PROCEEDINGS OF SPIE

Modeling, Signal Processing, and Control for Smart Structures 2007

Douglas K. Lindner
Editor

19–21 March 2007
San Diego, California, USA

Sponsored and Published by
SPIE—The International Society for Optical Engineering

Cosponsored by
American Society of Mechanical Engineers (USA)

Cooperating Organizations
Intelligent Materials Forum (Japan)
Jet Propulsion Laboratory (USA)
National Science Foundation (USA)

Volume 6523

The International Society for Optical Engineering

Proceedings of SPIE—The International Society for Optical Engineering, 9780819466440, v. 6523

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:
Author(s), "Title of Paper," in *Modeling, Signal Processing, and Control for Smart Structures 2007*, edited by Douglas K. Lindner, Proceedings of SPIE Vol. 6523 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 0277-786X
ISBN 9780819466440

Published by
SPIE—The International Society for Optical Engineering
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone 1 360/676-3290 (Pacific Time) · Fax 1 360/647-1445
http://www.spie.org

Copyright © 2007, The Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is $18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at http://www.copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/07/$18.00.

Printed in the United States of America.

Contents

vii *Symposium Committee*
ix *Conference Committee*

SESSION 1 SMART DEVICES I

652302 **Dynamic analysis of a biology-inspired miniature directional microphone** [6523-01]
Z. Chen, M. Yu, Univ. of Maryland, College Park (USA)

652303 **Jitter control for an initially stablized tactical rifle** [6523-02]
A. White, D. K. Lindner, Virginia Tech (USA); C. LaVigna, Technosciences Inc. (USA); D. Brei, Univ. of Michigan (USA)

652304 **Design and quasi-static characterization of SMASH (SMA Stabilizing Handgrip)** [6523-03]
A. Pathak, D. Brei, J. Luntz, Univ. of Michigan (USA); C. LaVigna, H. Kwatny, Techno-Sciences, Inc. (USA)

652305 **Modeling and sensitivity study of the dual-chamber SMART (SMA ReseTtable) lift device** [6523-04]
J. E. Luntz, J. R. Young, D. Brei, J. Radice, Univ. of Michigan (USA); K. A. Strom, General Motors Research and Development (USA)

652306 **Model identification and controller design of a fish-like robot** [6523-05]
I. Ariyanto, T. Kang, W. L. Chan, Y. Lee, Konkuk Univ. (South Korea)

SESSION 2 AIRCRAFT WING DESIGN AND CONTROL

652307 **Tendon actuated cellular mechanisms for morphing aircraft wing** [6523-06]
S. Bharti, M. Frecker, G. Lesieutre, J. Browne, Pennsylvania State Univ. (USA)

652308 **Energy-based aeroelastic analysis of a morphing wing** [6523-07]
R. De Breuker, M. Abdalla, Z. Gürdal, Delft Univ. of Technology (Netherlands); D. Lindner, Virginia Tech. (USA)

Pagination: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

652309 **Active aeroelastic control aspects of an aircraft wing by using synthetic jet actuators: modeling, simulations, experiments** [6523-08]
K. O'Donnell, S. Schober, M. Stolk, P. Marzocca, Clarkson Univ. (USA); R. De Breuker, M. Abdalla, E. Nicolini, Z. Gürdal, Delft Univ. of Technology (Netherlands)

65230A **Comparison of active flow control devices on bluff body shapes** [6523-09]
S. J. Haack, A. B. Flatau, Univ. of Maryland, College Park (USA)

SESSION 3 SMART DEVICES II

65230B **Lyapunov stability of periodically modulated cosine drivers for resonance tuning of harmonic oscillators** [6523-10]
J. B. Aldrich, S. Sherrit, X. Bao, M. Badescu, Y. Bar-Cohen, Z. Chang, Jet Propulsion Lab. (USA)

65230C **Piezoactuator design considering the optimum placement of FGM piezoelectric material** [6523-11]
R. C. Carbonari, Escola Politécnica da Univ. de São Paulo (Brazil); S. Nishiwaki, Kyoto Univ. (Japan); G. H. Paulino, Univ. of Illinois at Urbana-Champaign (USA); E. C. Nelli Silva, Escola Politécnica da Univ. de São Paulo (Brazil)

65230D **Control modeling of LIPCA using miniaturized piezoelectric actuator driver** [6523-12]
M. Song, T. Kang, Konkuk Univ. (South Korea); I. Kang, Pukyung National Univ. (South Korea); K. Yoon, S. Y. Lee, Konkuk Univ. (South Korea)

65230F **Estimation of control capacity for squeeze mode MR damper with electro-magnetic system** [6523-14]
G. Heo, Konyang Univ. (South Korea); J. Jeon, G. Lee, Chungnam National Univ. (South Korea); J. Lee, D. Lee, Konyang Univ. (South Korea)

SESSION 4 CONTROL OF SYSTEMS WITH HYSTERSIS

65230I **Passivity-based control of magnetostrictive materials** [6523-17]
S. Valadkhan, K. Morris, A. Khajepour, Univ. of Waterloo (Canada)

65230J **Modeling and identification of the hysteretic dynamics of an MR actuator for its application to semiactive control of flexible structures** [6523-18]
M. Zapateiro, Univ. of Girona (Spain); E. Taylor, S. J. Dyke, Washington Univ. in Saint Louis (USA); N. Luo, Univ. of Girona (Spain)

SESSION 5 ROBUST CONTROL

65230K **Active fault tolerant control of a flexible beam** [6523-19]
Y. Bai, WorleyParsons Sea Ltd. (USA); K. M. Grigoriadis, G. Song, Univ. of Houston (USA)

65230L **Energy-to-peak induced norm upper bound control approach for collocated structural systems** [6523-20]
M. Meisami-azad, J. Mohammadpour, K. M. Grigoriadis, Univ. of Houston (USA)

65230M **Control and integrated design of smart material systems using analytical upper bound method** [6523-21]
M. Meisami-Azad, K. M. Grigoriadis, Univ. of Houston (USA); M. A. Demetriou, Worcester Polytechnic Institute (USA)

65230N **Utilizing spatial robustness measures for the optimization of a PZT-actuated flexible beam** [6523-22]
M. A. Demetriou, Worcester Polytechnic Institute (USA); K. M. Grigoriadis, Univ. of Houston (USA)

SESSION 6 CONTROL THEORY

65230P **Exact controllability of a multilayer Rao-Nakra beam with minimal number of boundary controls** [6523-25]
S. W. Hansen, Iowa State Univ. (USA)

65230Q **Adaptive control of vibration transmission in a strut system** [6523-26]
C.-M. Liao, Univ. of Maryland, College Park (USA); D. R. Mahapatra, Indian Institute of Science (India); B. Balachandran, Univ. of Maryland, College Park (USA)

SESSION 7 IDENTIFICATION OF COMPLEX STRUCTURES

65230S **High-speed parameter estimation algorithms for nonlinear smart materials** [6523-28]
J. M. Ernstberger, R. C. Smith, North Carolina State Univ. (USA)

65230T **Tracking of transient displacements of plates with support excitations** [6523-29]
M. Krommer, Johannes Kepler Univ. (Austria); M. Nader, Linz Ctr. of Mechatronics GmbH (Austria); H. Irschik, Johannes Kepler Univ. (Austria)

65230U **On the identification of modal couplings and inherent capacitances of piezoelectric structures** [6523-30]
C. Maurini, Institut Jean Le Rond d'Alembert, CNRS, Univ. Pierre et Marie Curie (France); M. Porfiri, Polytechnic Univ. (USA); J. Pouget, Institut Jean Le Rond d'Alembert, CNRS, Univ. Pierre et Marie Curie (France)

65230W **Parameter estimation in active laminated plate structures** [6523-32]
C. M. Mota Soares, Technical Univ. of Lisbon (Portugal); A. L. Araújo, Polytechnic Institute of Bragança (Portugal); P. Pedersen, Technical Univ. of Denmark (Denmark); J. Herskovits, Federal Univ. of Rio de Janeiro (Brazil)

SESSION 8 WAVELETS

65230X **Wavelet-based signal processing applied to deformable mirror PZT actuators for wavefront control** [6523-33]
K. J. Jones, Rice Univ. (USA)

65230Y **Damage assessment of a two-span RC slab using wavelet analysis** [6523-34]
X. Q. Zhu, H. Hao, Univ. of Western Australia (Australia)

65230Z **Numerical modelling and simulations for optimal sensor location in damage detection with Lamb waves** [6523-45]
B. C. Lee, W. J. Staszewski, Sheffield Univ. (United Kingdom)

SESSION 9 ALGORITHMS FOR DAMAGE DETECTION

652310 **Non-invasive methodology for diagnostics of bearing impacts** [6523-36]
J. N. Chi, Massachusetts Institute of Technology (USA)

652311 **Hidden Markov model based classification of structural damage** [6523-37]
W. Zhou, N. Kovvali, A. Papandreou-Suppappola, D. Cochran, A. Chattopadhyay, Arizona State Univ. (USA)

652313 **Cable 3D nonlinear model and damping systems on stayed bridges** [6523-39]
R. Alvarado Cárdenas, Univ. Autónoma de Querétaro (Mexico); F. J. Carrión Viramontes, Univ. Autónoma de Querétaro (Mexico) and Instituto Mexicano del Transporte (Mexico); G. Herrera Ruiz, A. Domínguez González, Univ. Autónoma de Querétaro (Mexico)

SESSION 10 MATERIAL MODELING

652314 **Monte Carlo simulation of ion transport of the high strain ionomer with conducting powder electrodes** [6523-40]
X. He, D. J. Leo, Virginia Tech (USA)

652315 **An investigation into the electrical breakdown characteristics of cellulose based electro-active paper** [6523-41]
J. S. Dong, Inha Univ. (South Korea); P. Basappa, Norfolk State Univ. (USA); J. Kim, Inha Univ. (South Korea)

652316 **Load-dependent hysteresis of magnetostrictive materials** [6523-42]
S. Valadkhan, Univ. of Waterloo (Canada); A. Shum, Queen's Univ. (Canada); K. A. Morris, Univ. of Waterloo (Canada)

Symposium Plenary Presentation:
Revolutionary transitions of GE technology in NDE prognostics and health monitoring
Ed Hindle, Thadd Patton, GE Aviation (USA); Tom Batzinger, GE Global Research Ctr. (USA)

Author Index

Symposium Committee

Symposium Chairs

Yoseph Bar-Cohen, Jet Propulsion Laboratory (USA)
Alison B. Flatau, University of Maryland, College Park (USA)
Norbert G. Meyendorf, University of Dayton (USA) and Fraunhofer Institute of Non-Destructive Testing (Germany)
George Y. Baaklini, NASA Glenn Research Center (USA)

Executive Committee

Mehdi Ahmadian, Virginia Polytechnic Institute and State University (USA)
George Y. Baaklini, NASA Glenn Research Center (USA)
Yoseph Bar-Cohen, Jet Propulsion Laboratory (USA)
Marcelo J. Dapino, The Ohio State University (USA)
L. Porter Davis, Honeywell, Inc. (USA)
Michael A. Demetriou, Worcester Polytechnic Institute (USA)
Aaron A. Diaz, Pacific Northwest National Laboratory (USA)
Alison B. Flatau, University of Maryland, College Park (USA)
Victor Giurgiutiu, University of South Carolina (USA)
B. K. Henderson, Air Force Research Laboratory (USA)
Kumar Jata, Air Force Research Laboratory (USA)
Gabor M., Kovacs, EMPA (Switzerland)
Tribikram Kundu, The University of Arizona (USA)
Donald J. Leo, DARPA (USA) and Virginia Polytechnic Institute and State University (USA)
Douglas K. Lindner, Virginia Polytechnic Institute and State University (USA)
Ajit K. Mal, University of California, Los Angeles (USA)
Yuji Matsuzaki, Nagoya University (Japan)
M. Brett McMickell, Honeywell, Inc. (USA)
Norbert G. Meyendorf, University of Dayton (USA)
Zoubeida Ounaies, Texas A&M University (USA)
Kara J. Peters, North Carolina State University (USA)
Peter J. Shull, The Pennsylvania State University (USA)
Masayoshi Tomizuka, University of California, Berkeley (USA)
Eric Udd, Columbia Gorge Research (USA)
Vijay K. Varadan, University of Arkansas (USA)
Dietmar W. Vogel, Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (Germany)
H. Felix Wu, National Institute of Standards and Technology (USA)
Chung-Bang Yun, Korea Advanced Institute of Science and Technology (South Korea)

Conference Committee

Conference Chair

Douglas K. Lindner, Virginia Polytechnic Institute and State University (USA)

Conference Cochair

Michael A. Demetriou, Worcester Polytechnic Institute (USA)

Program Committee

Mary I. Frecker, The Pennsylvania State University (USA)
Karolos M. Grigoriadis, University of Houston (USA)
Scott W. Hansen, Iowa State University (USA)
Hans Irschik, Johannes Kepler Universität Linz (Austria)
Katherine J. Jones, Rice University (USA)
Jaehwan Kim, Inha University (South Korea)
Andrew J. Kurdila, Virginia Polytechnic Institute and State University (USA)
Liviu I. Librescu, Virginia Polytechnic Institute and State University (USA)
Arnold Lumsdaine, The University of Tennessee (USA)
S. O. Reza Moheimani, The University of Newcastle (Australia)
Emílio C. Nelli Silva, Escola Politécnica da Universidade de São Paulo (Brazil)
Stefan Seelecke, North Carolina State University (USA)
Robert E. Skelton, University of California, San Diego (USA)
Ralph C. Smith, North Carolina State University (USA)
Wieslaw J. Staszewski, The University of Sheffield (United Kingdom)
Miao Yu, University of Maryland, College Park (USA)

Session Chairs

1 Smart Devices I
Miao Yu, University of Maryland, College Park (USA)

2 Aircraft Wing Design and Control
Mary I. Frecker, The Pennsylvania State University (USA)

3 Smart Devices II
Emílio C. Nelli Silva, Escola Politécnica da Universidade de São Paulo (Brazil)

4 Control of Systems with Hystersis
Sina Valadkhan, University of Waterloo (Canada)

5 Robust Control
Michael A. Demetriou, Worcester Polytechnic Institute (USA)

6 Control Theory
Scott W. Hansen, Iowa State University (USA)

7 Identification of Complex Structures
Maurizio Porfiri, Polytechnic University (USA)

8 Wavelets
Katherine J. Jones, Rice University (USA)

9 Algorithms for Damage Detection
Aditi Chattopadhyay, Arizona State University (USA)

10 Material Modeling
Vishnu Baba Sundaresan, Virginia Polytechnic Institute and State University (USA)