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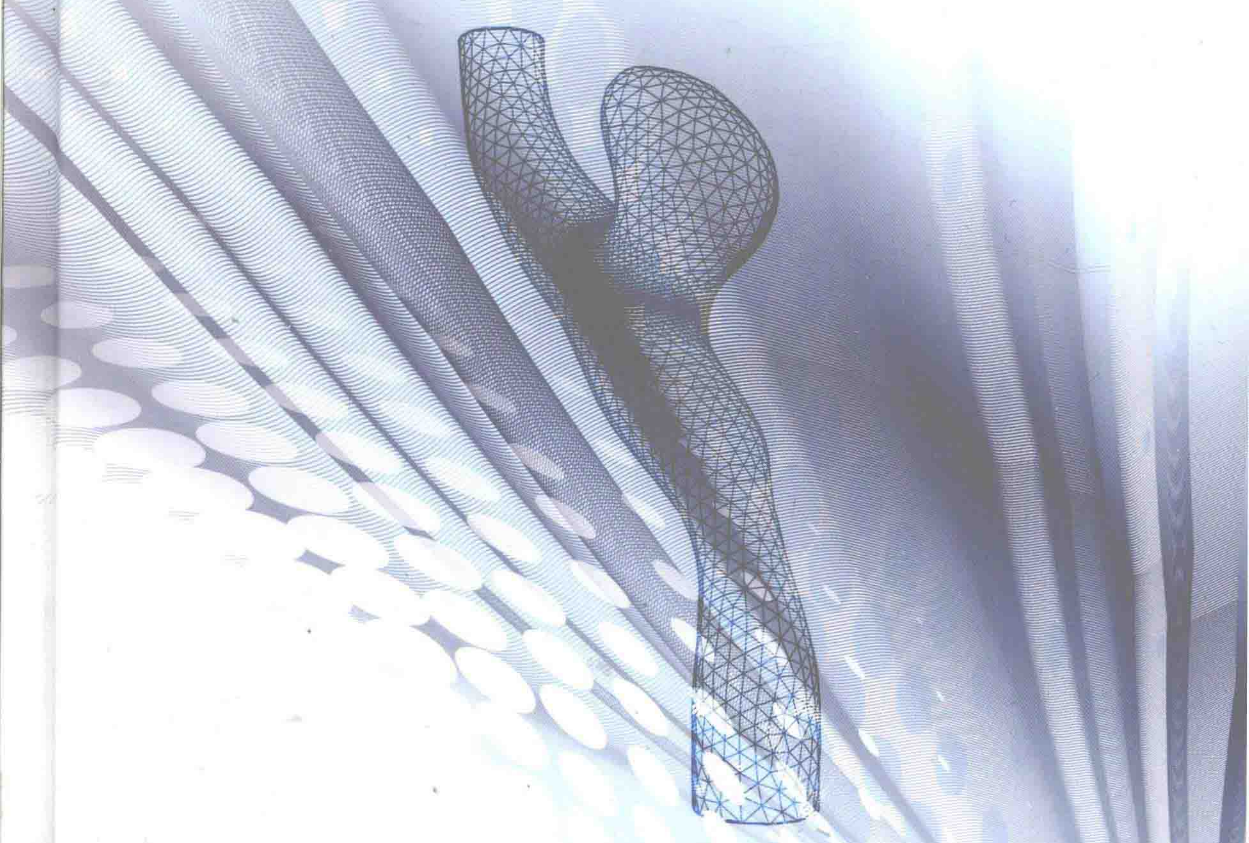
MULTISCALE SIMULATIONS AND MECHANICS OF BIOLOGICAL MATERIALS



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MULTISCALE SIMULATIONS AND MECHANICS OF BIOLOGICAL MATERIALS

About the Editors

Dr. Shaofan Li is currently a Professor of Applied and Computational Mechanics at the University of California–Berkeley. Dr. Li graduated from the Department of Mechanical Engineering at the East China University of Science and Technology (Shanghai, China) with a Bachelor Degree of Science in 1982; he also holds Master Degrees of Science from both the Huazhong University of Science and Technology (Wuhan, China) and the University of Florida (Gainesville, FL, USA) in Applied Mechanics and Aerospace Engineering in 1989 and 1993, respectively. In 1997 Dr. Li received a PhD degree in Mechanical Engineering from the Northwestern University (Evanston, IL, USA), and he was also a post-doctoral researcher at the Northwestern University during 1997–2000. In 2000 Dr. Li joined the faculty of the Department of Civil and Environmental Engineering at the University of California–Berkeley. Dr. Shaofan Li has also been a visiting Changjiang professor in the Huazhong University of Science and Technology, Wuhan, China (2007–2010). Dr. Shaofan Li is the recipient of the A. Richard Newton Research Breakthrough Award (2008) and an NSF Career Award (2003). Dr. Li has published more than 100 articles in peer-reviewed scientific journals, and he is the author and co-author of two research monographs/graduate textbooks. (li@ce.berkeley.edu)

Dr. Dong Qian is an associate professor in the Department of Mechanical Engineering at the University of Texas at Dallas. He obtained his BS degree in Bridge Engineering in 1994 from Tongji University in China. He came to the USA in 1996 and obtained an MS degree in Civil Engineering at the University of Missouri–Columbia in 1998. He continued his study at Northwestern University from 1998 and received his PhD in Mechanical Engineering in 2002. Shortly after his graduation, he was hired as an assistant professor at the University of Cincinnati. In 2008 he was promoted to the rank of associate professor with tenure and served as the Director of Graduate Studies from 2010. In the Fall of 2012 he joined the mechanical engineering department at the University of Texas at Dallas as an associate professor (tenured). His research interests include nonlinear finite-element and meshfree methods, fatigue and failure analysis and life prediction, surface engineering, residual stress analysis, and modeling and simulation of manufacturing processes (peening, forming, etc.) and nanostructured materials with a focus on mechanical properties and multiphysics coupling mechanisms. (dong.qian@utdallas.edu)

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3. *Development of meshfree formulations known as reproducing kernel particle methods.* These methods provide exceptional accuracy for the simulation of solids undergoing extremely large deformation and have been implemented in many commercial and laboratory software systems:
   (i) shell elements in DYNA3D, ABAQUS, LS-DYNA, ANSYS, and Argonne National Laboratory (ANL) software;
   (ii) explicit–implicit methods in US Ballistic Laboratory EPIC-2/EPIC-3 programs, and ANL software;
   (iii) Lagrangian–Eulerian methods adopted by ANL, Kawasaki, Mitsubishi, Ford Motors, and Grumman;
   (iv) various meshfree methods implemented by Sandia National Labs, Lawrence Livermore National Lab, General Motors, Ford Motors, Delphi, Ball Aerospace, and Caterpillar;
   (v) multiscale methods adopted by Goodyear for the design of tires and by Sandia in their TAHOE code for multiscale analysis.

Professor Wing Kam Liu is the recipient of numerous awards and honors that include: the 2012 Gauss–Newton Medal (IACM Congress Medal), the highest award given by IACM; the 2009 ASME Dedicated Service Award; the 2007 ASME Robert Henry Thurston Lecture Award; the 2007 USACM John von Neumann Medal, the highest honor given by USACM; the 2004 Japan Society of Mechanical Engineers (JSME) Computational Mechanics Award; the 2002 IACM Computational Mechanics Award; the 2001 USACM Computational Structural Mechanics Award; the 1995 ASME Gustus L. Larson Memorial Award; the 1985 ASME Pi Tau Sigma Gold Medal; the 1979 ASME Melville Medal (for best paper); the 1989 Thomas J. Jaeger Prize of the International Association for Structural Mechanics; and the 1983 Ralph R. Teetor Educational Award, American Society of Automotive Engineers. In 2001, he is listed by ISI as one of the most highly cited and influential researchers in engineering.

This large number of accolades highlights Wing Liu as a scholar and educator of extraordinary international reputation. This is also underlined by the fact that the present book comprises contributions from North American, Europe, and Asia, and from a very diverse group of people: colleagues, friends, collaborators, and former and current PhD students and post-docs. A wide range of topics is covered in this book: multiscale methods, atomistic simulations, micromechanics, and biomechanics/biophysics. These contributions represent either Wing Kam Liu's own research activities or topics he has taken an interest in over recent years. Moreover, the dedications of the contributing authors show that Wing Liu has represented more than just a scientist to a great number of people, to whom he also serves as friend, supporter, and source of inspiration. We are glad to have the opportunity of editing this book and would like to thank Wiley for its helpful collaboration, the authors for their contributions and making this book a success, and Wing Liu for his inspiring and initiating novel research in computational mechanics.

On behalf of the authors, we congratulate Wing Kam Liu to his 60th birthday and wish him happiness, health, success, and continued intellectual creativity for the years to come.

Shaofan Li and Dong Qian
Houston, Texas
November 2012

Preface

This book is dedicated to Professor Wing Kam Liu (or Wing Liu for those who know him well) on the occasion of his 60th birthday.

In 1976, Professor Wing Kam Liu received a BS degree in Engineering Science from the University of Illinois at Chicago with honors. It was his time at UIC where Wing Liu met Ted Belytschko, then a young assistant professor, and took his graduate course on finite-element methods. After graduation from UIC, Wing Liu was admitted as a graduate assistant at the California Institute of Technology (Caltech) under the supervision of the young Thomas J.R. Hughes, who was beginning his academic career there. During his Caltech years, Wing Liu worked on a number of research topics, including finite-element shell elements, which is known today as the Hughes–Liu element.

Wing Liu received both his MS degree (1977) and PhD degree (1980) in Civil Engineering from Caltech, and he then came back to Chicago to become an assistant professor at Northwestern University, joining Ted Belytschko and kicking off a 30-year collaboration between them. In his 32-year academic career, Professor Liu has made numerous contributions to computational mechanics and micromechanics. Among his most noteworthy contributions are:

1. *Development of multiscale methods that bridge quantum to continuum mechanics.* Using these methods, he has developed software for the analysis and design of nanoparticles in materials, bio-sensing, and drug delivery.
2. *Development of new finite-element techniques.* These include introducing new shell elements, arbitrary Eulerian–Lagrangian methods, and explicit–implicit integration techniques that have significantly enhanced the accuracy and speed in software for crashworthiness and prototype simulations. Wing Liu was also the first to develop nonlinear probabilistic finite-element techniques that made nonlinear stochastic and reliability analyses possible.

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