned mass damper parameters using energy approach

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Abstract

In this work a reliability based optimization (RBO) strategy of Tuned Mass Damper (TMD) parameters is presented. The strategy is based on an energetic approach. The strategy consists to optimize the TMD parameters so that we minimize the failure probability (objective function) characterized by the exceedence of the power dissipated in the primary structure of a certain threshold value during some interval time. The evaluation of the objective function is carried out using the classical Rice's formula. The strategy is, firstly, applied to linear single-degree of freedom (SDOF) system, subjected to seismic motion, and then extended to linear multi-degree of freedom (MDOF) system. The use of the Rice's formula requires the knowledge of the joint probability density function (PDF) of the considered processes; to this end, exact expression of the joint PDF is presented for the SDOF system and an approximation is presented for the evaluation of the failure probabilities for the MDOF system. By making use of the obtained joint PDF, for the SDOF system, as the a priori joint PDF, the approximation of the joint PDF, for the MDOF system, has been performed using the Minimum cross-entropy method (MinxEnt).

To highlight the good effectiveness of the proposed strategy, a ten-story shear building, subjected to different earthquakes, is considered. The obtained results are compared with other from literature, and it has been shown the superiority of the proposed strategy.

Keywords

Reliability based optimization of TMD, energy approach, joint PDF of non-Gaussian processes, Rice's formula, minimum cross-entropy

1. Introduction

Many researchers have shown interest in passive control using tuned mass damper (TMD) in randomly driven linear structure in recent years (Li et al., 2010; Marano and Greco, 2010; Marano et al., 2007, 2008; Morga and Marano, 2013; Tigli, 2012; Yu et al., 2013; Zuo, 2009; Mishra et al., 2013b; Xiang and Nishitani, 2014; Casciati and Giuliano, 2009). The interest is particularly focused on the optimization of the TMD parameters when the primary structure is subject to Gaussian stationary stochastic loadings. In most works, the TMD optimization is carried out by minimizing some objective function explicitly related to the displacement response of the primary structure (Adam and Furtmüller, 2010). In the literature, among the existent optimization strategies (see for example

Marano et al., 2010 and Mrabet et al., 2015), one can cite: (1) the stochastic structural optimization problem (SSO), where the root mean square displacement of the primary structure is minimized (Chakraborty and

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Metaheuristics and Optimization in Civil Engineering Xin-She Yang, Gebrail Bekdaş, Sinan Melih Nigdeli, 2015-12-10

This timely book deals with a current topic i.e. the applications of metaheuristic algorithms with a primary focus on optimization problems in civil engineering. The first chapter offers a concise overview of different kinds of metaheuristic algorithms explaining their advantages in solving complex engineering problems that cannot be effectively tackled by traditional methods and citing the most important works for further reading. The remaining chapters report on advanced studies on the applications of certain metaheuristic algorithms to specific engineering problems. Genetic algorithm bat algorithm cuckoo search harmony search and simulated annealing are just some of the methods presented and discussed step by step in real application contexts in which they are often used in combination with each other. Thanks to its synthetic yet meticulous and practice oriented approach the book is a perfect guide for graduate students researchers and professionals willing to applying metaheuristic algorithms in civil engineering and other related engineering fields such as mechanical transport and geotechnical engineering. It is also a valuable aid for both lectures and advanced engineering students.

Harmony Search Algorithm Javier Del Ser, 2017-01-20. This book presents state of the art technical contributions based around one of the most successful evolutionary optimization algorithms published to date. Harmony Search Contributions span from novel technical derivations of this algorithm to applications in the broad fields of civil engineering energy transportation mobility and health among many others and focus not only on its cross domain applicability but also on its core evolutionary operators including elements inspired from other meta heuristics. The global scientific community is witnessing an upsurge in groundbreaking new advances in all areas of computational intelligence with a particular flurry of research focusing on evolutionary computation and bio inspired optimization. Observed processes in nature and sociology have provided the basis for innovative algorithmic developments aimed at leveraging the inherent capability to adapt characterized by various animals including ants fireflies wolves and humans. However it is the behavioral patterns observed in music composition that motivated the advent of the Harmony Search algorithm a meta heuristic optimization algorithm that over the last decade has been shown to dominate other solvers in a plethora of application scenarios. The book consists of a selection of the best contributions presented at ICHSA a major biannual event where leading global experts on meta heuristic optimization present their latest findings and discuss the past present and future of the exciting field of Harmony Search optimization. It provides a valuable reference resource for researchers working in the field of optimization meta heuristics and a solid technical base for frontline investigations around this algorithm.

[Proceedings of 6th International Conference on Harmony Search, Soft Computing and Applications](#) Sinan Melih Nigdeli, Joong Hoon Kim, Gebrail Bekdaş, Anupam Yadav, 2020-11-16. This book covers different aspects of real world applications of optimization algorithms. It provides insights from the Sixth International Conference on Harmony Search Soft Computing and Applications held at

Istanbul University Turkey in July 2020 Harmony Search HS is one of the most popular metaheuristic algorithms developed in 2001 by Prof Joong Hoon Kim and Prof Zong Woo Geem that mimics the improvisation process of jazz musicians to seek the best harmony The book consists of research articles on novel and newly proposed optimization algorithms the theoretical study of nature inspired optimization algorithms numerically established results of nature inspired optimization algorithms and real world applications of optimization algorithms and synthetic benchmarking of optimization algorithms

Design and Modeling of Mechanical Systems - II Mnaouar Chouchane, Tahar Fakhfakh, Hachmi Ben Daly, Nizar Aifaoui, Fakher Chaari, 2015-03-24 This book offers a collection of original peer reviewed contributions presented at the 6th International Congress on Design and Modeling of Mechanical Systems CMSM 2015 held in Hammamet Tunisia from the 23rd to the 25th of March 2015 It reports on both recent research findings and innovative industrial applications in the fields of mechatronics and robotics dynamics of mechanical systems fluid structure interaction and vibroacoustics modeling and analysis of materials and structures and design and manufacturing of mechanical systems Since its first edition in 2005 the CMSM Congress has been held every two years with the aim of bringing together specialists from universities and industry to present the state of the art in research and applications discuss the most recent findings and exchange and develop expertise in the field of design and modeling of mechanical systems The CMSM Congress is jointly organized by three Tunisian research laboratories the Mechanical Engineering Laboratory of the National Engineering School of Monastir the Mechanical Laboratory of Sousse part of the National Engineering School of Sousse and the Mechanical Modeling and Manufacturing Laboratory at the National Engineering School of Sfax

Innovative Computing and Communications Aboul Ella Hassanien, Sameer Anand, Ajay Jaiswal, Prabhat Kumar, 2024-07-26 This book includes high quality research papers presented at the Seventh International Conference on Innovative Computing and Communication ICICC 2024 which is held at the Shaheed Sukhdev College of Business Studies University of Delhi Delhi India on 16 17 February 2024 Introducing the innovative works of scientists professors research scholars students and industrial experts in the field of computing and communication the book promotes the transformation of fundamental research into institutional and industrialized research and the conversion of applied exploration into real time applications

Nonlinear Dynamics, Volume 1 Gaetan Kerschen, 2018-06-06 Nonlinear Dynamics Volume 1 Proceedings of the 36th IMAC A Conference and Exposition on Structural Dynamics 2018 the first volume of nine from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Nonlinear Dynamics including papers on Nonlinear System Identification Nonlinear Modeling Simulation Nonlinear Reduced order Modeling Nonlinearity in Practice Nonlinearity in Aerospace Systems Nonlinearity in Multi Physics Systems Nonlinear Modes and Modal Interactions Experimental Nonlinear Dynamics

Decision Science in Action Kusum Deep, Madhu Jain, Said Salhi, 2018-09-12 This book provides essential insights into a range of newly developed numerical optimization

techniques with a view to solving real world problems Many of these problems can be modeled as nonlinear optimization problems but due to their complex nature it is not always possible to solve them using conventional optimization theory Accordingly the book discusses the design and applications of non conventional numerical optimization techniques including the design of benchmark functions and the implementation of these techniques to solve real world optimization problems The book s twenty chapters examine various interesting research topics in this area including Pi fraction based optimization of the Pantoja Bretones Martin PBM antenna benchmarks benchmark function generators for single objective robust optimization algorithms convergence of gravitational search algorithms on linear and quadratic functions and an algorithm for the multi variant evolutionary synthesis of nonlinear models with real valued chromosomes Delivering on its promise to explore real world scenarios the book also addresses the seismic analysis of a multi story building with optimized damper properties the application of constrained spider monkey optimization to solve portfolio optimization problems the effect of upper body motion on a bipedal robot s stability an ant colony algorithm for routing alternate fuel vehicles in multi depot vehicle routing problems enhanced fractal dimension based feature extraction for thermal face recognition and an artificial bee colony based hyper heuristic for the single machine order acceptance and scheduling problem The book will benefit not only researchers but also organizations active in such varied fields as Aerospace Automotive Biotechnology Consumer Packaged Goods Electronics Finance Business Banking Oil Gas Geosciences and Pharma to name a few

Metaheuristic Applications in Structures and Infrastructures Gebrail Bekdaş, Sinan Melih Nigdeli, 2013-01-31

Optimization of Tuned Mass Dampers Gebrail Bekdaş, Sinan Melih Nigdeli, 2022-04-07 This book is a timely book to summarize the latest developments in the optimization of tuned mass dampers covering all classical approaches and new trends including metaheuristic algorithms Also artificial intelligence and machine learning methods are included to predict optimum results by skipping long optimization processes Another difference and advantage of the book are to provide chapters about several types of control types including passive tuned mass dampers active tuned mass dampers tuned liquid dampers tuned liquid column dampers and inerter dampers Tuned mass dampers TMDs are vibration absorber devices used in all types of mechanic systems The key factor in the design is an effective tuning of TMDs for the desired performance In practice several high rise structures and bridges were designed by including TMDs Also TMDs were installed after the construction of the structures after several negative experiences resulting from the disturbing sway of the structures In optimum design several closed form expressions have been proposed for optimum frequency and damping ratio of TMDs but the exact optimization requires iterative optimization approaches The current trend is to use evolutionary algorithms and metaheuristic optimization methods to reach the goal

Active Isolation and Innovative Tuned Mass Dampers for Vibration Reduction Jose A. Inaudi, 1993

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Optimization and Control in Civil and Structural Engineering B.

Kumar, B. H. V. Topping, 1999 Contains a selection of papers presented at The Seventh International Conference on Civil and Structural Engineering and The Fifth International Conference on the Applications of Artificial Intelligence to Civil and Structural Engineering held concurrently from 13-15 September 1999 at Oxford England Abstract Journal in Earthquake Engineering, 1996 **Dissertation Abstracts International**, 2005 **Proceedings of the ASME Design Engineering Division ...**, 2005 **The Journal of the Acoustical Society of America** Acoustical Society of America, 2005 *Wind Engineering* 1983 J. D. Holmes, P. S. Jackson, W. H. Melbourne, 1984 **Detection, Utilization and Avoidance of Nonlinear Dynamical Effects in Engineering Applications** Karl Popp, 2001 **Control of Structures** Horst H. E. Leipholz, M. Abdel-Rohman, 1986-05-31 This book is an outgrowth of several years of teaching and research of the two authors in the field of structural dynamics and control The content of the book is based on structural dynamics classical and modern control theory and involves also recent developments that took place with respect to the control of systems with distributed masses It is hoped that the book will serve the researcher and the practicing engineer in the areas of civil mechanical and aeronautical engineering It may also be of interest to applied mathematicians and to physicists There is no question that the book can be used as a reference book for advanced courses in the above mentioned areas The numerous examples will provide students with the necessary material for exercising themselves and for self studying Thanks are due to Mrs Cynthia Jones for preparing patiently and competently the typescript of the book The services of Mrs Linda Strouth Solid Mechanics Division University of Waterloo rendered in producing the camera ready copy of the book with great skill and devotion are gratefully acknowledged Special thanks go to Mr Ir Ad C Plaizier at Martinus Nijhoff Dr W Junk who with much understanding and enthusiasm supervised the production of the book as Publisher May the readers of it enjoy it and may they have the feeling of having gained something in turning to it and using it

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