25th Anniversary Volume



Artificial Intelligence for Engineering Design, Analysis and Manufacturing

Yan Jin, Editor





Artificial Intelligence for Engineering Design, **Analysis and Manufacturing**

EDITOR

YAN JIN University of Southern California

ASSOCIATE EDITORS

Amaresh Chakrabarti, Indian Institute of Science, Bangalore, India Ashok K. Goel, Georgia Institute of Technology, Atlanta, GA

Mary Lou Maher, University of Sydney, Australia Kristina Shea, Technische Universität München, Garching, Germany

EDITORIAL BOARD

Alice M. Agogino, University of California, Berkeley, CA Frances M.T. Brazier, Delft University of Technology, The Netherlands David C. Brown, Worcester Polytechnic Institute Jonathan Cagan, Carnegie Mellon University, Pittsburgh, PA Matthew I. Campbell, University of Texas, Austin, TX Per Christiansson, Aalborg University, Denmark Ellen Yi-Luen Do, Georgia Institute of Technology, Atlanta, GA Andy Dong, University of Sydney, Australia Alex H.B. Duffy, University of Strathclyde, Scotland Boi Faltings, Federal Institute of Technology, Lausanne, Switzerland Donal Finn, University College, Dublin, Ireland John S. Gero, George Mason University, Fairfax, VA Roderick A. Grupen, University of Massachusetts, Amherst, MA Sean Hanna, University College London, United Kingdom Mark Klein, Massachusetts Institute of Technology, Cambridge, MA

John C. Kunz, Stanford University, Stanford, CA Jean-Claude Latombe, Stanford University, Stanford, CA Wolfgang Nejdl, Institut für Verteilte Systeme, Germany Panos Papalambros, University of Michigan, Ann Arbor, MI H. Van Dyke Parunak, New Vectors LLC, Ann Arbor, MI William C. Regli, Drexel University, Philadelphia, PA Warren Seering, Massachusetts Institute of Technology, Cambridge, MA Ian Smith, Federal Institute of Technology, Lausanne, Switzerland Tim Smithers, University of Strathclyde, Scotland Robert B. Stone, Oregon State University, Corvallis, OR Rudi Stouffs, Delft University of Technology, The Netherlands Markus Stumptner, University of South Australia, Adelaide, Tetsuo Tomiyama, Delft University of Technology, The Netherlands

FOUNDING EDITOR EMERITUS (1986-1996)

(1997-2001)

Jan H. Vandenbrande, The Boeing Company, Seattle, WA

CLIVE L. DYM, Harvey Mudd College WILLIAM P. BIRMINGHAM, Grove City College

EDITOR EMERITUS (2001-2011)DAVID C. BROWN, Worcester Polytechnic Institute

AIEDAM: Artificial Intelligence for Engineering Design, Analysis and Manufacturing is a journal intended to reach two audiences: engineers and designers who see AI technologies as powerful means for solving difficult engineering problems; and researchers in AI and Computer Science who are interested in applications of AI and in the theoretical issues that arise from such applications (for detailed information refer to the Aims and Scope section at the inside back cover).

EDITOR EMERITUS

AIEDAM is also interested in original, major applications of state-of-the-art AI techniques to important engineering problems (practicum papers). In addition to the rapid publication and dissemination of unsolicited research papers, AIEDAM is committed to producing special issues on important, timely topics. AIEDAM is indexed in Compendex Plus, SciSearch, Research Alert, and CompuMath Citation Index.

Editorial Office: Prof. Yan Jin, Editor, AIEDAM: Artificial Intelligence for Engineering Design, Analysis and Manufacturing, Department of Aerospace & Mechanical Engineering, University of Southern California, 3650 McClintock Avenue, OHE-430, Los Angeles, CA 90089-1453, USA. Telephone: 626-538-5615. E-mail: aiedam@usc.edu. Website: http://aiedam.usc.edu/

Publishing, Subscription, and Advertising Offices: Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, USA; and (outside the US and Canada) Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU, UK.

AIEDAM is part of the Cambridge Journals Online (CJO) service. Access to online tables of contents and article abstracts is available to all researchers at no additional costs for institutional subscribers. Access to full text articles online is currently included with the cost of the print subscription. Subscription must be activated; see http://journals.cambridge.org for details.

Subscription Information: AIEDAM: Artificial Intelligence for Engineering, Design, Analysis and Manufacturing (ISSN 0890-0604) is published quarterly by Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, USA / Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU, UK. Annual subscription rates for Volume 26, 2012: Institutions print and electronic: US \$899.00 in the US, Canada, and Mexico; UK £525.00 + VAT elsewhere. Institutions electronic only: US \$765.00 in the US, Canada, and Mexico; UK £465.00 + VAT elsewhere. Institutions print only: US \$860.00 in the US, Canada, and Mexico; UK £515.00 + VAT elsewhere. Individuals print and electronic: US \$270.00 in the US, Canada, and Mexico; UK £165.00 + VAT elsewhere. Individuals electronic only: US \$257 in the US, Canada, and Mexico; UK £142 + VAT elsewhere. Individuals print only: US \$260.00 in the US, Canada, and Mexico; UK £155.00 + VAT elsewhere. Prices include postage and insurance.

@ Cambridge University Press 2012. All rights reserved. No part of this publication may be reproduced, in any form or by any means, electronic, photocopy, or otherwise, without permission in writing from Cambridge University Press. For further information see http://us.cambridge.org/ information/rights or http://cambridge.org/uk/information/rights. Photocopying information for users in the USA: The Item-Fee Code for this publication (0890-0604/12 \$25.00) indicates that copying for internal or personal used beyond that permitted by Sec. 107 or 108 of the US Copyright Law is authorized for users duly registered with the Copyright Clearance Center (CCC), provided that the appropriate remittance per article is paid directly to: CCC, 222 Rosewood Drive, Danvers, MA 01923. Specific written permission must be obtained for all other copying.

Printed in the United States of America.

AIEDAM: Artificial Intelligence for Engineering, Design, Analysis and Manufacturing (ISSN 0890-0604) is published quarterly by Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, USA. Periodicals postage is paid at New York, NY, and additional mailing offices. POST-MASTER send address changes in the US, Canada, and Mexico to AIEDAM: Artificial Intelligence for Engineering Design, Analysis and Manufacturing, Cambridge University Press, 100 Brook Hill Drive, West Nyack, NY 10994-2133. https://doi.org/10.1017/S0890060412000200 Published online by Cambridge University Press



VOLUME 26 AUGUST 2012 NUMBER 3

SPECIAL ISSUE

Sketching and Pen-Based Design Interaction

Guest Editors

Maria C. Yang Levant Burak Kara

