



Volume 25 Number 4  
November 2011

# AI EDAM

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

---

**David C. Brown, Editor**

**CAMBRIDGE  
UNIVERSITY PRESS**

ISSN 0890-0604

**EDITOR**

DAVID C. BROWN  
*Worcester Polytechnic Institute*

**ASSOCIATE EDITORS**

**Australia and Asia:** Mary Lou Maher, *University of Sydney, Australia*  
**Europe:** Ian Smith, *Federal Institute of Technology, Lausanne, Switzerland*

**EDITORIAL BOARD**

Alice M. Agogino, *University of California, Berkeley, CA*  
Frances M.T. Brazier, *Delft University of Technology, The Netherlands*  
Jonathan Cagan, *Carnegie Mellon University, Pittsburgh, PA*  
Matthew I. Campbell, *University of Texas, Austin, TX*  
Amaresh Chakrabarti, *Indian Institute of Science, Bangalore, India*  
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*  
Ashok K. Goel, *Georgia Institute of Technology, Atlanta, GA*  
Roderick A. Grupen, *University of Massachusetts, Amherst, MA*  
Sean Hanna, *University College London, United Kingdom*

Yan Jin, *University of Southern California, Los Angeles, CA*  
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*  
Kristina Shea, *Technische Universität München, Garching, Germany*  
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, Australia*  
Tetsuo Tomiyama, *Delft University of Technology, The Netherlands*  
Jan H. Vandenbrande, *The Boeing Company, Seattle, WA*

**FOUNDING EDITOR EMERITUS (1986–1996)**

CLIVE L. DYM, *Harvey Mudd College*

**EDITOR EMERITUS (1997–2001)**

WILLIAM P. BIRMINGHAM, *Grove City College*

**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).

**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. David C. Brown, Editor, **AIEDAM: Artificial Intelligence for Engineering Design, Analysis and Manufacturing**, Computer Science Department, Fuller Labs, Worcester Polytechnic Institute, 100 Institute Road, Worcester, MA 01609, USA. Telephone: (508) 831-5618. Fax: (508) 831-5776. E-mail: aiedam@cs.wpi.edu. Website: www.cs.wpi.edu/~aiedam/

**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 25, 2011: Institutions print and electronic: US \$865.00 in the US, Canada, and Mexico; UK £500.00 + VAT elsewhere. Institutions electronic only: US \$730.00 in the US, Canada, and Mexico; UK £440.00 + VAT elsewhere. Institutions print only: US \$820.00 in the US, Canada, and Mexico; UK £490.00 + VAT elsewhere. Individuals print and electronic: US \$265.00 in the US, Canada, and Mexico; UK £155.00 + VAT elsewhere. Individuals electronic only: US \$245 in the US, Canada, and Mexico; UK £135 + VAT elsewhere. Individuals print only: US \$255.00 in the US, Canada, and Mexico; UK £145.00 + VAT elsewhere. Prices include postage and insurance.

© Cambridge University Press 2011. 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 (0890-0604/11 \$25.00) indicates that copying for internal or personal use 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. POSTMASTER 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.



---

VOLUME 25

NOVEMBER 2011

NUMBER 4

---

**SPECIAL ISSUE**

*Representing and Reasoning About  
Three-Dimensional Space*

**Guest Editors**

SEAN HANNA  
WILLIAM REGLI

