

---

# Handbook of Real-Time Computing

---

Yu-Chu Tian • David C. Levy  
Editors

# Handbook of Real-Time Computing

Volume 1

With 442 Figures and 75 Tables



Springer

### *Editors*

Yu-Chu Tian  
School of Computer Science  
Queensland University of Technology  
Brisbane, QLD, Australia

David C. Levy  
School of Electrical and  
Information Engineering  
The University of Sydney  
Sydney, NSW, Australia

ISBN 978-981-287-250-0

ISBN 978-981-287-251-7 (eBook)

<https://doi.org/10.1007/978-981-287-251-7>

© Springer Nature Singapore Pte Ltd. 2022

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.  
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

---

## Preface

Real-time computing correlates the performance of a computer, embedded system, or communication network together with time. It focuses on the design of application systems that must complete a task or return a response within a certain time frame, which is known as deadline. Depending on the application, the deadline requirement could range from nanosecond in computer network communications to millisecond in medical diagnosis or even seconds or minutes in many industrial control systems. Missing the deadline will violate the system requirements, while completing a task much earlier than the deadline may also deteriorate the system performance. Fast responses and/or precise timing control with or without fast response requirements are typical features of real-time computing. This can be interpreted as completing computing tasks at right times in real-time computing.

Real-time computing is widely used in various applications. In industrial systems such as power plants and power transmission and distribution networks, real-time monitoring and control over the whole communication networked systems become essential for system stability, performance, safety, and reliability. In our daily life, with the increasing demand on high-speed communication and network activities, real-time computing has become one of the key technologies to provide ultimate real-time networked services.

The *Handbook of Real-Time Computing* aims to summarize the state of the art of real-time computing. It is organized into five sections, which cover five selected aspects of real-time computing from theory to applications. The five sections are

- Principles and Theories of Real-Time Computing
- Real-Time Scheduling
- Real-Time Systems
- Real-Time Networks and Communications
- Real-Time Multi-agent Systems

Each of these five sections is edited by an expert in the specific domain. Authors of all chapters are experts on their respective topics, and many of them are well-recognized world-leading researchers. We congratulate all section editors and authors for their contributions, which reflect their expertise and knowledge, to the present handbook. We hope that the collection of these sections each with a number of chapters in the present handbook will provide a full and quick technical reference

with a high-level historic review, detailed technical descriptions, and latest practical applications in real-time computing.

It has been a long journey to present this five-section handbook to readers. We would like to acknowledge all section editors and authors for their creative contributions, without which the production of this handbook would have not been possible. We are grateful to Springer's MRW (Major Reference Works) publisher Mr. Stephen Yeung, who initiated this handbook project and demonstrated his enthusiasm, professionalism, support, and patience throughout the process of the project. Last but not the least, special thanks go to Springer's project coordinators (Books), Ms. Rekha Sukumar, Ms. Juby George, Meena Thiagarajan, Akshara P P, Nivedita Baroi, and Mr. Ramesh Nath Premnath, who coordinated the project at different times leading to the production of the handbook. It has been an enjoyable experience to work with these professionals and Springer.

Let us look forward to further development and evolution of new theories and technologies of real-time computing.

Brisbane, Australia  
Sydney, Australia  
July 2022

Dr. Yu-Chu Tian  
Dr. David C. Levy

---

# Contents

## Volume 1

<b>Part I Principles and Theories of Real-Time Computing . . . . .</b>	<b>1</b>
Tao Yue	
<b>1 Timing and Timing Control . . . . .</b>	<b>3</b>
H. Kopetz	
<b>2 Modeling of Real-Time Software Systems . . . . .</b>	<b>25</b>
Bran Selić	
<b>3 Uncertainty Theories for Real-Time Systems . . . . .</b>	<b>99</b>
Torsten Bandyszak, Thorsten Weyer, and Marian Daun	
<b>4 Interface Design for Embedded and Real-Time Systems . . . . .</b>	<b>133</b>
Bruce Montgomery	
<b>Part II Real-Time Scheduling . . . . .</b>	<b>173</b>
Arvind Easwaran	
<b>5 Semi-partitioned Multiprocessor Scheduling . . . . .</b>	<b>175</b>
Björn Andersson	
<b>6 Practical Considerations in Optimal Multiprocessor Scheduling . . . . .</b>	<b>193</b>
George Lima, Ernesto Massa, and Paul Regnier	
<b>7 Soft Real-Time Scheduling . . . . .</b>	<b>233</b>
Jeremy P. Erickson and James H. Anderson	
<b>8 Hierarchical Scheduling . . . . .</b>	<b>269</b>
Jin Hyun Kim, Deepak Gangadharan, Kyong Hoon Kim, Insik Shin, and Insup Lee	
<b>9 Mixed-Criticality Uniprocessor Scheduling . . . . .</b>	<b>303</b>
Sanjoy Baruah	

<b>10 Probabilistic Analysis</b> .....	323
Dorin Maxim, Liliana Cucu-Grosjean, and Robert I. Davis	
<b>11 Multiprocessor Real-Time Locking Protocols</b> .....	347
Björn B. Brandenburg	
<b>12 Parallel Real-Time Scheduling</b> .....	447
Jing Li, Kunal Agrawal, and Chenyang Lu	
<b>13 Real-Time Task Models</b> .....	469
Yue Tang, Nan Guan, and Wang Yi	
<b>14 Complexity of Uniprocessor Scheduling Analysis</b> .....	489
Pontus Ekberg and Wang Yi	
<b>Part III Real-Time Systems</b> .....	<b>507</b>
Jiong Jin	
<b>15 Real-Time Cyber-physical Systems: State-of-the-Art and Future Trends</b> .....	509
Mehdi Korki, Jiong Jin, and Yu-Chu Tian	
<b>16 Real-Time Data Analytics in Internet of Things Systems</b> .....	541
Tianqi Yu and Xianbin Wang	
<b>17 Authentication and Integrity Protection for Real-Time Cyber-Physical Systems</b> .....	569
Sye Loong Keoh, Heng Chuan Tan, and Zhaohui Tang	
<b>18 Real-Time Simulation Support for Real-Time Systems</b> .....	591
Xi Zheng	
<b>19 Real-Time Control Systems with Applications in Mechatronics</b> .....	605
Hai Wang, Youhao Hu, Mao Ye, Jie Zhang, Zhenwei Cao, Jinchuan Zheng, and Zhihong Man	
<b>20 PANTHEON: SCADA for Precision Agriculture</b> .....	641
Laura Giustarini, Sebastian Lamprecht, Rebecca Retzlaff, Thomas Udelhoven, Nico Bono Rossellò, Emanuele Garone, Valerio Cristofori, Mario Contarini, Marco Paolucci, Cristian Silvestri, Stefano Speranza, Emanuele Graziani, Romeo Stelliferi, Renzo Fabrizio Carpio, Jacopo Maiolini, Riccardo Torlone, Giovanni Ulivi, and Andrea Gasparri	
<b>21 Smart Grid and Demand Side Management</b> .....	681
Ruilong Deng	
<b>22 Vehicle Communications for Infotainment Applications</b> .....	705
Bach Long Nguyen, Duy T. Ngo, and Hai L. Vu	

<b>23</b>	<b>Cloud Empowered Real-Time Virtual Manufacturing Systems . . . .</b>	<b>723</b>
	Sourabh Dani, Akhlaqur Rahman, Jiong Jin, and Ambarish Kulkarni	
<b>24</b>	<b>Real-Time Internet of Things for Smart Environments . . . . .</b>	<b>761</b>
	Gowri Sankar Ramachandran and Bhaskar Krishnamachari	
<b>25</b>	<b>CyreamE: A Real-Time Situational Awareness and Decision-Making Blockchain-Based Architecture for the Energy Internet . . . . .</b>	<b>787</b>
	Abubakar Sadiq Sani, Dong Yuan, Stephen Ogaji, and Zhao Yang Dong	
<b>26</b>	<b>A Real-Time Robotic System for Sewing Personalized Stent Grafts . . . . .</b>	<b>837</b>
	Bidan Huang, Ya-Yen Tsai, and Guang-Zhong Yang	

## Volume 2

<b>Part IV</b>	<b>Real-Time Networks and Communications . . . . .</b>	<b>859</b>
	Naveen Chilamkurti	
<b>27</b>	<b>Low-Latency Multicast and Broadcast Technologies for Real-Time Applications in Smart Grid . . . . .</b>	<b>861</b>
	Yuemin Ding and Xiaohui Li	
<b>28</b>	<b>The Efficacy and Real-Time Performance of Refraction Networking . . . . .</b>	<b>893</b>
	Andrew Stephens and Mohammad Hammoudeh	
<b>29</b>	<b>Providing Real-Time and Reliable Transmission in Routing Protocols for Large-Scale Sensor Networks . . . . .</b>	<b>911</b>
	Lapas Pradittasnee	
<b>30</b>	<b>Software-Defined Networking for Real-Time Network Systems . . . . .</b>	<b>933</b>
	Bhargavi Goswami, Shuwen Hu, and Yanming Feng	
<b>31</b>	<b>Satellite Communication Networks . . . . .</b>	<b>959</b>
	Muhammad Furqan and Bhargavi Goswami	
<b>Part V</b>	<b>Real-Time Multi-Agent Systems . . . . .</b>	<b>981</b>
	Yang Tang	
<b>32</b>	<b>Event-Triggering Impulsive Differential Evolution . . . . .</b>	<b>983</b>
	Wei Du and Yang Tang	



<b>33</b>	<b>Distributed Impulsive Control of Leader-Following Multi-agent Systems</b> .....	<b>1019</b>
	Wangli He, Feng Qian, Guanrong Chen, and Qing-Long Han	
<b>34</b>	<b>Impulsive Control of Multi-agent Systems with Partial Information</b> .....	<b>1073</b>
	Ming-Feng Ge, Zhi-Wei Liu, and Li Ding	
<b>35</b>	<b>Analysis and Design of Synchronization for a Heterogeneous Network</b> .....	<b>1111</b>
	Yuanqing Wu, Renquan Lu, Peng Shi, Hongye Su, and Zheng-Guang Wu	
<b>36</b>	<b>Consensus of Multi-agent Systems with Intermittent Communication and Its Extensions</b> .....	<b>1143</b>
	Guanghui Wen, Wenwu Yu, Zhisheng Duan, and Peijun Wang	
<b>37</b>	<b>Synchronization in Coupled Harmonic Oscillator Systems Based on Sampled Position Data</b> .....	<b>1199</b>
	Qiang Song, Fang Liu, Guanghui Wen, Jinde Cao, and Yang Tang	
<b>38</b>	<b>Synchronization of Nonlinear Dynamical Networks with Heterogeneous Impulses</b> .....	<b>1223</b>
	Wenbing Zhang, Yang Tang, and Qingying Miao	
<b>39</b>	<b>Adaptive Consensus of Multiple Lagrangian Systems</b> .....	<b>1245</b>
	Jie Mei	
<b>40</b>	<b>On Discrete-Time Convergence for General Linear Multi-agent Systems Under Dynamic Topology</b> .....	<b>1263</b>
	Jiahu Qin, Huijun Gao, and Changbin Yu	
<b>41</b>	<b>Distributed Consensus of Stochastic Delayed Multi-agent Systems Under Asynchronous Switching</b> .....	<b>1283</b>
	Xiaotai Wu, Yang Tang, Jinde Cao, and Wenbing Zhang	
<b>42</b>	<b>Outer Synchronization of Partially Coupled Dynamical Networks via Pinning Impulsive Controllers</b> .....	<b>1311</b>
	Jianquan Lu, Chengdan Ding, Jungang Lou, and Jinde Cao	
<b>43</b>	<b>Time-Varying Formation Control Under Switching Interaction Topologies Theories and Applications</b> .....	<b>1333</b>
	Xiawang Dong, Yongzhao Hua, Zixuan Liang, Qingdong Li, and Zhang Ren	
<b>44</b>	<b>Semi-global Consensus of Multi-agent Systems with Impulsive Approach</b> .....	<b>1369</b>
	Zhen Li, Jian-an Fang, Tingwen Huang, Wenqing Wang, and Wenbing Zhang	

---

<b>45</b>	<b>Event-Triggered Schemes for Leader-Following Consensus of Multi-agent Systems</b> .....	<b>1403</b>
	Wenying Xu and Daniel W. C. Ho	
<b>46</b>	<b>Ultra-fast Formation Control of High-Order, Discrete-Time Multi-Agent Systems Based on Multistep Predictive Mechanism</b> .....	<b>1445</b>
	Wenle Zhang, Jianchang Liu, and Honghai Wang	
<b>47</b>	<b>Particle Swarm Optimization of Real-Time PID Controllers</b> .....	<b>1467</b>
	David C. Levy, Yongzhong Lu, Danping Yan, Min Zhou, and Shiping Chen	
	<b>Index</b> .....	<b>1497</b>

---

## About the Editors



**Professor Yu-Chu Tian** is a computer scientist working as Professor of Computer Science in the School of Computer Science, Queensland University of Technology (QUT), Brisbane QLD, Australia. He received his Ph.D. degree in computer and software engineering in 2009 from the University of Sydney, Sydney NSW, Australia, and his Ph.D. degree in industrial automation in 1993 from Zhejiang University, Hangzhou, China. He has worked in a number of universities including Zhejiang University (Hangzhou, China), Hong Kong University of Technology (Hong Kong, China), Curtin University (Perth WA, Australia), the University of Maryland at College Park (MD, USA), and Queensland University of Technology (Brisbane QLD, Australia).

Professor Tian has been playing a leadership role in QUT's research and development as well as teaching and learning in big data computing, cloud computing, real-time computing, computer networks, and cyber-physical system security. He has been working at QUT initially as a lecturer, and later as a senior lecturer and associate professor, and currently as a full professor. At QUT, he has established and headed the Networks and Systems Group, the Discipline of Networks and Communications, and the Big Data Lab. So far, Professor Tian has supervised over 30 PhD and Master of Research students to completion. He has also mentored and supervised over 30 research fellows.

Professor Tian is an Australian Research Council (ARC) recognized expert with international standing. He has secured over 20 competitive research grants in excess of \$7 million funds in total for leading-edge research and development. From his research, he has published a book on the computation of mathematical models for complex industrial processes. He has also

published more than 250 refereed research articles. He holds a patent on real-time control of large-scale and continuous galvanizing line. Professor Tian's current research interests include big data computing, cloud computing, real-time computing, computer networks, smart grid communications and control, optimization and machine learning, networked control systems, and cyber-physical system security.

Contact Professor Tian via email [y.tian@qut.edu.au](mailto:y.tian@qut.edu.au).



**Dr. David C. Levy** is an honorary associate professor in the School of Electrical and Information Engineering at the University of Sydney. He was head of the disciplines of computer and software engineering and Head of School prior to his leaving to pursue a private consulting career. He now acts as a technical advisor to two start-ups and has done some occasional teaching in Australia and China. He has supervised over 50 graduate students to completion, received grants totaling in excess of \$2.5 million, and been on the organizing committee of 17 conferences, chairing 6. He is a member of the IEEE and the ACM, and has served on the CDIO Council and on the Real Time Architectures committee of IFAC. He has acted as an assessor for grant applications in South Africa and Australia and has served as a reviewer for many research papers.

Dr. Levy received his B.E. degree in electrical engineering from the University of Natal, Durban, South Africa, in 1970, followed by M.Sc. and Ph.D. from the same institution. He taught electronic engineering at the University of Natal, with stints at the Technion, Israel, and Clemson, USA. After an extended visit to the CSIRO in Australia, Dr. Levy took up a position at the University of Sydney in 1994 where he led major curriculum revisions and served as Head of School.

Dr. Levy holds two patents on embedded systems for chemical sensors. He has over 200 refereed papers on his publication record, along with 1 book and 2 book chapters.

---

## Section Editors

### Section: Real-Time Networks and Communications



**Naveen Chilamkurti**  
La Trobe University  
Melbourne, Australia

### Section: Real-Time Scheduling



**Arvind Easwaran**  
Nanyang Technological University  
School of Computer Science and Engineering  
Singapore, Singapore

**Section: Real-Time Systems****Jiong Jin**

Swinburne University of Technology  
School of Science, Computing and  
Engineering Technologies  
Melbourne, VIC, Australia

**Section: Real-Time Multi-Agent Systems****Yang Tang**

East China University of Science and Technology  
The Key Laboratory of Advanced Control  
and Optimization for Chemical  
Processes, Ministry of Education  
Shanghai, China

**Section: Principles and Theories of Real-Time Computing****Tao Yue**

Nanjing University of Aeronautics and  
Astronautics, Simula Research Laboratory  
Nanjing University of Aeronautics and Astronautics  
Nanjing, China

---

## Contributors

**Kunal Agrawal** Washington University in St. Louis, St. Louis, MO, USA

**Björn Andersson** Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, USA

**James H. Anderson** Department of Computer Science, The University of North Carolina, Chapel Hill, NC, USA

**Torsten Bandyszak** The Ruhr Institute for Software Technology, University of Duisburg-Essen, Essen, Germany

**Sanjoy Baruah** Department of Computer Science and Engineering, Washington University in St. Louis, St. Louis, MO, USA

**Björn B. Brandenburg** Max Planck Institute for Software Systems (MPI-SWS), Kaiserslautern, Germany

**Jinde Cao** School of Mathematics, Southeast University, Nanjing, China

**Zhenwei Cao** School of Software and Electrical Engineering, Swinburne University of Technology, Melbourne, VIC, Australia

**Renzo Fabrizio Carpio** Rome Tre University, Rome, Italy

**Guanrong Chen** Department of Electronic Engineering, City University of Hong Kong, Kowloon, Hong Kong

**Shipping Chen** Data61, Commonwealth Scientific and Industrial Research Organization, Marsfield, NSW, Australia

**Mario Contarini** University of Tuscia, Viterbo, Italy

**Valerio Cristofori** University of Tuscia, Viterbo, Italy

**Liliana Cucu-Grosjean** Inria, Paris, France

**Sourabh Dani** Swinburne University of Technology, Melbourne, VIC, Australia

**Marian Daun** The Ruhr Institute for Software Technology, University of Duisburg-Essen, Essen, Germany

**Robert I. Davis** University of York, York, UK

**Ruilong Deng** College of Control Science and Engineering, School of Cyber Science and Technology, Zhejiang University, Hangzhou, China

**Chengdan Ding** Department of Mathematics, Southeast University, Nanjing, China

**Li Ding** School of Electrical Engineering and Automation, Wuhan University, Wuhan, China

**Yuemin Ding** Tecnun School of Engineering, University of Navarra, San Sebastian, Spain

**Xiwang Dong** School of Automation Science and Electrical Engineering, Science and Technology on Aircraft Control Laboratory, Beihang University, Beijing, P.R. China

Key Laboratory of System Control and Information Processing, Ministry of Education, Shanghai, P.R. China

Beijing Advanced Innovation Center for Big Data and Brain Computing, Beihang University, Beijing, P.R. China

**Zhao Yang Dong** School of Electrical Engineering and Telecommunications, University of New South Wales, Sydney, NSW, Australia

**Wei Du** Key Laboratory of Advanced Control and Optimization for Chemical Processes, Ministry of Education, East China University of Science and Technology, Shanghai, China

**Zhisheng Duan** State Key Laboratory for Turbulence and Complex Systems, Department of Mechanics and Engineering Science, College of Engineering, Peking University, Beijing, P. R. China

**Pontus Ekberg** Department of Information Technology, Uppsala University, Uppsala, Sweden

**Jeremy P. Erickson** Department of Computer Science, The University of North Carolina, Chapel Hill, NC, USA

**Jian-an Fang** School of Information Science and Technology, Donghua University, Shanghai, China

**Yanming Feng** School of Computer Science, Queensland University of Technology, Brisbane, QLD, Australia

**Muhammad Furqan** Queensland University of Technology, Brisbane, QLD, Australia

**Deepak Gangadharan** Department of Computer and Information Science, University of Pennsylvania, Philadelphia, PA, USA

**Huijun Gao** Research Institute of Intelligent Control and Systems, Harbin Institute of Technology, Harbin, China



**Emanuele Garone** Université Libre de Bruxelles, Brussels, Belgium

**Andrea Gasparri** Rome Tre University, Rome, Italy

**Ming-Feng Ge** School of Mechanical Engineering and Electronic Information, China University of Geosciences, Wuhan, China

**Laura Giustarini** Ferrero, Senningerberg, Luxembourg

**Bhargavi Goswami** School of Computer Science, Queensland University of Technology, Brisbane, QLD, Australia

**Emanuele Graziani** SIGMA Consulting, Rome, Italy

**Nan Guan** The Hong Kong Polytechnic University, Kowloon, Hong Kong

**Mohammad Hammoudeh** Manchester Metropolitan University, Manchester, UK

**Qing-Long Han** School of Software and Electrical Engineering, Swinburne University of Technology, Melbourne, VIC, Australia

**Wangli He** Key Laboratory of Advanced Control and Optimization for Chemical Processes, East China University of Science and Technology, Shanghai, China

**Daniel W. C. Ho** Department of Mathematics, City University of Hong Kong, Hong Kong SAR, China

**Shuwen Hu** School of Computer Science, Queensland University of Technology, Brisbane, QLD, Australia

**Youhao Hu** School of Electrical and Automation Engineering, Hefei University of Technology, Hefei, China

**Yongzhao Hua** School of Automation Science and Electrical Engineering, Science and Technology on Aircraft Control Laboratory, Beihang University, Beijing, P.R. China

**Bidan Huang** Tencent Robotics X, Shenzhen, China

**Tingwen Huang** The Science Program, Texas A&M University, Doha, Qatar

**Jiong Jin** School of Science, Computing and Engineering Technologies, Swinburne University of Technology, Melbourne, VIC, Australia

**Sye Loong Keoh** School of Computing Science, University of Glasgow, Glasgow, UK

**Jin Hyun Kim** Department of Information and Communication Engineering, Gyeongsang University, Jinju, Gyeongnam, South Korea

**Kyong Hoon Kim** Department of Informatics, Gyeongsang National University, Jinju, Gyeongnam, South Korea

**H. Kopetz** Technical University of Vienna, Vienna, Austria

**Mehdi Korki** School of Science, Computing and Engineering Technologies, Swinburne University of Technology, Melbourne, VIC, Australia

**Bhaskar Krishnamachari** University of Southern California, Los Angeles, CA, USA

**Ambarish Kulkarni** Swinburne University of Technology, Melbourne, VIC, Australia

**Sebastian Lamprecht** Trier University, Trier, Germany

**Insup Lee** Department of Computer and Information Science, University of Pennsylvania, Philadelphia, PA, USA

**David C. Levy** School of Electrical and Information Engineering, The University of Sydney, Sydney, NSW, Australia

**Jing Li** New Jersey Institute of Technology, Newark, NJ, USA

**Qingdong Li** School of Automation Science and Electrical Engineering, Science and Technology on Aircraft Control Laboratory, Beihang University, Beijing, P.R. China

**Xiaohui Li** School of Information Science and Engineering, Wuhan University of Science and Technology, Wuhan, China

**Zhen Li** School of Automation, Xi'an University of Posts & Telecommunications, Xi'an, China

**Zixuan Liang** School of Aerospace Engineering, Beijing Institute of Technology, Beijing, P.R. China

**George Lima** Department of Computer Science, Institute of Mathematics and Statistics, Federal University of Bahia, Salvador, Bahia, Brazil

**Fang Liu** School of Information Engineering, Henan International Joint Laboratory of Behavior Optimization Control for Smart Robots, Huanghuai University, Henan, China

**Jianchang Liu** College of Information Science and Engineering, Northeastern University, Shenyang, P. R. China

State Key Laboratory of Synthetical Automation for Process Industries, Northeastern University, Shenyang, P. R. China

**Zhi-Wei Liu** School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan, China

Key Laboratory of Image Processing and Intelligent Control, Ministry of Education, Huazhong University of Science and Technology, Wuhan, China

**Jungang Lou** School of Information Engineering, Huzhou University, Huzhou, China

**Chenyang Lu** Washington University in St. Louis, St. Louis, MO, USA

**Jianquan Lu** Department of Mathematics, Southeast University, Nanjing, China

**Renquan Lu** Guangdong Key Laboratory of IoT Information Processing, School of Automation, Guangdong University of Technology, Guangzhou, China

**Yongzhong Lu** School of Software Engineering, Huazhong University of Science and Technology, Wuhan, China

**Jacopo Maiolini** Rome Tre University, Rome, Italy

**Zhihong Man** School of Software and Electrical Engineering, Swinburne University of Technology, Melbourne, VIC, Australia

**Ernesto Massa** State University of Bahia and Unifacs, Salvador, Bahia, Brazil

**Dorin Maxim** University of Lorraine, Nancy, France

**Jie Mei** Harbin Institute of Technology, Shenzhen, Guangdong, China

**Qingying Miao** School of Continuing Education, Shanghai Jiao Tong University, Shanghai, China

**Bruce Montgomery** Department of Computer Science, University of Colorado Boulder, Boulder, CO, USA

**Duy T. Ngo** School of Electrical Engineering and Computing, The University of Newcastle, Callaghan, NSW, Australia

**Bach Long Nguyen** School of Electrical Engineering and Computing, The University of Newcastle, Callaghan, NSW, Australia

**Stephen Ogaji** Department of Fuel and Gas, Niger Delta Power Holding Company, Abuja, Nigeria

**Marco Paolucci** University of Tuscia, Viterbo, Italy

**Lapas Pradittasnee** King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

**Feng Qian** Key Laboratory of Advanced Control and Optimization for Chemical Processes, East China University of Science and Technology, Shanghai, China

**Jiahui Qin** University of Science and Technology of China, Hefei, China

**Gowri Sankar Ramachandran** University of Southern California, Los Angeles, CA, USA

**Akhlaqur Rahman** Engineering Institute of Technology, Melbourne, VIC, Australia

**Paul Regnier** Department of Computer Science, Institute of Mathematics and Statistics, Federal University of Bahia, Salvador, Bahia, Brazil

**Zhang Ren** School of Automation Science and Electrical Engineering, Science and Technology on Aircraft Control Laboratory, Beihang University, Beijing, P.R. China

**Rebecca Retzlaff** Trier University, Trier, Germany

**Nico Bono Rossellò** Université Libre de Bruxelles, Brussels, Belgium

**Abubakar Sadiq Sani** School of Electrical and Information Engineering, The University of Sydney, Sydney, NSW, Australia

**Bran Selić** Malina Software Corp, Nepean, ON, Canada

Faculty of Information Technology, Monash University, Clayton, VIC, Australia

**Peng Shi** College of Automation, Harbin Engineering University, Harbin, China

College of Engineering and Science, Victoria University, Melbourne, VIC, Australia

**Insik Shin** Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Yuseong-gu, South Korea

**Cristian Silvestri** University of Tuscia, Viterbo, Italy

**Qiang Song** College of Electrical Engineering, Henan University of Technology, Zhengzhou, China

**Stefano Speranza** University of Tuscia, Viterbo, Italy

**Romeo Stelliferi** Azienda Agricola Stelliferi, Nepi (VT), Italy

**Andrew Stephens** Manchester Metropolitan University, Manchester, UK

**Hongye Su** National Laboratory of Industrial Control Technology, Institute of Cyber Systems and Control, Zhejiang University, Hangzhou, China

**Heng Chuan Tan** Advanced Digital Science Centre, Singapore, Singapore

**Yang Tang** Key Laboratory of Advanced Control and Optimization for Chemical Processes, Ministry of Education, East China University of Science and Technology, Shanghai, China

**Yue Tang** The Hong Kong Polytechnic University, Kowloon, Hong Kong

**Zhaohui Tang** University of Southern Queensland, QLD, Australia

**Yu-Chu Tian** School of Computer Science, Queensland University of Technology, Brisbane, QLD, Australia

**Riccardo Torlone** Rome Tre University, Rome, Italy

**Ya-Yen Tsai** Hamlyn Centre for Robotic Surgery, Imperial College London, London, UK

**Thomas Udelhoven** Trier University, Trier, Germany

**Giovanni Ulivi** Rome Tre University, Rome, Italy

**Hai L. Vu** Department of Civil Engineering, Institute of Transport Studies, Monash University, Clayton, VIC, Australia

**Hai Wang** Discipline of Engineering and Energy, Center for Water, Energy and Waste, Harry Butler Institute, Murdoch University, Perth, WA, Australia

**Honghai Wang** College of Information Science and Engineering, Northeastern University, Shenyang, P. R. China

State Key Laboratory of Synthetical Automation for Process Industries, Northeastern University, Shenyang, P. R. China

**Peijun Wang** School of Mathematics, Southeast University, Nanjing, P. R. China

**Wenqing Wang** School of Automation, Xi-an University of Posts & Telecommunications, Xi-an, China

**Xianbin Wang** Department of Electrical and Computer Engineering, Western University, London, ON, Canada

**Guanghui Wen** School of Mathematics, Southeast University, Nanjing, P. R. China

**Thorsten Weyer** The Ruhr Institute for Software Technology, University of Duisburg-Essen, Essen, Germany

**Xiaotai Wu** The School of Mathematics and Physics, Anhui Polytechnic University, Wuhu, China

**Yuanqing Wu** Guangdong Key Laboratory of IoT Information Processing, School of Automation, Guangdong University of Technology, Guangzhou, China

**Zheng-Guang Wu** National Laboratory of Industrial Control Technology, Institute of Cyber Systems and Control, Zhejiang University, Hangzhou, China

**Wenying Xu** School of Mathematics, Southeast University, Nanjing, China

Department of Mathematics, City University of Hong Kong, Hong Kong SAR, China

**Danping Yan** College of Public Administration, Huazhong University of Science and Technology, Wuhan, China

**Guang-Zhong Yang** Hamlyn Centre for Robotic Surgery, Imperial College London, London, UK

**Mao Ye** School of Electrical and Automation Engineering, Hefei University of Technology, Hefei, China

**Wang Yi** Department of Information Technology, Uppsala University, Uppsala, Sweden

**Changbin Yu** Australian National University and NICTA Ltd, Canberra, ACT, Australia

**Tianqi Yu** Department of Electrical and Computer Engineering, Western University, London, ON, Canada

**Wenwu Yu** School of Mathematics, Southeast University, Nanjing, P. R. China

**Dong Yuan** School of Electrical and Information Engineering, The University of Sydney, Sydney, NSW, Australia

**Jie Zhang** School of Electrical and Automation Engineering, Hefei University of Technology, Hefei, China

**Wenbing Zhang** Department of Mathematics, Yangzhou University, Jiangsu, China

**Wenle Zhang** College of Information Science and Engineering, Northeastern University, Shenyang, P. R. China

State Key Laboratory of Synthetical Automation for Process Industries, Northeastern University, Shenyang, P. R. China

**Jinchuan Zheng** School of Software and Electrical Engineering, Swinburne University of Technology, Melbourne, VIC, Australia

**Xi Zheng** Department of Computing, Macquarie University, Sydney, NSW, Australia

**Min Zhou** College of Public Administration, Huazhong University of Science and Technology, Wuhan, China