



Editorial

Special Section: IFAC Symposium on Biological and Medical Systems – BMS 2015



This special section is dedicated to the 9th IFAC Symposium on Biological and Medical Systems, BMS 2015, which was held in Berlin, from August 31st to September 2nd, 2015. The triennial symposium provides an excellent forum for the presentation of new developments in the important interdisciplinary field of biological and medical systems. This involves the development and application of concepts, methods and techniques of modelling, informatics and control of complex biomedical and biological systems, as well as advances in medical technology.

The symposium BMS 2015 was organized by the Technical Committee on Biological and Medical Systems (TC 8.2) of the International Federation of Automatic Control (IFAC). Technical co-sponsors were five other IFAC TCs (TC 1.1, TC 1.2, TC 4.2, TC 4.3 and TC 9.4), the German VDI/VDE Society for Measurement and Automatic Control (GMA), the German Society for Biomedical Engineering within VDE (DGBMT), the German Technical Committees Automation in Medicine – AUTOMED – and Biosignals within DGBMT/GMA, the Control Systems Group at the Technische Universität Berlin, and the Physikalisch Technische Bundesanstalt (PTB) – the National Metrology Institute of Germany.

The symposium BMS 2015 was a great opportunity to exchange ideas, discuss exciting problems in the field of biological and medical systems, interact with colleagues, and make new friends. In total, 135 participants from 24 countries took advantage of this opportunity during the three days of the symposium. The proceedings of BMS 2015, which are accessible via IFAC-PapersOnLine, include 99 papers with corresponding authors from 21 countries. The accepted contributions have been selected from 124 submissions after a rigorous reviewing process.

Contributions covering the broad spectrum of application areas in biological and medical systems have been selectively invited for this special section based on previous outstanding conference papers. All papers have been significantly extended prior to passing through the journal's peer review process. The following seven papers have been finally accepted for publication:

- Juliana Almeida et al., Controller design for neuromuscular blockade level tracking based on optimal control.
- Kamuran Turksoy et al., Real-time insulin bolusing for unannounced meals with artificial Pancreas.
- Nor Azlan Othman et al., Tracking the progression to type 2 diabetes with a proportional-derivative insulin secretion model.
- Christian Brendle et al., Closed-loop control of extracorporeal oxygen and carbon dioxide gas transfer.
- Saverio Farsoni et al., A low-cost high-fidelity ultrasound simulator with the inertial tracking of the probe pose.
- Anake Pomprapa et al., Optimal learning control of oxygen saturation using a policy iteration algorithm and a proof-of-concept in an interconnecting three-tank system.
- Naji Alibeji et al., An adaptive low-dimensional control to compensate for actuator redundancy and FES-induced muscle fatigue in a hybrid neuroprosthesis.

The work by Juliana Almeida et al. is about the control design for the NeuroMuscular Blockade (NMB) level, typically consisting in tracking a reference NMB constant trajectory. An optimal control problem, with an input positivity constraint, is solved with different approximation techniques and the performance is evaluated by simulations using parameters from a patient database.

The second contribution by Kamuran Turksoy et al. presents a meal-detection and meal bolusing algorithm for an artificial pancreas based on continuous glucose measurements without manual information from the type 1 diabetes patients. The algorithm is tested in simulation and clinical environments and decreases the frequency, duration and magnitude of hyperglycemia without causing any additional hypoglycemia.

Christian Brendle et al. tackle the problem of closed-loop control of extracorporeal oxygen and carbon dioxide gas transfer during treatment of severe lung disease. A complete automation solution is proposed based on a decentralized MIMO controller that regulates both oxygen and carbon dioxide gas transfer rates. Also, an external control loop of the extracorporeal blood flow is included in the proposed system. The research results are presented through in-silico models and animal testing.

The nature of insulin secretion during the pathogenesis of type 2 diabetes is investigated by Nor Azlan Othman et al. The authors propose a proportional-derivative insulin secretion model to track the progression to type 2 diabetes, based on the physiological, closed-loop insulin secretion response to increasing glucose and glucose excursions. By employing experimental data of a 10-week dietary intervention trial, the authors conclude that the proposed model framework provides a clear relationship between insulin secretion profile and readily available metabolic state of each participant.

The paper by Anake Pomprapa et al. deals with the control of arterial oxygen saturation in ventilated patients without resorting to mathematical

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models of the controlled plant. Specifically, a “policy iteration algorithm” (PIA) is used. This is a nonlinear optimal control technique based on iterative evaluation of the Hamiltonian cost function and consequent synthesis of the control action until convergence to optimum is achieved.

Saverio Farsoni et al. describe the development of a low-cost high-fidelity ultrasound simulator. The proposed system relies on data from a RFID reader and a nine-degrees-of-freedom inertial and magnetic sensor unit, processed to track the pose of a hand-guided ultrasound simulator probe. The authors develop and investigate several tracking methods for the probe orientation, exploiting a sensor fusion technique to filter the noisy measurements from inertial sensors. Results show that a nonlinear complementary filter and a quaternion-based filter meet the requirements and involve a lower computational time, when compared to a classical Kalman Filter.

The authors Naji Alibeji et al. of the last paper investigate control concepts for a hybrid walking neuroprosthesis that combines a powered exoskeleton and Functional Electrical Stimulation (FES). The control design is inspired from human motor control and involves an adaptive muscle synergy-based feedforward component which requires a fewer number of control signals to actuate multiple effectors in the hybrid neuroprosthesis. The controller was tested in computer simulations and with one able-bodied subject.

We would like to thank the editor Andreas Kugi for giving us the opportunity to assemble this special section and all the contributors who accepted our invitation to submit their work in this section.

Thomas Schauer, Guest Editor
Technische Universität Berlin, Control Systems Group, Berlin, Germany
E-mail address: schauer@control.tu-berlin.de

Berno J.E. Misgeld, Guest Editor
RWTH Aachen University, Philips Chair for Medical Information Technology, Helmholtz-Institute for Biomedical Engineering, Aachen, Germany
E-mail address: misgeld@hia.rwth-aachen.de

Fabio Previdi, Guest Editor
Control Systems and Automation Laboratory Dipartimento di Ingegneria Gestionale, dell'Informazione e della Produzione Università degli Studi di Bergamo, Italy
E-mail address: fabio.previdi@unibg.it