

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



**ScienceDirect**

IFAC-PapersOnline 52-3 (2019) i–viii



International Federation of Automatic Control

# **15<sup>th</sup> IFAC Symposium on Large Scale Complex Systems LSS 2019**

Delft, The Netherlands, 26–28 May 2019

## **PROCEEDINGS**

Edited by  
Giulia Giordano  
*TU Delft*



**ELSEVIER**

Copyright © 2019 IFAC (International Federation of Automatic Control)  
Hosting by Elsevier Ltd. All rights reserved.

All rights reserved. No parts of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means: electronics, electrostatics, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing form the copyright holders.

IFAC Proceedings Volumes (IFAC-PapersOnline) — ISSN 2405-8963

*Published by:*  
International Federation of Automatic Control (IFAC)

*Available online at*

[www.sciencedirect.com](http://www.sciencedirect.com)

*Publication date*  
June 2019

## **Copyright conditions**

All publication material submitted for presentation at an IFAC-sponsored meeting (Congress, Symposium, Conference, Workshop) must be original and hence cannot be already published, nor can it be under review elsewhere. The authors take responsibility for the material that has been submitted. IFAC-sponsored conferences will abide by the highest standard of ethical behavior in the review process as explained on the Elsevier webpage (<https://www.elsevier.com/authors/journal-authors/policies-and-ethics>), and the authors will abide by the IFAC publication ethics guidelines, <https://www.ifac-control.org/events/organizers-guide/PublicationEthicsGuidelines.pdf/view>.

Accepted papers that have been presented at an IFAC meeting will be published in the proceedings of the event using the open-access IFAC-PapersOnLine series hosted on ScienceDirect (<https://sciencedirect.com/>). To this end, the author(s) must confer the copyright to IFAC when they submit the final version of the paper through the paper submission process. The author(s) retain the right to use a copy of the paper for personal use, internal institutional use at the author(s)' institution, or scholarly posting at an open web site operated by the author(s) or their institution, limited to noncommercial use. Any other use of the paper requires approval by IFAC.

(<https://www.ifac-control.org/publications/copyright-conditions>).

# 15th IFAC Symposium on Large Scale Complex Systems –LSS 2019

## **Sponsored by**

International Federation of Automatic Control (IFAC)

- Technical Committee on Large Scale Complex Systems, TC 5.4

## **Co-Sponsored by**

- IFAC TC 1.5 Networked Systems.

## **International Programme Committee**

Xiaofan Wang (CN), Co-Chair  
Mario di Bernardo (IT), Co-Chair  
Giulia Giordano (NL), Co-Chair

Hyo-Sung Ahn  
Yongcan Cao  
Balazs Csanad Csaji  
Franco Davoli  
Jinliang Ding  
Antonio Correia Dourado  
Luminita Duta  
Yasumasa Fujisaki  
Sergio Grammatico  
Soohee Han  
Valeria Javalera Rincon  
Tamas Keviczky  
Alena Kozakova  
Kauko Leiviska

Rudy Negenborn  
Maciej Niedzwiecki  
Carlos Ocampo Martinez  
Danica Rosinova  
Xiaoe Ruan  
Kazunori Sakurama  
Oliver Sawodny  
Chrysostomos Stylios  
Wen Yang  
Constantin Bala Zamfirescu  
Jianhua Zhang  
Shiyu Zhao  
Weixing Zheng  
Tomasz Zubowicz

## **National Organizing Committee**

Ming Cao (University of Groningen), Co-Chair  
Sergio Grammatico (TU Delft), Co-Chair

Simone Baldi (TU Delft), Publicity Co-Chair  
Erik Steur (TU Delft), Publicity Co-Chair

Riccardo Ferrari (TU Delft)  
Maurice Heemels (TU Eindhoven)  
Bayu Jayawardhana (University of Groningen)  
Tamas Keviczky (TU Delft)  
Manon Kok (TU Delft)

Manuel Mazo (TU Delft)  
Peyman Mohajerin Esfahani (TU Delft)  
Mathias Staudigl (University of Maastricht)  
Siep Weiland (TU Eindhoven)

# IFAC-PapersOnline Editorial Board

## Editor-in-Chief

Juan A. de la Puente  
Universidad Politécnica de Madrid  
Spain

## Deputy Editor-in-Chief

Dimitri Peaucelle  
LAAS-CNRS  
France

## Advisor

Dong-il (Dan) Cho  
Seoul National University,  
Republic of Korea

## Editors

### Systems and Signals

Hideaki Ishii  
Tokyo Inst. of Technology, Japan

### Design Methods

Alessandro Astolfi  
Imperial College, United Kingdom

### Computer, Cognition and Communication

Klaus Schilling  
Universität Würzburg, Germany

### Mechatronics, Robotics and Components

Klaus Janschek  
Technische Universität Dresden,  
Germany

### Manufacturing and Logistics Systems

Hervé Panetto  
Université de Lorraine, France

### Process and Power Systems

Jay H. Lee  
KAIST, Republic of Korea

### Transportation and Vehicle Systems

Lars Eriksson  
Linköping University, Sweden

### Bio & Ecological Systems

Mustafa Khammash  
ETH Zürich, Switzerland

### Social Systems

Lawrence (Larry) Stapleton  
Waterford Institute of Technology,  
Ireland

## Associate Editors

Alessandro Chiuso  
Università di Padova, Italy

Fouad Giri  
University of Caen Normandie,  
France

Jörg Raisch  
TU Berlin, Germany

Subrakanti Dey  
Uppsala University, Sweden

Maurice Heemels  
TU Eindhoven, Netherlands

Laura Menini  
Università di Roma Tor Vergata,  
Italy

Silviu-Iulian Niculescu  
CNRS-CentraleSupélec, France

Christophe Priour  
Gipsa-lab Grenoble, France

Erik Kerrigan  
Imperial College, United Kingdom

Mario Sznaiar  
Northeastern University, USA

Ralph C. Smith  
North Carolina State University,  
USA

Birgit Vogel-Heuser  
TU München, Germany

Thierry Marie Guerra  
Université de Valenciennes et  
Hainaut-Cambrésis, France

Ulrich Jumar  
ifak e.V Magdeburg, Germany

Tsu-Chin Tsao  
UCLA, USA

Ivan Petrovic  
University of Zagreb, Croatia

Jianhua Zhang  
East China University of Science  
and Technology, China

Benoit Iung  
CRAN, France

Dmitry Ivanov  
Hochschule für Wirtschaft &  
Recht Berlin, Germany

Georg Weichhart  
PROFACTOR GmbH, Austria

Xiaofan Wang  
Shanghai Jiao Tong University  
(SJTU), China

Richard D. Braatz  
Massachusetts Institute of  
Technology, USA

Andreas Kugi  
TU Wien, Austria

Kwang Y. Lee  
Baylor University, USA

Thomas Parisini  
Imperial College, United Kingdom

Per Tunestal  
Lund Institute of Technology,  
Sweden

Roberto Galeazzi  
Technical University of Denmark

Antonios Tsourdos  
Cranfield University,  
United Kingdom

Bart De Schutter  
TU Delft, Netherlands

Paul G. Plöger  
Hochschule Bonn-Rhein-Sieg,  
Germany

Manoj Karkee  
Washington State University  
USA

Thomas Desaive  
University of Liege, Belgium

Ronald van Nooijen  
TU Delft, Netherlands

Alejandro Vargas Casillas  
UNAM, Mexico

Fei-Yue Wang  
Chinese Academy of Sciences,  
China

Wilfrid Perruquetti  
École Centrale de Lille, France

Qing-Shan (Samuel) Jia  
Tsinghua University, China

John (Anthony) Rossiter  
University of Sheffield,  
United Kingdom

Peter Kopacek  
TU Vienna, Austria



# FOREWORD

The 15th IFAC Symposium on Large Scale Complex Systems (LSS 2019) was held at the Delft University of Technology (TU Delft), on May 26th-28th 2019.

The members of the International Program Committee, together with additional reviewers, provided multiple thorough reviews for the 47 submitted contributions. Based on the received reviews, 33 high-quality contributions were accepted for presentation during the 6 sessions, organised in two parallel tracks, at the 2-day conference. Of the 33 contributions, 28 are full papers and are included in the proceedings, while 5 are extended abstracts (for presentation and dissemination, without inclusion in the proceedings).

The 6 thematic sessions ranged over the following topics: theory-oriented sessions dealing with *Complex Network Systems*, *Decentralised and Distributed Control Systems*, *Efficient Strategies and Optimisation for Large Scale Complex Systems*, and *Multi-Agent Systems*, and application-oriented sessions dealing with *Transportation Systems* and *Applications to Aerospace Engineering and Fault Tolerant Control*. The four most represented keywords at the event were “Decentralised and distributed control systems”, “Multi-agent systems”, “Transportation systems” and “Complex network systems”.

A highlight of the symposium IFAC LSS 2019 was the presence of two exceptional invited plenary speakers: Giancarlo Ferrari Trecate, from École Polytechnique Fédérale de Lausanne (EPFL), Switzerland, giving a talk on “Scalable control design for systems with flexible structure”, and Jacquélien Scherpen, from the University of Groningen, The Netherlands, presenting “Classical model reduction methods for structure preserving reduction of networks of systems”.

IFAC LSS 2019 was a success in terms of diversity: the attendees came from all over the world. The represented countries were China, France, Germany, Italy, Japan, Netherlands, Poland, Russia, South Africa, Switzerland, Turkey, United Kingdom, United States of America. Gender diversity was ensured also by the two distinguished plenary speakers. Numerous students and young researchers participated in the event, thus accomplishing the educational and training mission of the IFAC LSS Symposium. To promote the visibility of excellent young researchers, the IFAC Young Author Award was assigned by the selection committee composed of Ming Cao, Giulia Giordano, Sergio Grammatico, Mathias Staudigl and Siep Weiland.

## The Program

After a welcome reception on Sunday evening, the Monday program started with the plenary lecture by Giancarlo Ferrari-Trecate (École Polytechnique Fédérale de Lausanne, CH).

Then, on Monday morning we had two parallel sessions: *Transportation systems*, with presentations of the work by Dekker and Panja (Utrecht University, NL), by Tao, Jain and Baldi (TU Delft, NL), by Chen, Wang, van Arem and Alkim (TU Delft, NL), by Nnene, Joubert and Zuidgeest (Universities of Cape Town and of Pretoria, ZA), and by Davydenko and Fransen (TNO, NL); and *Complex Network Systems*, which included presentations of the work by Xue and Roy (Washington State University, US), by Lavaei and Zamani (TUM, DE, and University of Colorado Boulder, US), by Wendt, Dhal and Roy (Washington State University, US), by Casagrande, Krajewski and Viaro (University of Udine, IT, and Polish Academy of Sciences, PL), by Zhang, Yang and Wang (Shanghai Jiao Tong University and Jiangsu University, CN), and by Hofman (TNO, NL).

After a break for lunch and networking, the two parallel sessions on Monday afternoon were: *Applications to Aerospace Engineering and Fault Tolerant Control*, including presentations of the work by Macktoobian, Gillet and Kneib (EPFL, CH), by Zhou, Kawano and Cao (Fujian University,

CN, and University of Groningen, NL), by Akca and Efe (Hacettepe University, TR), by Sun, Li and Jia (Shenyang Jianzhu University, CN), and by Sun, Li, Jia, and Ying (Shenyang Jianzhu University, CN); and *Decentralised and distributed control systems*, featuring presentations of the work by Kubo and Fujisaki (Osaka University, JP), by Tedesco, Sarkar and Casavola (University of Calabria, IT), by La Bella, Bonassi, Farina and Scattolini (Politecnico di Milano, IT), by Iftar (Eskisehir Technical University, TR), by Xu, Wen, Wang, Xie (Guangxi University and Peking University, CN), and by Broecker (Heilbronn University, DE).

On Monday evening, a conference banquet was organised at Royal Delft, where the participants had dinner surrounded by the world-famous white and blue porcelain, hand-painted in Delft since 1653.

The Tuesday morning program kicked off with the plenary lecture by Jacquélien Scherpen (University of Groningen, NL).

Then, the recipient of the IFAC Young Author Award was announced by Mathias Staudigl and Siep Weiland: the committee assigned the award to Alessio La Bella (Politecnico di Milano, IT), while the other two finalists were Abolfazl Lavaei (Technical University of Munich, DE) and Matin Macktoobian (EPFL, CH).

Finally, two parallel sessions were held: *Efficient Strategies and Optimisation for Large Scale Complex Systems*, which included presentations of the work by Staudigl and Mertikopoulos (Maastricht University, NL, and CNRS, FR), by Estrella, Belgioioso and Grammatico (TU Eindhoven and TU Delft, NL), by Bai, Thomopoulos, Crisostomi and Pannocchia (University of Pisa, IT), by Wenzel and Engell (TU Dortmund, DE), by Ye, Roy, Godjevac and Baldi (TU Delft and Allseas, NL), and by Tsyganov (Russian Academy of Sciences, RU); and *Multi-Agent Systems*, with presentations of the work by Govaert and Cao (University of Groningen, NL), by Sharifi Kolarijani, Proskurnikov and Mohajerin Esfahani (TU Delft, NL), by Fele and Margellos (Oxford University, UK), by Liu and Zhang (Nankai University, CN), and by Gao, Yang, Zhao and Wang (East China University and Shanghai Jiao Tong University, CN).

## **Acknowledgements**

First, I would like to thank the authors for entrusting their most recent work to IFAC LSS 2019, and the high-profile invited speakers Giancarlo Ferrari-Trecate and Jacquélien Scherpen, who accepted to open the symposium in the morning with their inspiring plenary talks.

Thanks also to the LSS steering committee, to all the supporters and sponsors, to the members of the National Organising Committee and to the head of the event secretariat, Martha Otte, for all the hard work required for the organisation and the logistics.

Finally, my most heartfelt thanks to the members of the International Program Committee and the reviewers, whose role was fundamental to ensure the high quality of the accepted contributions, and to the attendees who joined the IFAC LSS 2019, making it a memorable event.

Giulia Giordano  
*IFAC LSS 2019 Editor and Program Co-Chair*