IUTAM Symposium on Nonlinear Stochastic Dynamics and Control

IUTAM BOOKSERIES

VOLUME 29

Serious Editors

G.M.L. Gladwell, *University of Waterloo, Waterloo, Ontario, Canada*
R. Moreau, *INPG, Grenoble, France*

Editorial Board

J. Engelbrecht, *Institute of Cybernetics, Tallinn, Estonia*
L.B. Freund, *Brown University, Providence, USA*
A. Kluwick, *Technische Universitt, Vienna, Austria*
H.K. Moffatt, *University of Cambridge, Cambridge, UK*
N. Olhoff, *Aalborg University, Aalborg, Denmark*
K. Tsutomu, *IIDS, Tokyo, Japan*
D. van Campen, *Technical University Eindhoven, Eindhoven, The Netherlands*
Z. Zheng, *Chinese Academy of Sciences, Beijing, China*

Aims and Scope of the Series

The IUTAM Bookseries publishes the proceedings of IUTAM symposia under the auspices of the IUTAM Board.

For other titles published in this series, go to
www.springer.com/series/7695

W.Q. Zhu, Y.K. Lin, and G.Q. Cai

Editors

IUTAM Symposium on Nonlinear Stochastic Dynamics and Control

Proceedings of the IUTAM Symposium held
in Hangzhou, China, May 10–14, 2010

Editors

W.Q. Zhu
Zhejiang University
Zhe Da Road 38
310027 Hangzhou
People's Republic of China
E-mail: wqzhu@yahoo.com

G.Q. Cai
Florida Atlantic University
College of Engineering and
Computer Science
33431 Boca Raton Florida
USA
E-mail: caig@fau.edu

Y.K. Lin
Florida Atlantic University
College of Engineering and
Computer Science
33431 Boca Raton Florida
USA

ISSN 1875-3507
ISBN 978-94-007-0731-3
DOI 10.1007/978-94-007-0732-0
Springer Dordrecht Heidelberg London New York

e-ISSN 1875-3493
e-ISBN 978-94-007-0732-0

Library of Congress Control Number: 2011921007

© Springer Science+Business Media B.V. 2011

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work.

Cover design: VTEX, Vilnius

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The history of stochastic dynamics may be traced back over 100 years ago to Einstein's paper on Brownian motion in 1905. Since then, its scope and depth have been broadened and enhanced by a wide variety of applications in science and engineering. From 1972 to 2002 ten symposia on stochastic dynamics were sponsored by International Union of Theoretical and Applied Mechanics (IUTAM). More recently, much progress on various aspects of nonlinear stochastic dynamics has been made and the research activities in the field have placed greater emphasis on systems with high nonlinearity, and on systems in which controllers play an important role.

This volume contains the papers presented at the IUTAM Symposium on Nonlinear Stochastic Dynamics and Control, held in Zhejiang University, China, May 10-14, 2010. The scientific committee appointed by the Bureau of IUTAM includes the following members:

W.Q. Zhu, Hangzhou, China (Chairman)
Y.K. Lin, Boca Raton, USA (Co-chairman)
A. Naess, Trondheim, Norway
W. Schiehlen, Stuttgart, Germany
G.I. Schüller, Innsbruck, Austria
K. Sobczyk, Warsaw, Poland
T.T. Soong, Buffalo, USA

A total of 44 active scientists from 13 countries (regions) accepted the invitation from the scientific committee, and 31 presentations, covering the following six groups of topics, were scheduled for the symposium:

1. Response and reliability of nonlinear stochastic systems. K. Sobczyk and P. Holobut gave a brief analysis of the entropy/information change in stochastic dynamical system with a special emphasis on the effect of the system parameters and intensities of random noise. V.V. Malanin and I.E. Poloskov proposed a scheme of study for systems with different forms of time aftereffect which has a transparent algorithm and can be simply combined with Monte Carlo method. W. Xu *et al* focused on the steady-state analysis of a class of nonlinear dynamical systems with multi-delayed feedbacks. J.Q. Sun presented a finite-dimensional Markov process approximation which opens a gate to various studies of stochastic dynamical systems with time delay. G.Q. Cai and Y.K. Lin studied the stochastic nonlinear behavior of two competing species of grass and woody vegetation. M.L. Deng and W.Q. Zhu investigated the stochastic energy transition of peptide-bond (PB) in enzyme-substrate-complex (ESC) by using stochastic averaging method and

Monte Carlo simulation. X.L. Jin and Z.L. Huang obtained the non-stationary probability densities of system responses for multi-degree-of-freedom nonlinear systems subject to stochastic parametric and external excitations. Y. Zeng and W.Q. Zhu proposed a stochastic averaging method for single-degree-of-freedom strongly nonlinear oscillators under Poisson white noise excitation using the so-called generalized harmonic functions. Cho W. S. To presented a novel approach for response analysis of MDOF nonlinear systems under non-Gaussian nonstationary random excitations using the stochastic central difference method, co-ordinate transformation and adaptive time scheme. M. Vasta and M. Di Paola obtained an approximate explicit response probability density function of a beam under external impulsive random Poisson excitation as approximate solution of integro-differential KF equation. G.K. Er and V.P. Iu proposed a method for determining the probabilistic stationary solutions for multi-dimensional nonlinear stochastic dynamic systems. S. Narayanan and P. Kumar developed an efficient numerical implementation for the path integral (PI) method based on non-Gaussian transition probability density function (PDF) and the Gauss-Legendre integration scheme. P.D. Spanos and I.A. Kougiumtzoglou proposed a novel harmonic wavelet-based statistical linearization approach for determining the evolutionary power spectrum (EPS) of the response of nonlinear oscillators subject to stochastic excitation. C.H. Loh *et al* developed methods for analyzing the seismic response data and the long-term static data of the Fei-tsui arch dam and thus setting an early warning threshold level for dam safety evaluation. A. Naess *et al* considered the first-passage type failure for systems subject to multiplicative and additive white noises excitations and obtained the numerical results using the path integration method.

2. Stability, bifurcation and chaos of nonlinear stochastic systems. M. F. Dimentberg *et al* found that temporal random variations of parameters in dynamic systems might “smear” classical neutral stability boundaries. The system’s response within such a “twilight zone” of marginal instability was found to be of an intermittent nature, with alternating periods of zero (or almost zero) response and rare short outbreaks. S.H. Li and X.B Liu investigated the p th moment Lyapunov exponent of a co-dimension two bifurcation system, that is on a three-dimensional centermanifold and excited parametrically by a white noise. T. Fang *et al* proposed a practical strategy for studying stochastic chaos based on orthogonal polynomial approximation and ergodic theorem. C.B. Gan studied the noisy scattering dynamics in the randomly-driven Henon-Heiles oscillator when the energy was large enough to permit particles to escape from the exits. The author paid special attention to the computation of the exit basins, which show a rich pattern of noisy fractal structures and the uncertainty dimensions of the fractal sets. N. Gaus and C. Proppe investigated the bifurcation behavior of the non-smooth mass on a belt system.

3. Resonance and synchronization of nonlinear stochastic systems. W. Wedig investigated stochastic resonances (SR), a phenomenon that nonlinear system synchronizes with noise to boost a resonant-like behavior, for road-vehicle systems

and related bifurcation problems. Y.B. Yang and B.H. Xu presented a review on the parametric SR technique and its applications in signal processing and target detection in shallow water reverberation. X.J. Sun and Q.S. Lu discussed the synchronization behavior of a clustered neuronal network with additive noise to reveal the role played by the clustered structure of networks and the effects of the coupling strength and cluster number.

4. Control of nonlinear stochastic systems. Z.H. Liu and W.Q. Zhu studied stochastic optimal time-delay control and stabilization of quasi-integrable Hamiltonian systems by converting the original control problem into a stochastic optimal control problem without time-delay. P. Kaczkynski and L. Socha solved the problem of quasi-optimal control for Duffing oscillator with parametric and external Gaussian and Poisson noise excitations, using an iterative procedure combining Gaussian statistical linearization and LQGP technique. V. Gattulli *et al* presented semi-active control strategies for asymmetric structures based on optimal sizing of an equivalent Kelvin-Voight model describing the constitutive behavior of semi-active magneto-rheological devices, when operating in passive modality with maximum achievable modal damping.

5. Modeling of stochastic dynamical systems and stochastic excitations. J. Li *et al* presented a review on modeling stochastic dynamic excitations, which is incorporated with a probability density evolution method for response analysis of nonlinear structures. G. I. Schuëller and B. Goller proposed model updating procedures to improve the match between experimental data and corresponding model output. X.Q. Wang *et al* proposed a nonparametric stochastic modeling technique to reduce the order of geometrically nonlinear structural models.

6. Structural health monitoring. B. F. Spencer *et al* proposed a RDT-based decentralized data aggregation approach for efficient data condensation and feature extraction, and verified experimentally the results. The performance of decentralized RDT was assessed in terms of accuracy of the estimated modal properties and efficiency in the wireless data communication. R. Zhang *et al* proposed a wave-based approach to model and analyze seismic building motion, providing additional perspective of seismic behavior of building structures, not clearly obtainable with the traditional vibration-based approach.

We wish to thank all participants of this IUTAM Symposium, and all organizers for their enthusiastic and valuable contributions to the Symposium. In addition, we gratefully acknowledge the financial supports from IUTAM and National Natural Science Foundation of China.

Symposium Chairmen
W.Q. Zhu
Y.K. Lin

Contents

Part 1: Response and Reliability of Nonlinear Stochastic Systems	
Nonlinear Stochastic Ecosystem of Two Competing Species	3
<i>G.Q. Cai, Y.K. Lin</i>	
Energy Transition Rate at Peptide-Bond Using Stochastic Averaging Method	13
<i>M.L. Deng, W.Q. Zhu</i>	
A New Method for the Probabilistic Solutions of Large-Scale Nonlinear Stochastic Dynamic Systems	25
<i>G.K. Er, V.P. Iu</i>	
Nonstationary Probability Densities of Nonlinear Multi-Degree-of-Freedom Systems under Gaussian White Noise Excitations	35
<i>X.L. Jin, Z.L. Huang</i>	
Feature Extraction within the Fei-Tsui Arch Dam under Environmental Variations	45
<i>C.H. Loh, J.H. Weng, C.H. Chen, Y.W. Chang</i>	
About Some Schemes of Study for Systems with Different Forms of Time Aftereffect	55
<i>V.V. Malanin, I.E. Poloskov</i>	
Reliability of Linear and Nonlinear Dynamic Systems under Multiplicative and Additive Noise	65
<i>A. Naess, D. Iourtchenko, O. Batsevych</i>	

Numerical Solution of Fokker-Planck Equation for Nonlinear Stochastic Dynamical Systems	77
<i>S. Narayanan, Pankaj Kumar</i>	
An Approximate Approach for Nonlinear System Evolutionary Response Spectrum Determination via Wavelets	87
<i>P.D. Spanos, I.A. Kougoumtzoglou</i>	
On Information/Entropy Flow in Stochastic Dynamical Systems	97
<i>K. Sobczyk, P. Holobut</i>	
Finite Dimensional Markov Process Approximation for Time-Delayed Stochastic Dynamical Systems	107
<i>Jian-Qiao Sun</i>	
Response Analysis of Nonlinear Multi-degree of Freedom Systems to Non-Gaussian Random Excitations	117
<i>Cho W. Solomon To</i>	
Stationary and Nontationary Response Probability Density Function of a Beam under Poisson White Noise	127
<i>M. Vasta, M. Di Paola</i>	
Steady State Analysis of Stochastic Systems with Multiple Time Delays	137
<i>W. Xu, C.Y. Sun, H.Q. Zhang</i>	
Stochastic Averaging of Strongly Nonlinear Oscillators under Poisson White Noise Excitation	147
<i>Y. Zeng, W.Q. Zhu</i>	
 Part 2: Stability, Bifurcation and Chaos of Nonlinear Stochastic Systems	
Marginal Instability and Intermittency in Stochastic Systems	159
<i>M.F. Dimentberg, A. Hera, A. Naess</i>	
A Practical Strategy to Study Stochastic Chaos	171
<i>T. Fang, C.L. Wu, X.L. Yang</i>	
Fractal Basin Boundaries and Chaotic Dynamics in the Randomly-Driven Henon-Heiles Oscillator	183
<i>C.B. Gan</i>	

Moment Lyapunov Exponent for a Three Dimensional Stochastic System	191
<i>Shenghong Li, Xianbin Liu</i>	
Bifurcation Analysis of Stochastic Non-smooth Systems	201
<i>Nicole Gaus, Carsten Proppe</i>	
Part 3: Resonance and Synchronization of Nonlinear Stochastic Systems	
Synchronization Behavior of a Clustered Neuronal Network in a Noisy Environment	213
<i>X.J. Sun, Q.S. Lu</i>	
Stochastic Parameter Resonance of Road-Vehicle Systems and Related Bifurcation Problems	221
<i>Walter V. Wedig</i>	
A Review of Parameter-Induced Stochastic Resonance and Current Applications in Two-Dimensional Image Processing	229
<i>Yibing Yang, Bohou Xu</i>	
Part 4: Control of Nonlinear Stochastic Systems	
Design of Damper Viscous Properties for Semi-active Control of Asymmetric Structures	241
<i>V. Gattulli, M. Lepidi, F. Potenza</i>	
Iterative Procedures in Application of the LQGP Approach to the Duffing Oscillator	251
<i>Piotr Kaczyński, Lesław Socha</i>	
Stochastic Optimal Time-Delay Control and Stabilization of Quasi-Integrable Hamiltonian Systems	261
<i>Z.H. Liu, W.Q. Zhu</i>	
Part 5: Modeling of Stochastic Dynamical Systems and Stochastic Excitations	
Modeling of Stochastic Dynamic Excitations and the Probability Density Evolution Theory for Nonlinear Stochastic Dynamics	273
<i>J. Li, Q. Yan, J.B. Chen</i>	

**On the Consideration of Model Uncertainties in Model
Updating of Dynamic Systems** 283
G.I. Schuëller, B. Goller

**Stochastic Reduced Order Models for Uncertain
Infinite-Dimensional Geometrically Nonlinear Dynamical
Systems- Stochastic Excitation Cases** 293
X.Q. Wang, M.P. Mignolet, C. Soize, V. Khanna

Part 6: Structural Health Monitoring

**Decentralized Random Decrement Technique for Data
Aggregation and System Identification in Wireless Smart
Sensor Networks** 305
*Sung-Han Sim, B.F. Spencer Jr., Hongki Jo,
Juan Francisco Carbonell-Márquez*

**A Wave-Based Approach for Seismic Response Analyses of
High-Rise Buildings** 315
R. Zhang, S. Al Hilali, A. Abdulla, M. Al Kurbi

Author Index 327

List of Participants

Names

G.Q. Cai
Y.W. Chang
C.H. Chen
J.B. Chen
M.L. Deng
G.K. ER
T. Fang
C.B. Gan
V. Gattulli
B. Goller
N. Gaus
R.H. Huan
Z.L. Huang
P. Kaczyński
X.L. Leng
Y. Lei
H. Li
J. Li
Y.K. Lin
X.B. Liu
Z.H. Liu
C.H. Loh

Q.S. Lu
A. Naess
S. Narayanan
I.E. Poloskov
M.D. Paola
K. Sobczyk
L. Socha
T.T. Soong
C. Soize
P. Spanos
B.F. Spencer
J.Q. Sun
W.L. Sun
Cho W.S. To
M. Vasta
W.V. WEDIG
W. Xu
Y.B. Yang
Y. Zeng
H.Q. Zhang
R.C. Zhang
W.Q. Zhu

1. B.F. Spencer
2. C. Soize
3. A. Naess
4. Y.K. Lin
5. W. Yang
6. W.Q. Zhu
7. T.T. Soong
8. K. Sobczyk
9. P. Spanos
10. I.E. Poloskov
11. T. Fang
12. Q.S. Lu
13. G.Q. Cai
14. R. Zhang
15. W. Wedig
16. S. Narayanan
17. N. Gaus
18. G.K. Er
19. R.H. Huan
20. X.L. Leng
21. H.Q. Zhang
22. J.Q. Sun
23. X.B. Liu
24. J.B. Chen
25. B. Goller
26. L. Socha
27. Z.G. Huang
28. C.H. Chen
29. Y.W. Chang
30. Z.L. Huang
31. H.W. Rong
32. Y. Zeng
33. Z.H. Liu
34. P. Kaczyński
35. Y. Lei
36. J. Li
37. H. Li
38. W. Xu
39. C.B. Gan
40. Cho W.S. To
41. V. Gattulli