Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnline 54-15 (2021) i–vii

International Federation of Automatic Control

11th IFAC Symposium on Biological and Medical Systems BMS 2021

Ghent, Belgium, 19-22 September 2021

PROCEEDINGS

Edited by
Balazs Benyo
Budapest University of Technology and Economics

ELSEVIER

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

IFAC PapersOnline — ISSN 2405-8963

Published by:
International Federation of Automatic Control (IFAC)
Hosting by Elsevier Ltd.

Available online at

www.sciencedirect.com

Publication date
September 2021

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 grant exclusive publishing rights to IFAC under a Creative Commons license when they submit the final version of the paper. The copyright belongs to the authors, who have the right to share the paper in the same terms allowed by the end user license, and retain all patent, trademark and other intellectual property rights (including research data).

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

11th IFAC Symposium on Biological and Medical Systems
BMS 2021

Sponsored by

International Federation of Automatic Control (IFAC)
- Technical Committee on Biological and Medical Systems, TC 8.2.

Co-Sponsored by

- IFAC TC 1.1. Modelling, Identification and Signal Processing
- IFAC TC 1.2. Adaptive and Learning Systems
- IFAC TC 2.1. Control Design
- IFAC TC 4.3. Robotics
- IFAC TC 8.4. Biosystems and Bioprocesses
- IEEE CSS IEE EMBS

Supported by

International Programme Committee

Steffen Leonhardt, DE (IPC Chair)
Thomas Desaive, BE (IPC Co-Chair)
Iven Mareels, AU (IPC Vice-Chair from Industry)

T. Cai, AU
G. Kronreif, AT
T. Desaive, BE
D. Copot, BE
A. Coene, BE
E. Volcke, BE
L. Platisa, BE
D. Prodanov, BE
M. Tsuzuki, BR
J. Liu, CA
I. Petrovic, HR
F. Giri, FR
I. Queinnec, FR
M.N. Pons, FR
T. Schauer, DE
S. Leonhardt, DE
K. Moeller, DE
B. Misgeld,DE
C. Ngo, DE
M. Walter, DE
L. Kovacs, HU
A. Chiusso, IT
A. Visioli, IT
J. Choi, KR
F. Clovis, LB
S.C. Yeong, MY
E. Steur, NL
B. Jayawardhana, NL
G. Chase, NZ
P. Docherty, NZ
T. Mendonça, PT
C.I. Muresan, RO
J. Banga, ES
A. Medvedev, SE
M. Cescon, US
W. Levine, US
B. Pasik-Duncan, US

National Organizing Committee

Clara Ionescu, BE (NOC Chair)
Dirk Verellen, BE (NOC Co-Chair)
Ljiljana Platisa, BE (NOC Vice-Chair from Industry)
Dimiter Prodanov, BE (NOC Vice-Chair from Industry)

Isabela Birs, BE
Annelies Coene, BE
Cosmin Copot, BE
Dana Copot, BE
Denis Dochain, BE
Maria Ghita, BE
Mihaela Ghita, BE
Eveline Volcke, BE

IFAC-PapersOnline Editorial Board

FOREWORD

About three years ago when the decision had been made to organize the 11th IFAC Symposium on Biological and Medical Systems in Ghent, Belgium, our ambition was to make it one of the greatest events of our main sponsoring TC 8.2. It turned out the world had a different plan altogether. There is a great deal to be said and learned from the years following the official IFAC approval, yet human nature (as a biological system with perfect control) has the ability to embrace the challenging, sensational, and inspiring times that have taken over our lives and tamed our ambitions – even if only for a while.

More than ever, control, as the invisible thread of technology and its best application, has proved to be essential in service of humanity. Whether societal, economic, or simply instrumentation, control was always there. IFAC – The International Federation of Automatic Control – once again, feels like the beating heart of millions of researchers who wish to address the great challenges ahead.

Our Symposium held every three years on medical and biological systems remains at the core of the societal and economic challenges faced all over the world. Our researchers' response to pandemic has again demonstrated the essential role played by inter-disciplinarity should never be ignored or underestimated in its potential to overcome the biggest challenges. Following the previous editions in Berlin (2015) and Sao Paulo (2018), the 11th IFAC Symposium on Biological and Medical Systems stands under the sign of inter-disciplinarity.

This landmark event has brought together contributions and scientific discussions from 148 academics (97 engineering and 51 medical sciences), 20 research institutions and 9 medical companies across the world. More precisely, 436 authors from 32 countries, including 95 female contributors, as our TC helps lead the increasing contributions from under-represented peoples and society.

Our 4-day hybrid event featured 97 oral presentations distributed over 16 sessions and provided 10 plenaries. A benchmark simulator was provided for design and test of control of hemodynamic and sedation variables during general anesthesia and received significant attention from the control applications community. As expected, the core biomedical applications were in pulmonary and cardiac dynamics, glucose control, biomechanics, and COVID-19 pandemic rollout. Echoing worldwide technology trends, from our 5 Open Invited Tracks the track on artificial intelligence applications and solutions in medicine received the largest number of contributions. However, perhaps most importantly, and to our delight and that of our attendees, the majority of contributions feature significant and increasing amounts of experimental and clinical data, showing how our field continues to push forward.

The plenary speakers and paper contributors guaranteed the high scientific quality of the conference. The members of the organizing committees, sponsors associated editors, reviewers, and session chairs voluntarily made this event possible. Although only a limited number (17%) of attendees were able to physically enjoy the cultural, art, and long-standing history of the city of Gent situated at the heart of the Flanders BioTech Valley, we hope IFAC BMS2021 was an inspiring experience for all the participants.

Balázs Benyó	Clara Ionescu	Steffen Leonhardt	Thomas Desaive	Geoff Chase
Editor	NOC Chair	IPC Chair	IPC Co-Chair	TC 8.2 Deputy Chair