WELCOME from the MMAR 2019 Organizing Committee

I would like to invite you to Międzyzdroje, Poland for the 24th International Conference on Methods and Models in Automation and Robotics. Over 156 draft papers have been submitted, from which the International Program Committee, chaired by Professor Tadeusz Kaczorek, has selected 122 papers for presentation.

As before also this year Conference is organized under the auspices of the IEEE Robotics & Automation Society and the IEEE Control Systems Society. And as usual it is co-sponsored by the Committee of Automation and Robotics of the Polish Academy of Sciences and the Polish Society for Measurement, Automatic Control and Robotics.

The Conference starts on Monday afternoon, 26 August 2019. The first three days of the conference begin with a plenary lecture delivered by a distinguished scientist, and further 10 papers are to be presented in the invited sessions organized by very active researchers from various countries. All other papers will be presented in three parallel regular sessions. Furthermore, several poster sessions will take place. Moreover, all the MMAR 2019 papers will be submitted for publishing in the IEEE Xplore Digital Library.

I hope that our conference will give the participants an opportunity to present the progress of their research work and to discuss related problems of current and mutual interest. I also hope that the conference social program – including the conference banquet and the touristic program – will guarantee you unforgettable time in Międzyzdroje.

I wish you a pleasant stay in Międzyzdroje and many fruitful meetings and discussions.

Prof. Zbigniew Emirsajłow
Chairman of the MMAR 2019 Organizing Committee
Faculty of Electrical Engineering
West Pomeranian University of Technology, Szczecin

Organizer

Faculty of Electrical Engineering,
West Pomeranian University
of Technology,
Szczecin, Poland

Organizing Committee

Zbigniew Emirsajłow (PL) - Chairman
Paweł Dworak (PL)
Jacek Piskorowski (PL)
Adam Łukomski (PL)

Technical Support

Michał Brasel
Ewelina Chołodowicz
Jarosław Fastowicz
Daniel Figurowski
Sławomir Kocoń
Michał Kubicki
Diana Olejnik
Piotr Okoniewski
Agnieszka Opałka

Sponsors

IEEE Control Systems Society

IEEE Robotics and Automation Society

Committee of Automation and Robotics,
Polish Academy of Sciences

Polish Society for Measurement, Automatic Control and Robotics

Conference Secretariat

Justyna Jończyk

Social media and website

Agnieszka Opałka

During the Conference

Amber Baltic Hotel
Promenada Gwiazd 1
PL-72-500 Międzyzdroje, Poland
Phone: +4891 328 1000
Fax: +4891 328 1022

Contact information

West Pomeranian University
of Technology, Szczecin
Faculty of Electrical Engineering
ul. 26 Kwietnia 10
71-126 Szczecin, Poland
Phone: +4891 449 41 13
Fax: +4891 449 45 56
E-mail: `mmar@mmar.edu.pl`

WWW Site

The Final Program
of the MMAR 2019 Conference
can also be found on the Internet at:
`http://www.mmar.edu.pl`

Conference Proceedings

The Conference Proceedings will be submitted for inclusion in the IEEE *Xplore* Digital Library at
`http://ieeexplore.ieee.org`

The Conference Proceedings are also attached to this booklet on USB pendrive.

Objectives

The objective of the Conference is to bring together scientists and engieneers to present and discuss recent developments in automation and robotics, to access the current status of research and technology, and to focus on future prospects and possible new directions in this active area of science.

This Conference is the 24th in a series which started in 1994.

Venue and dates

The Conference will be held at the Amber Baltic Hotel in Miedzyzdroje, from Monday, 26 August till Thursday, 29 August 2019. The Conference registration desk in Amber Baltic Hotel will be opened on the Monday morning, 26 August and during each day of the Conference. The Conference will start on Monday, 26 August at 3:00 p.m.

Presentation facilities

Overhead and slide projectors, as well as Personal Computers (with Microsoft Windows operating system) together with video projectors will be available for all sessions. Time allotted for presentation of papers is about 20 minutes (inclusive of discussion time).

The official language of the Conference is English.

International Program Committee

We would like to thank the program committee members for contributing to the success of MMAR 2019 and their efforts in coordinating the review process.

T. Kaczorek (PL) - Chairman
K. Kozłowski (PL) - Co-Chairman
A. Bartoszewicz (PL) - Co-Chairman
J. Sasiadek (CA) - Co-Chairman
F. Allgower (DE)
H. Aschemann (DE)
P. Antsaklis (USA)
H. S. Chang (KR)
A. Chemori (FR)
S. Domek (PL)
P. Dworak (PL)
A. Dzieliński (PL)
Z. Emirsajłow (PL)
B. Finkemeyer (DE)
P. Fiorini (IT)
E. Fornasini (IT)
K. Gałkowski (PL)
A. Giua (IT)
P. O. Gutman (IL)
W. Hunek (PL)
J. Kacprzyk (PL)
J. Klamka (PL)
D. Kocur (SK)
J. Korbicz (PL)
Z. Kowalczuk (PL)
A. Kowalewski (PL)
A. Krzyżak (CA)
I. Lasiecka (US)
K. Latawiec (PL)
J. Levine (FR)
K. Malinowski (PL)
A. Mazur (PL)
P. Morin (FR)
G. Oriolo (IT)
D. H. Owens (GB)
B. Pasik-Duncan (US)
J. Piskorowski (PL)
V. Piuri (IT)
A. Rauh (DE)
J. Reuter (DE)
J. Sokołowski (FR)
M. Spong (US)
R. Tadeusiewicz (PL)
P. Tatjewski (PL)
K. Tchoń (PL)
S. Townley (GB)
M. E. Valcher (IT)
D. Weidemann (DE)
C. Zieliński (PL)

Reviewers

We would like to thank the following individuals for their efforts in the review process of MMAR 2019:

Adamiak Katarzyna
Adams Will
Ait-Oufroukh Naima
Arnold Eckhard
Aschemann Harald
Auer Ekaterina
Babiarz Artur
Baranowski Jerzy
Barbosa Ramiro
Bartecki Krzysztof
Becker Andreas
Beer Michael
Belter Dominik
Ben Hariz Maher
Beniak Ryszard
Bernat Jakub
Błachuta Marian
Borkowski Dariusz
Bouri Mohamed
Broel-Plater Bogdan
Brol Sebastian
Brouri Adil
Buchholz Michael
Casagrande Daniele
Chemori Ahmed
Chu Bing
Company Olivier
Cysewska-Sobusiak Anna
Czeczot Jacek
Delgado Emma
Domański Paweł
Domek Stefan
Domski Wojciech
Drexler Daniel A.
Dworak Paweł
Escorcia jonatan
Farsoni Saverio
Figwer Jarosław
Filatova Daria
Finkemeyer Bernd
Fragulis George
Frenkel Wiebke
Galicki Mirosław
Galkowski Krzysztof
Gavrikov Alexander
Gharib Mohammadreza
Ghommam Jawher
Giernacki Wojciech
Gonzalez Avalos Gilberto
Górecka Joanna
Görges Daniel
Graichen Knut
Grega Wojciech
Gritli Hassène
Grochowski Michał
Grzechca Damian
Harmati Istvan
Hasiewicz Zygmunt
Haskins Cecilia
Haus Benedikt
Herman Przemysław
Hfaiedh Afef
Horla Dariusz
Horn Joachim
Hunek Wojciech
Ignaciuk Przemysław
Imaev Damir
Iwanowski Marcin
Izydorczyk Jacek
Janczak Andrzej
Jardzioch Andrzej
Jaskuła Marek
Jeinsch Torsten
Jing Xingjian

Kalas Vinayak
Kamat Shivaram
Kamiński Marcin
Karpinski Mikolaj
Kasprzak Włodzimierz
Kek Sie Long
Kersten Julia
Kiełczewski Marcin
Klamka Jerzy
Knyazkov Dmitri
Korniak Jacek
Kostin Georgy
Kowalczuk Zdzislaw
Krajewski Wiesław
Kreinovich Vladik
Kroll Andreas
Kruger Norbert
Kumar Neelesh
Kumar Parmod
Kurek Jerzy
Laesniewski Piotr
Lamaury Johann
Laszczyk Piotr
Latawiec Krzysztof
Latosiński Paweł
Ławryńczuk Maciej
Lelowicz Kamil
Luzar Marcel
Maalej Boutheina
Macias Michał
Maidi Ahmed
Majewski Paweł
Malesza Wiktor
Mammar Said
Mandra Slawomir
Mazurek Przemyslaw
Menighed Kamel
Mercorelli Paolo
Michałek Maciej
Mickiewicz Witold
Milecki Andrzej
Mitkowski Wojciech
Mosiołek Przemysław
Mozyrska Dorota
Mzyk Grzegorz
Nahla Khraief
Narwekar Krupa
Nawrocka Agata
Nenchev Vladislav
Nowicki Marcin
Nuñez Cruz Rafael
Oprzędkiewicz Krzysztof
Ostalczyk Piotr
Oszust Mariusz
Pączko Dariusz
Palis Stefan
Paszke Wojciech
Pauk Jolanta
Pawelczyk Marek
Pawlowski Pawel
Pawłuszewicz Ewa
Pazdeski Dariusz
Pelc Mariusz
Peng Kemao
Perlikowski Przemysław
Petko Maciej
Petre Emil
Piatek Marcin
Piątek Paweł
Pilat Adam Krzysztof
Piskorowski Jacek
Polzin Christhard
Precup Radu-Emil
Pröhl Lukas
Rafajłowicz Ewaryst
Raisch Jörg
Rauh Andreas
Reger Johann
Reuter Johannes
Rogowski Krzysztof

Różycki Rafał
Rudek Radosław
Ruszewski Andrzej
Saidi Imen
Saied Hussein
Sajewski Łukasz
Sawodny Oliver
Scherer Carsten
Scherer Rafał
Schulte Horst
Scordamaglia Valerio
Selisteanu Dan
Siemiątkowska Barbara
Sierociuk Dominik
Skaf Ahmad
Skruch Paweł
Skrzypczynski Piotr
Skupin Piotr
Śliwiński Przemysław
Śmieja Jarosław
Smolinski Eike
Smołka Maciej
Smutnicki Czesław
Śniatała Paweł
Stanisławski Rafał
Stursberg Olaf
Sulikowski Bartłomiej
Świątek Jerzy
Świercz Mirosław
Szłapczyńska Joanna
Szymak Piotr
Tadeusiewicz Ryszard
Tar József
Tarin Cristina
Tarnawski Jarosław
Tchon Krzysztof
Todorov Yancho
Tokarz Krzysztof
Tomczewski Krzysztof
Tomera Mirosław
Trojnacki Maciej
Viaro Umberto
Vinagre Blas
Wache Alexander
Waligóra Grzegorz
Wallhoff Frank
Winkler Alexander
Witczak Marcin
Yordanova Snejana
Zajdel Roman
Żak Paweł
Zhang Jie
Zielinski Cezary
Ziętkiewicz Joanna

Monday, Aug 26th, 2019

	Room 1 **Marco Polo**	**Room 2** **Vasco da Gamma**	**Room 3** **Ferdinand Magellan**
11.00	Registration opens (Amber hotel main hall)		
15.00- 15.10	Conference Opening (Marco Polo)		
15.10- 16.10	Plenary Lecture (Marco Polo), Chair: *Tadeusz Kaczorek* , page 14 **Optimization of Decentralized Control Systems** speaker: Sanjay Lall		
16.10- 16.30	*Coffee break*		
16.30- 17.50	A2L-A, page 14 **Control & Systems Theory I** *Krzysztof Latawiec*	A2L-B, page 16 **Neural Networks** *Zdzisław Kowalczuk*	A2L-C, page 18 **Robotics I** *Ryszard Beniak*
16.30- 17.20	A3P-D, page 19 **Poster Session I** *Krzysztof Okarma*		
19.00	Welcome Party (Amber, Christopher Columbus room)		

Tuesday, Aug 27th, 2019

	Room 1 **Marco Polo**	**Room 2** **Vasco da Gamma**	**Room 3** **Ferdinand Magellan**
9.00- 10.00	Plenary Lecture (Marco Polo), Chair: *Krzysztof Kozłowski* , page 25 **Normal Forms of Nonlinear Control Systems** speaker: Witold Respondek		
10.00- 11.00	B2L-A, page 25 **Adaptive Contol** *Dirk Weidemann*	B2L-B, page 27 **Robotics II** *Przemysław Herman*	B2L-C, page 28 **Scheduling** *Rafał Stanisławski*
10.00- 12.00	B3P-D, page 29 **Poster Session II** *Jerzy Baranowski*		
11.00- 11.20	*Coffee break*		
11.20- 13.00	B4L-A, page 35 **Fractional Order Systems I** *Tadeusz Kaczorek*	B4L-B, page 37 **Path Planning & Trajectory Tracking** *Wojciech Hunek*	B4L-C, page 39 **Control Applications** *Andreas Rauh*
13.00- 15.00	*Lunch* (Amber hotel)		
15.00- 16.20	B5L-A, page 40 **SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles I** *Paweł Skruch*	B5L-B, page 42 **Control & Systems Theory II** *Harald Aschemann*	B5L-C, page 44 **Optimization** *Czesław Smutnicki*
19.00	Conference Banquet (Międzyzdroje International House of Culture)		

Wednesday, Aug 28th, 2019

	Room 1 **Marco Polo**	**Room 2** **Vasco da Gamma**	**Room 3** **Ferdinand Magellan**
9.00- 10.00	Plenary Lecture (Marco Polo), Chair: *Andrzej Bartoszewicz* , page 49 **Game Theory and Distributed Control** speaker: Jeff S. Shamma		
10.00- 11.00	C2L-A, page 49 **Observers** *Wojciech Hunek*	C2L-B, page 51 **Robotics III** *Krzysztof Kozłowski*	C2L-C, **IEEE Control System Society, Polish Section Chapter CS23** *Technical Meeting*
10.00- 12.00	C3P-D, page 52 **Poster Session III** *Paweł Dworak*		
11.00- 11.20	*Coffee break*		
11.20- 13.00	C4L-A, page 57 **Fractional Order Systems II** *Piotr Ostalczyk*	C4L-B, page 59 **Identification** *Jacek Kabziński*	C4L-C, page 62 **Modelling & Simulation** *Stefan Siegmund*
13.00- 15.00	*Lunch*		
16.30	Touristic Programme (bus is leaving from the front of the Amber Hotel)		

Thursday, Aug 29th, 2019

	Room 1 **Marco Polo**	**Room 2** **Vasco da Gamma**	**Room 3** **Ferdinand Magellan**
9.00- 10.20	D1L-A, page 66 **SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles II** *Paweł Skruch*	D1L-B, page 67 **Nonlinear Systems & Control** *Wiesław Krajewski*	D1L-C, page 70 **Intelligent Systems & Methods** *Andrzej Świerniak*
10.20- 10.40	*Coffee break* (in front of Kalman/Lehar)		
10.40- 12.00	D2L-A, page 72 **SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles III** *Paweł Skruch*	D2L-B, page 74 **Signal Processing & Communication** *Witold Byrski*	D2L-C, page 76 **Robotics IV** *Przemysław Herman*
12.15- 12.30	Conference Program Committee Meeting *Young Author Prize*		
13.00- 13.15	Roman Kaszyński Award for Young Author Best Paper Ceremony (in the Christopher Columbus room)		
13.15	Farewell Lunch (at the Amber hotel)		

Monday
August 26th, 2019

Plenary 1: Sanjay Lall, A1L-A

Day: Monday, August 26, 2019
Time: 15:10 - 16:10
Room: Marco Polo
Chair: Tadeusz Kaczorek

Paper: **4160** **A1L-A**

Optimization of Decentralized Control Systems

Sanjay Lall[1]

[1] *Stanford University* lall@stanford.edu

Control & Systems Theory I, A2L-A

Day: Monday, August 26, 2019
Time: 16:30 - 17:50
Room: Marco Polo
Chair: Krzysztof Latawiec

Paper: **4008** **A2L-A**

Stability and Angles Between State Matrices of Positive Linear Systems

Tadeusz Kaczorek[1]

[1] *Białystok University of Technology* kaczorek@pw.edu.pl

The stability and the angles between state matrices of positive continuous-time and discrete-time linear systems are addressed. It is shown that: 1) The angles between matrices can be useful tool for analysis of the stability of positive continuous-time and discrete-time linear systems; 2) The positive linear system is asymptotically stable if and only if the symmetrical part of the state matrix is Hurwitz for continuous-time systems and Schur for discrete-time systems; 3) Using the angles between matrices necessary and sufficient conditions are established for the asymptotic stability of the positive linear systemst.

Paper: **4027** **A2L-A**

Extremal Problems for Integral Time Lag Parabolic Systems

Adam Kowalewski[1], **Marek Miśkowicz**[2]

[1] *AGH University of Science and Technology* ako@agh.edu.pl
[2] *AGH University of Science and Technology* miskow@agh.edu.pl

Extremal problems for integral time lag parabolic systems are presented. An optimal boundary control problem for distributed parabolic systems in which integral time lags appear in the state equations and in the boundary conditions simultaneously is solved. Such equations constitute in a linear approximation a universal mathematical model for many diffusion processes. The time horizon is fixed. Making use of the Dubovicki-Milutin scheme, necessary and sufficient conditions of optimality for the Neumann problem with the quadratic performance functionals and constrained control are derived.

Paper: **4117** **A2L-A**

On Asymptotic Properties of Discrete Volterra Equations of Convolution Type

Pham The Anh[1], **Artur Babiarz**[2], **Adam Czornik**[3], **Michal Niezabitowski**[4], **Stefan Siegmund**[5]

[1] *Le Quy Don Technical University* phamtheanhhn@gmail.com
[2] *Silesian University of Technology* artur.babiarz@polsl.pl
[3] *Silesian University of Technology* adam.czornik@polsl.pl
[4] *Silesian University of Technology* michal.niezabitowski@polsl.pl
[5] *Technische Universitat Dresden* stefan.siegmund@tu-dresden.de

This paper discusses dynamic properties of discrete Volterra equations of convolution type. The asymptotic separation of solutions is studied. More precisely, a polynomial lower bound for the norm of differences between two different solutions of discrete Volterra equations of convolution type is presented. We apply this result to the theory of fractional difference equations.

Paper: **4119** **A2L-A**

Techniques for Verified Reachability Analysis of Quasi-Linear Continuous-Time Systems

Andreas Rauh[1], **Julia Kersten**[2], **Harald Aschemann**[3]

[1] *University of Rostock* andreas.rauh@uni-rostock.de
[2] *University of Rostock* julia.kersten@uni-rostock.de
[3] *University of Rostock* harald.aschemann@uni-rostock.de

Quasi-linear continuous-time state-space representations are common for a large variety of dynamic systems described by ordinary differential equations (ODEs) with continuously differentiable smooth right-hand sides. Such models arise, for example, after representing technical systems by the use of first-principle techniques and subsequently factoring out

the state vectors so that a set of ODEs is obtained that has a structure similar to linear dynamics. However, in the case of quasi-linear ODEs, the system matrix (as well as the corresponding input matrix) are explicit functions of the state variables. Thus, analytic solutions to corresponding initial value problems (IVPs) are, even in cases of a-priori defined closed-form control inputs, hardly available. Therefore, this paper aims at giving an overview of interval-based techniques which allow for determining outer enclosures of the reachable states by either numerical iteration procedures or by similarity transformations of the state equations.

Neural Networks, A2L-B

Day: Monday, August 26, 2019
Time: 16:30 - 17:50
Room: Vasco da Gamma
Chair: Zdzisław Kowalczuk

Paper: **4046** **A2L-B**

Selection of Training Options for Deep Learning Neural Network Using Genetic Algorithm

Piotr Szymak[1]

[1] *Polish Naval Academy* p.szymak@amw.gdynia.pl

Recently, a growing usage and consequently a developing level of autonomy of Autonomous Underwater Vehicles (AUVs) can be seen. One of the most often used sensors of the AUV is a video camera, which in connection with the Deep Learning Neural Network (DLNN) can be used for the underwater images recognition. The goal of the paper is to examine the genetic algorithm optimization method for the selection of the training options for the DLNN used for the underwater images recognition. In the research, the pretrained AlexNet DLNN and the Stochastic Gradient Descent with Momentum (SGDM) training method have been used.

Paper: **4075** **A2L-B**

Deep Neural Network Architecture Search Using Network Morphism

Arkadiusz Kwasigroch[1], **Michał Grochowski**[2], **Mateusz Mikołajczyk**[3]

[1] *Gdańsk University of Technology* arkadiusz.kwasigroch@pg.edu.pl
[2] *Gdańsk University of Technology* michal.grochowski@pg.edu.pl
[3] *Gdańsk University of Technology* m.u.mikolajczyk@gmail.com

We proposed the algorithm that was inspired by the [xxx] work. Utilization of NAS algorithm allowed for selection of well-performing architecture in a very short time (1.3 GPU days) due to the utilized hill-climbing and the use of function-preserving transformations.

We have shown that architecture that was found by the algorithm performs comparably well to the ones selected manually. Moreover, the architecture has much fewer parameters. The results are important in the age of deep learning when the structure search space is huge due to many factors and many architectural elements that CNN can be built from. This work could also help those with less experience successfully implement machine learning algorithms that are adapted to the solved problem. Promising results encourage to research in the NAS field to find an even better solution to automatic architecture selection. The future work of authors will involve searching better NAS algorithms that are based on simple solutions. Moreover, the incorporation of hyperparameters optimization methods to the system is planned.

Paper: **4151** **A2L-B**

Enhanced Process Fault Diagnosis Through Integrating Neural Networks and Andrews Plot

Shengkai Wang[1], **Jie Zhang**[2]

[1] *Newcastle University* S.wang42@newcastle.ac.uk
[2] *Newcastle University* jie.zhang@newcastle.ac.uk

With industrial production processes becoming more and more sophisticated, traditional fault diagnosis systems may not achieve reliable diagnosis performance. In order to improve fault diagnosis performance, this paper proposes an enhanced fault diagnosis system by integrating neural networks with Andrews plot. On-line measurements are first processed by Andrews plot and then fed to a neural network for fault classification. Application to a simulated CSTR process indicates that the proposed method can give more reliable and earlier diagnosis than the traditional neural network based fault diagnosis method.

Paper: **4074** **A2L-B**

Style Transfer-Based Image Synthesis As an Efficient Regularization Technique in Deep Learning

Agnieszka Mikołajczyk[1], **Michał Grochowski**[2]

[1] *Gdańsk University of Technology* agnieszka.mikolajczyki@pg.edu.pl
[2] *Gdańsk University of Technology* michal.grochowski@pg.edu.pl

In the paper we presented current state-of-the-art of regularization techniques along with a variety of different data augmentation techniques. We proposed our own regularization technique based on the data synthesis and we tested it on the very demanding case of skin lesion classification. We created images with neural style transfer where we mixed benign content and malignant style to synthetize new skin lesion images. Next, we created pseudo-labels for each image by using CNN and prepared specific dataset split – we put all of the synthetized images into a training set, while the real images were split into

validation and test set. At the end, such prepared data were used to train four different, representative types of convolutional neural networks architectures.

Robotics I, A2L-C

Day: Monday, August 26, 2019
Time: 16:30 - 17:50
Room: Ferdinand Magellan
Chair: Ryszard Beniak

Paper: **4004** **A2L-C**

Model-Based Controller Using Quasi-Velocities for Some Vehicles

Przemyslaw Herman[1], Wojciech Adamski[2]

[1]*Poznań University of Technology* przemyslaw.herman@put.poznan.pl
[2]*Poznań University of Technology* wojciech.adamski@put.poznan.pl

This paper deals with the problem of trajectory tracking control for some vehicles (underwater vehicles, and indoor airships). The approach uses a velocity transformation which results from the inertia matrix decomposition. Next, a model-based non-adaptive nonlinear tracking controller in terms of the Generalized Velocity Components (GVC) is proposed. An important property of the algorithm is that the control gains are closely related to the dynamics of the vehicle (especially dynamical couplings). The general algorithm was given for a 6 DOF vehicle and tested using simulation. The results obtained for a full airship model have shown that the control scheme guarantees satisfactory performance.

Paper: **4005** **A2L-C**

Localization of Workpieces by Robot Manipulators Using RFID Technology

Christian Thormann[1], Alexander Winkler[2]

[1]*Hochschule Mittweida University of Applied Sciences* thormann@hs-mittweida.de
[2]*Hochschule Mittweida University of Applied Sciences* alexander.winkler@hs-mittweida.de

The paper investigates an additional application of RFID technology (Radio Frequency Identification) in combination with industrial robots. Besides identification and data storage in transponders, it is also possible to use RFID to localize objects. Some examples can be found in the field of mobile robotics. In this contribution, RFID technology is applied to robotic manipulators. In a final Industry 4.0 scenario, they may create a map of objects in the work cell in parallel to their main task, such as handling or finishing. Therefore, this paper considers the possibilities of RFID-based object localization with an industrial robot, which is equipped with an RFID antenna. First, the localization in two dimensions is investigated by the additional modification of transmission power.

Thereafter, the spatial position of a single transponder is estimated. Finally, multiple transponders are localized. All algorithms proposed in this paper are successfully verified by practical experiments and some ideas for further work are presented.

Paper: **4011** **A2L-C**

Cooperative Target Tracking in Elliptical Formation

Lili Ma[1]

[1] *New York City College of Technology* LMa@citytech.cuny.edu

This paper presents cooperative tracking of a moving target using a group of mobile robots in an elliptical formation. This result is obtained based on the balanced circular formation obtained earlier, by further applying a similarity transformation. Orientation of the elliptical formation can be specified by a design parameter. Since our control law to each agent was designed as the summation of two control components (i.e., tracking and formation), only the formation control component needs to be modified. The extension to elliptical formation is achieved for both single-integrator and double-integrator robot models. For the communication topology, the cyclic pursuit strategy is used. The effectiveness of the proposed schemes is demonstrated by simulation examples.

Poster Session I, A3P-D

Day: Monday, August 26, 2019
Time: 16:30 - 17:50
Room: Poster Area
Chair: Krzysztof Okarma

Paper: **4002** **A3P-D**

Neuro-Fuzzy Control of a Position-Position Teleoperation System Using FPGA

Hocine Khati[1], **Rabah Mellah**[2], **Hand Talem**[3]

[1] *University Mouloud Mammeri of Tizi-Ouzou* hoc.khati@gmail.com
[2] *University Mouloud Mammeri of Tizi-Ouzou* mellah.rab@gmail.com
[3] *University Mouloud Mammeri of Tizi-Ouzou* talemhand2015@gmail.com

This paper presents an ANFIS (adaptive neuro-fuzzy inference system) controller for a teleoperation system using FPGA (Field Programmable Gate Array). The proposed controller allows adapting to the dynamic variations of the master and slave models by adjusting the output parameters of the neuro-fuzzy network using a learning algorithm, while taking advantage of the benefits of the FPGA computing power and its high sampling frequency. The ANFIS controllers are developed in MATLAB-Simulink environment and implemented using Simulink's Fixed point tool and HDL Coder. These features provide a fast and accurate control algorithm while optimizing the hardware resources used by

the FPGA. The proposed controllers are implemented on a teleoperation system with one degree of freedom. The experimental position tracking results clearly show that the proposed control algorithm guarantees better performance compared to conventional control methods (PID).

Paper: **4028** **A3P-D**

Slippage Influence in Skid-Steering Platform Trajectory Tracking Quality with Unicycle Approximation

Wojciech Domski[1], **Alicja Mazur**[2]

[1] *Wrocław University of Science and Technology* wojciech.domski@pwr.edu.pl
[2] *Wrocław University of Science and Technology* alicja.mazur@pwr.edu.pl

In this paper the problem of quality control of a SSMP platform with a kinematics of an unicycle was addressed. During the movement of a SSMP platform a slippage occurs when the vehicle is changing its orientation. On the other hand, the presence of slippage is unavoidable because the platform has to induce a differential velocity on each side to change its orientation. However, when the platform moves on a trajectory without a curvature then there is no lateral slippage. It was shown that the kinematics of a SSMP platform can be approximated with a kinematics of an unicycle. The quality of the approximation depends on how much the slipping effect is introduced into the system.

Paper: **4033** **A3P-D**

Mechatronics Design, Modelling and Controlling of the Stewart-Gough Platform

Dawid Owoc[1], **Krzysztof Ludwiczak**[2], **Robert Piotrowski**[3]

[1] *Gdansk University of Technology* dawidowoc6@gmail.com
[2] *Gdansk University of Technology* krzysztof_ludwiczak07@wp.pl
[3] *Gdansk University of Technology* robert.piotrowski@pg.edu.pl

This paper presents mechatronics design of a low cost Stewart-Gough platform (SGP) with rotary actuators. The designed SGP is supposed to be applied in a ball & plate control system. A mechatronics design process of the SGP was conducted with computer aided design (CAD) software. Five geometry constants which affect the final range of movement of the SGP were defined. An interactive movable 3D model of the SGP was created. A mathematical model of a ball & plate system was designed. A control synthesis was conducted with rapid control prototyping using MATLAB environment.

Paper: **4052** **A3P-D**

Application of Artificial Intelligence in Sustainable Building Design – Optimisation Methods

Ewa Gilner[1], **Adam Gałuszka**[2], **Tomasz Grychowski**[3]

[1] *Silesian Technical University/Rolfe Judd Sp. z o.o.* ewa.gilner@polsl.pl
[2] *Silesian Technical University* adam.galuszka@polsl.pl
[3] *Silesian Technical University* tomasz.grychowski@polsl.pl

The need to reduce energy consumption, resources, the introduction of new and ecological materials, the multiplicity of modern technologies available, and the complexity and multi-branch nature of architectural and construction projects means that designers must make complex and difficult decisions. This work presents the subject of currently available and used in the AEC industry project tools and provides an overview of the possibilities of using artificial intelligence methods and tools, such as Knowledge Based Engineering (KBE), fuzzy logic, neural networks, genetic algorithms, Monte-Carlo simulation. These methods can be used in the early design stage to facilitate improve decision making process.

Paper: **4054** **A3P-D**

Premature Convergence in Motion Planning of Nonholonomic Systems and How to Counteract It

Arkadiusz Mielczarek[1], **Ignacy Duleba**[2]

[1] *Wrocław University of Science and Technology* arkadiusz.mielczarek@pwr.edu.pl
[2] *Wrocław University of Science and Technology* ignacy.duleba@pwr.edu.pl

In this paper an undesirable phenomenon of a premature convergence in nonholonomic motion planning is discussed. It relies on reaching a configuration where energy expensive motions are necessary to approach a goal configuration. An algorithm is proposed to counteract this phenomenon and to choose such sub-goals which allow to select more energy effective motions. Evaluation of how expensive or cheap directions of motion are, is based on verifying mainly degrees of Lie brackets generating the directions and checking other their properties. The algorithm is illustrated on a simple unicycle robot.

Paper: **4061** **A3P-D**

Adaptive Sliding Mode Control for Synchronization of Unified Hyperchaotic Systems

Wang-Long Li[1], Wei-Lun Liang[2], Kuo-Ming Chang[3]

[1] *National Cheng Kung University* dragonpuff@gmail.com
[2] *Gold Circuit Electronics Ltd.* d0077880@gmail.com
[3] *National Kaohsiung University of Science and Technology* koming@nkust.edu.tw

This paper addresses synchronization control of four-dimensional unified drive-response hyperchaotic systems. A unified four-dimensional hyperchaotic system can be implemented by an electrical circuit firstly. Then, using the sliding mode control technique and Lyapunov stability theory, an adaptive sliding mode controller is proposed for unified drive-response hyperchaotic systems with dead-zone input, unknown system parameters, and external disturbance to achieve the synchronization control goal. Finally, experimental results are given to demonstrate the effectiveness and robustness of the proposed control scheme.

Paper: **4069** **A3P-D**

Multi-Criteria Loop Quality Assessment: a Large-Scale Industrial Case Study

Paweł Domański[1], Maciej Ławryńczuk[2], Sebastian Golonka[3], Bartosz Moszowski[4], Piotr Matyja[5]

[1] *Warsaw University of Technology* p.domanski@ia.pw.edu.pl
[2] *Warsaw University of Technology* m.lawrynczuk@ia.pw.edu.pl
[3] *Grupa Azoty S.A.* sebastian.golonka@grupaazoty.com
[4] *Grupa Azoty S.A.* bartosz.moszowski@grupaazoty.com
[5] *Grupa Azoty S.A.* piotr.matyja@grupaazoty.com

This paper is concerned with Control Performance Assessment (CPA) of an industrial nitric fertilizer production installation. As many as more than 200 single or cascaded loops based on the PID control algorithm are considered. Effectiveness of various control loop quality measures is compared: integral indexes, factors of different probabilistic density functions and persistence fractal measures are taken into account. Finally, the most informative ones are integrated into a single radar plot being the common platform for comparison. Analysis is accompanied with PID settings analysis showing further tuning directions. As each of the installation elements is in different status, the results enable to point out necessary steps for future plant improvements.

Maintenance Scheduling of the Embroidery Machines Based on Fuzzy Logic

Marius Baban[1], **Calin Florin Baban**[2], **Edit Toth Kiss**[3]

[1] *University of Oradea* mbaban@uoradea.ro
[2] *University of Oradea* cbaban@uoradea.ro
[3] *University of Oradea* keditke85@gmail.com

Because of the wear of the sewing needles of embroidery machines defects can appear on the embroidery surface of the product. Therefore, it is necessary to schedule the moments of replacing the sewing needles of the embroidery machines based on the anticipation of their failure moments. Within this framework, the purpose of this study is to develop a fuzzy decision system for determining the moment of replacing of the sewing needles of embroidery machines, considering their amplitude of vibrations measured on the three axes of the Cartezian coordinate system.

Neural Network Training Using Particle Swarm Optimization – a Case Study

Marcin Kaminski[1]

[1] *Wrocław University of Science and Technology* marcin.kaminski@pwr.edu.pl

This paper presents implementation and results of gradient-less optimization applied for neural network training. For this purpose Particle Swarm Optimization was used. Combination of these two algorithms, that are often defined as intelligent, is useful method for problems in which a data set is available, without direct access to parameters and mathematical equations. The above conclusions are supported by the results concerning the calculations of Lorenz state variables and signals of the speed control structure of the electric drive.

Tuesday
August 27th, 2019

Plenary 2: Witold Respondek, B1L-A

Day: Tuesday, August 27, 2019
Time: 09:00 - 10:00
Room: Marco Polo
Chair: Krzysztof Kozłowski

Paper: **4161** **B1L-A**

Normal Forms of Nonlinear Control Systems

Witold Respondek[1]

[1] *Normandie Universite witold.respondek@insa-rouen.fr*

Adaptive Contol, B2L-A

Day: Tuesday, August 27, 2019
Time: 10:00 - 11:00
Room: Marco Polo
Chair: Dirk Weidemann

Paper: **4063** **B2L-A**

Robust and Adaptive Ship Path-Following Control Design with the Full Vessel Model

Zenon Zwierzewicz[1]

[1] *Szczecin Maritime University z.zwierzewicz@am.szczecin.pl*

The paper considers the problem of ship path-following system design based on realistic, nonlinear, full, surface ship model. The ship under consideration is an underactuated, course-unstable, nonlinear object. Since it is assumed that the ship's parameters are unknown and there are significant environmental disturbances and unmodeled dynamics, the applied design procedures combine the robust and adaptive control techniques. As the basis for controller synthesis, the adaptive output feedback linearization and H optimal control techniques have been used. Simulations of the ship path-following process are provided to illustrate the effectiveness and superiority of the proposed control scheme.

Paper: **4106** **B2L-A**

Adaptive, Nonlinear Control of a Third-Order Duffing–Holmes Type Chaotic Oscillator

Jacek Kabziński[1], **Przemysław Mosiołek**[2]

[1] *Łódź University of Technology* jacek.kabzinski@p.lodz.pl
[2] *Łódź University of Technology* przemyslaw.mosiolek@p.lodz.pl

A general tracking problem is formulated and solved for a third-order Duffing–Holmes type chaotic oscillator implemented as an electronic circuit with unknown parameters. Two nonlinear controllers, based on adaptive backstepping techniques, are derived and compared. Both are sufficiently robust and accurate for practical implementation. The same approach may be used for chaos stabilization and synchronization.

Paper: **4113** **B2L-A**

Adaptive Identification Method for Simulation and Control of Glass Melting Process

Witold Byrski[1], **Michał Drapała**[2]

[1] *AGH University of Science and Technology* wby@agh.edu.pl
[2] *AGH University of Science and Technology* mdrapala@agh.edu.pl

Adaptive identification method based on modulating function approach is described in this paper. The real glass melting process is modelled by a linear system, which parameters values can be changed on-line during the identification procedure. The overall model is composed of several submodels. The models, which inputs can be controlled, are approximated by the Strejc transfer function. This approach allows to reduce the number of model parameters. Moreover, PID tuning methods dedicated to the Strejc models can be applied. The developed procedure was applied for data collected from a real glass containers production installation.

Robotics II, B2L-B

Day: Tuesday, August 27, 2019
Time: 10:00 - 11:00
Room: Vasco da Gamma
Chair: Przemysław Herman

Paper: **4031** **B2L-B**

Fusion of Gesture and Speech for Increased Accuracy in Human Robot Interaction

Neha Baranwal[1], Avinash Kumar Singh[2], Thomas Hellström[3]

[1] *Umea University* neha@cs.umu.se
[2] *Umea University* avinash@cs.umu.se
[3] *Umea University* thomash@cs.umu.se

An approach for decision level fusion for gesture and speech based human robot interaction (HRI) is proposed. A rule-based method is compared with several machine learning approaches. Gestures and speech signals are initially classified using hidden Markov models, reaching accuracies of 89.6

Paper: **4078** **B2L-B**

The Quality Interaction Function Deployment for Lean Human-Robot Interaction

Marco Bonini[1], Augusto Urru[2], Wolfgang Echelmeyer[3]

[1] *Reutlingen University* marco.bonini@reutlingen-university.de
[2] *Reutlingen University* augusto.urru@reutlingen-university.de
[3] *Reutlingen University* wolfgang.echelmeyer@reutlingen-university.de

The automation of complex and unstructured tasks requires sophisticated, expensive and low-performing systems, whose impact on product quality is oftentimes not directly perceived by customers. As a result, the full automation of process chains in the general manufacturing or the logistic sectors is often a sub-optimal solution. Taking the distance from the false idea that a process should be either fully automated, or fully manual, this paper presents a novel heuristic method for design of lean human-robot interaction, the Quality Interaction Function Deployment, with the objective of the "right level of automation". Functions are divided among human and automated agents and several automation scenarios are created and evaluated with respect to their compliance to the requirements of all process stakeholders.

Paper: **4079** **B2L-B**

Achievable Stereo Vision Depth Accuracy with Changing Camera Baseline

Jurek Sasiadek[1], **Mark Walker**[2]

[1] *Carleton University* jurek.sasiadek@carleton.ca
[2] *Carleton University* mark.walker@carleton.ca

This paper examines the effect on achievable depth accuracy of a stereo vision system as the baseline between the two camera sensors changes. This is critical for Unmanned Aerial Vehicle navigation or UAV aerial refueling, and for space debris clearance operations. The theory behind stereo image depth calculation is explained and then synthetic pixel data is manufactured in order to determine a 95

Scheduling, B2L-C

Day: Tuesday, August 27, 2019
Time: 10:00 - 11:00
Room: Ferdinand Magellan
Chair: Rafał Stanisławski

Paper: **4070** **B2L-C**

A Memetic Algorithm for the Discrete Scheduling-Location Problem with Unrelated Machines

Mirosław Ławrynowicz[1], **Jerzy Józefczyk**[2]

[1] *Wrocław University of Science and Technology* miroslaw.lawrynowicz@pwr.edu.pl
[2] *Wrocław University of Science and Technology* jerzy.jozefczyk@pwr.edu.pl

This research explores integrated and sequential approaches to a combined task scheduling and discrete facility location optimization problem (ScheLoc). The makespan is considered as a criterion for task scheduling. A Tabu Search based Memetic Algorithm (TSMA) has been developed and applied for the former approach due to the NP-hardness of ScheLoc. For the latter approach, the problem is decomposed into two sub-problems m-median and parallel task scheduling with unrelated executors. Conducted computational experiments have also shown the improvement of results generated by TSMA in comparison with another algorithms known from the literature.

Paper: **4116** **B2L-C**

Cyclic Scheduling of Lots with Setup Times

Czeslaw Smutnicki[1]

[1] *Wrocław University of Science and Technology* czeslaw.smutnicki@pwr.edu.pl

The paper reports very recent results dealing with a prevalent case of so called cyclical manufacturing/production systems supplying various products in lots with inter-lots setup times. Setups appear between series of different goods. We propose a convenient approach for modeling and approximate solving, which uses our previous findings developed already for classical systems occurring in operations research (OR) field, namely job-shop scheduling problem with setups, as well as those proved for cyclical job-shop. Analysis is carried out for a general structure of manufacturing system, namely the job-shop scheduling problem because of practical applicability of this model. We consider chiefly the modelling aspect by using combinatorial representation of a solution with the support of unique class of graphs. We propose the method of finding/evaluating the minimal cycle time for given processing order by using the graph and some special features of the problem.

Paper: **4152** **B2L-C**

Scheduling Identical Jobs with Linear Resource Usage Profile to Minimize Schedule Length

Rafał Różycki[1], **Grzegorz Waligóra**[2]

[1] *Poznań University of Technology* rafal.rozycki@cs.put.poznan.pl
[2] *Poznań University of Technology* grzegorz.waligora@cs.put.poznan.pl

We consider a resource allocation problem, where a limited renewable continuous resource has to be assigned to independent nonpreemptable jobs in such a way that the schedule length is minimized. Each job is characterized be the same profile determined by a resource usage function. We assume that this function is linear and decreasing. Its initial value as well as a drop coefficient are the same for each job. Although, there is no additional discrete resource (i.e. the number of machines is unlimited), the problem may be treated as a scheduling problem, since a limited amount of the continuous resource prevents the parallel execution of all jobs. Thus, to find the schedule with the minimum length, it is necessary to find the optimal sequence of moments when consecutive jobs start. We propose an iterative algorithm to find such moments. Moreover we describe an interesting property of the solutions of the considered problem.

Poster Session II, B3P-D

Day: Tuesday, August 27, 2019
Time: 10:00 - 12:30
Room: Poster Area
Chair: Jerzy Baranowski

Paper: **4014** **B3P-D**

Constrained Controllability of Linear Systems

Jerzy Klamka[1]

[1] *Silesian University of Technology* jerzy.klamka@polsl.pl

In the paper constrained controllability of distributed parameter dynamical system defined in infinite-dimensional domain is considered. Using spectral theory of unbounded differential operators, necessary and sufficient conditions constrained controllability are formulated and proved. Remarks and comments on the relationships between different kinds of controllability are also given. Simple illustrative numerical examples of controllable systems are presented.

Paper: **4035** **B3P-D**

Robust Stabilization of a Discrete-Time Large-Scale Interconnected System Composed of Identical Subsystems

Branislav Rehák[1], **Volodymyr Lynnyk**[2]

[1] *Czech Academy of Sciences* rehakb@utia.cas.cz
[2] *Czech Academy of Sciences* voldemar@utia.cas.cz

Stabilization of a linear discrete-time large-scale interconnected systems composed of identical subsystems is studied. The controls of every subsystem are delayed. The control design is based on a state transformation that decouples the subsystems. Then, a suitable design method is used. Robustness to deal with systems with uncertainties is guaranteed. The results are illustrated by an example.

Paper: **4036** **B3P-D**

Stability Conditions for Fractional Discrete-Time State-Space Systems with Delays

Andrzej Ruszewski[1]

[1] *Bialystok University of Technology* a.ruszewski@pb.edu.pl

The stability problem of fractional discrete-time linear systems with delays has been analysed. The state-space model with a time shift in the difference has been considered. New necessary and sufficient conditions for the asymptotic stability and the practical stability have been established. The single delay systems have been also analysed. It has

been shown that such systems are asymptotically (practically) stable if all eigenvalues of the state matrix lie in the stability region of the complex plane.

Paper: **4066** **B3P-D**

Controllability of Switched Discrete-Time Fractional Order Systems with Constrained Switching Sequence

Artur Babiarz[1], Adam Czornik[2]

[1] *Silesian University of Technology* artur.babiarz@polsl.pl
[2] *Silesian University of Technology* adam.czornik@polsl.pl

The controllability problem for discrete-time linear fractional switched systems is considered. In the paper, it is assumed that there are some constraints posed on the switching signal. Moreover, a necessary and sufficient conditions of some kinds of controllability are formulated. Three types of controllability, namely: from zero initial state to any final state, from any initial state to zero final state and from any initial state to any final state are considered. At the end, an example is presented.

Paper: **4099** **B3P-D**

Position Control for Polynomial Underactuated Surface Vessels: a Sum-of-Squares Approach

Navid Vafamand[1], Mohammad-Hassan Khooban[2], Jalil Boudjadar[3]

[1] *Shiraz University* navidvafamand@gmail.com
[2] *Aarhus University* khooban@eng.au.dk
[3] *Aarhus University* jalil@eng.au.dk

With the advantages of marine vessel systems, the control problems of underactuated surface vessels (USVs) have become more and more significant in the last decade. The main challenge and difficulty of controlling the positon of the USVs is that they involve six nonlinear and polynomial dynamics; meanwhile the available control inputs are only two. Hence, the main goal of this study is to introduce a new polynomial structure for a class of marine systems with polynomial dynamics. The suggested technique relies on a polynomial modeling, a polynomial controller and a sum-of-squares (SOS) decomposition. The new proposed approach is completely compatible with the structure of the USV; since both has polynomial dynamics. The USV-based control structure is formulated in terms of SOS conditions and can be numerically solved by the existing solver through a semi-definite programming. Unlike the conventional approaches, the proposed approach can be easily implemented in the real-time and applied to a reasonably wide class of non-linear systems.

Paper: **4123** **B3P-D**

Discrete Time Sliding Mode Control in the Presence of State and Control Signal Constraints

Marek Jaskuła[1], **Piotr Leśniewski**[2]

[1] *Łódź University of Technology 800903@edu.p.lodz.pl*
[2] *Łódź University of Technology piotr.lesniewski@p.lodz.pl*

In this paper we consider the discrete time sliding mode control of the plant perturbed by the unknown, bounded external disturbances. The controller is designed using the reaching law approach. This method allows us to better control the systems dynamics up to the sliding phase. The rate of convergence of the sliding variable to zero is chosen in such a manner to ensure the fulfillment of the given constraints on the system state and the control signal. The properties of the proposed sliding mode controller are demonstrated analytically and in computer simulations.

Paper: **4126** **B3P-D**

New Approach for Minimalvariance Observer Design

Jerzy Kurek[1]

[1] *Politechnika Warszawska jkurek@mchtr.pw.edu.pl*

New approach for minimalvariance observer design is presented. The design is simple one and can be easily used in practice. The proposed observer enables ones simple state estimation for linear stochastic system. The proposed approach is illustrated by numerical example.

Paper: **4129** **B3P-D**

Application-Based Discussion of Verified Simulations of Interval Enclosure Techniques

Julia Kersten[1], **Andreas Rauh**[2], **Harald Aschemann**[3]

[1] *University of Rostock julia.kersten@uni-rostock.de*
[2] *University of Rostock andreas.rauh@uni-rostock.de*
[3] *University of Rostock harald.aschemann@uni-rostock.de*

Dynamical systems are often subject to uncertainties, whether it be parameter uncertainties or the interpretation of state dependencies in quasi-linear state-space representations as some kind of uncertain parameters. The first group of uncertainties arises from mathematical model simplifications, manufacturing tolerances, and imperfect measurements. Here, uncertainties can be represented in different forms like probability distributions in the stochastic case or interval representations in a bounded error framework. On the one hand, there exist numerous techniques to handle stochastic uncertainty, but those do not allow for the computation of worst-case bounds of the sets of reachable states. On the other hand, approaches based on interval analysis are capable of the latter aspect.

This paper deals with those methods from the perspective of an application scenario in the form of the robust stabilization of an inverted pendulum by using constant controller gains. Here, we assume an interval representation for the bounded influence of state dependencies in the system matrices by a polytopic uncertainty model.

Paper: **4137** **B3P-D**

Iterative Learning Control of Deflections in Vibrating Beam

Kamil Klimkowicz[1], Robert Maniarski[2], Maciej Patan[3]

[1] *University of Zielona Góra* k.klimkowicz@issi.uz.zgora.pl
[2] *University of Zielona Góra* r.maniarski@issi.uz.zgora.pl
[3] *University of Zielona Góra* M.Patan@issi.uz.zgora.pl

The paper discuss an effective approach to iterative learning control synthesis for a class of distributed parameter systems described by partial differential equations with biharmonic operator. The study is carried out based on the example of transverse displacements in a cantilever beam induced by the external loads. The sufficient conditions for the convergence of the proposed iterative control law are formulated. Also, the resulting control learning scheme supported by effective implementation based on the finite element method was investigated subject to the different configurations of actuator/sensor field.

Paper: **4145** **B3P-D**

Design of Distributed Robust Control of 1D-Spatially Interconnected Systems in the Repetitive Process Setting

Robert Maniarski[1], Kamil Klimkowicz[2], Wojciech Paszke[3]

[1] *University of Zielona Góra* r.maniarski@issi.uz.zgora.pl
[2] *University of Zielona Góra* k.klimkowicz@issi.uz.zgora.pl
[3] *University of Zielona Góra* w.paszke@issi.uz.zgora.pl

In this paper we consider the Hinf controller design problem for uncertain differential linear repetitive processes via full order dynamic output feedback controllers. The existence condition of desired robust Hinf controllers is expressed as a feasibility problem of a linear matrix inequality (LMI). Then it is shown that the developed results can be applied to robust distributed controller design for 1D-spatially interconnected systems that are composed of several linear continuous-time subsystems, where each directly interacts with neighboring subsystems. A simulation based case study on the model of a vehicle platoons system is given to demonstrate the feasibility and effectiveness of the new designs.

Paper: **4148** **B3P-D**

Selected Methods for Increasing the Accuracy of Vehicle Lights Detection

Piotr Bogacki[1], Rafał Długosz[2]

[1] *Aptiv Services Poland S.A.* piotr.bogacki@aptiv.com
[2] *Aptiv Services Poland S.A.* rafal.dlugosz@aptiv.com

The paper presents selected methods for improving the accuracy of classification of headlights and taillights of the vehicles and other light sources. The methods include analyzing blob properties and locations of the detections. A new feature for describing binary blob shape has been proposed. Moreover, data augmentation technique has been used to improve the results of the classification. The referenced system is based on convolutional neural networks (CNNs). New solutions have been tested with comprehensive set of video sequences (of total duration exceeding ten hours) under various weather conditions and from different road types.

Paper: **4084** **B3P-D**

JamesBot - an Intelligent Agent Playing StarCraft II

Zdzisław Kowalczuk[1], Jan Cybulski[2], Michał Czubenko[3]

[1] *Gdansk University of Technology* kova@pg.edu.pl
[2] *Gdansk University of Technology* unknown@mail.com
[3] *Gdansk University of Technology* unknown@mail.com

The most popular method for optimizing a certain strategy based on a reward is Reinforcement Learning (RL). Lately, a big challenge for this technique are computer games such as StarCraft II which is a real-time strategy game, created by Blizzard. The main idea of this game is to fight between agents and control objects on the battlefield in order to defeat the enemy. This work concerns creating an autonomous bot using reinforced learning, in particular, the Q-Learning algorithm for playing StarCraft. JamesBot consists of three parts. State Manager processes relevant information from the environment. Decision Manager consists of a table implementation of the Q-Learning algorithm, which assigns actions to states, and the epsilon-greedy strategy, which determines the behavior of the bot. In turn, Action Manager is responsible for executing commands. Testing bots involves fighting the default (simple) agent built into the game. Although JamesBot played better than the default (random) agent, it failed to gain the ability to defeat the opponent. The obtained results, however, are quite promising in terms of the possibilities of further development.

Fractional Order Systems I, B4L-A

Day: Tuesday, August 27, 2019
Time: 11:20 - 13:00
Room: Marco Polo
Chair: Tadeusz Kaczorek

Paper: **4009** **B4L-A**

Poles and Zeros of Standard and Fractional Positive Stable Linear Systems

Tadeusz Kaczorek[1], Łukasz Sajewski[2]

[1] *Białystok University of Technology* kaczorek@ee.pw.edu.pl
[2] *Białystok University of Technology* l.sajewski@pb.edu.pl

Standard and fractional positive stable continuous-time linear system with transfer matrices having only positive coefficients are analyzed. It is shown that if the positive system is asymptotically stable then its zeros are located in the open left-hand part of the complex plane. Some invariant properties of positive standard and fractional linear systems are discussed.

Paper: **4030** **B4L-A**

An Interpolation Approach to the Integer–Order Approximation of Fractional–Order Systems

Daniele Casagrande[1], Wiesław Krajewski[2], Umberto Viaro[3]

[1] *University of Udine* daniele.casagrande@uniud.it
[2] *Polish Academy of Sciences* krajewsk@ibspan.waw.pl
[3] *University of Udine* viaro@uniud.it

A state–space integer–order approximation of a commensurate-order systems is obtained using a data-driven interpolation approach based on Loewner matrices. Precisely, given the values of the original fractional–order transfer function at a number of generalised frequencies, a descriptor-form state–space model matching these frequency response values is constructed from a suitable Loewner matrix pencil, as already suggested for the reduction of high–dimensional integer–order systems. Even if the stability of the resulting integer–order system cannot be guaranteed, such an approach is particularly suitable for approximating (infinite–dimensional) fractional-order systems because: (i) the order of the approximation is bounded by half the number of interpolation points, (ii) the procedure is more robust and simple than alternative approximation methods, and (iii) the procedure is fairly flexible and often leads to satisfactory results, as shown by a pair of examples taken from the literature. Clearly, the approximation depends on the location, spacing and number of the generalised interpolation frequencies.

Paper: **4090** **B4L-A**

Variable-, Fractional-Order Linear MIMO System Matrix Description

Piotr Ostalczyk[1]

[1] *Łódź University of Technology* postalcz@p.lodz.pl

In the paper we propose a novelty method of the variable-, fractional-order (VFO) multi - input multi -output (MIMO) discrete-time linear system description. Although the description is based on block matrices each in upper triangular form it has many common features with the matrix transfer functions and matrix-fraction descriptions of multivariable systems. Selected properties of the proposed matrices are given. The investigations are supported by an example.

Paper: **4097** **B4L-A**

Expansion of a Solver for Nonlinear Fractional Problems - the Inclusion of Time Delays

Marcin Sowa[1], **Klaudia Dziedzic**[2]

[1] *Silesian University of Technology* marcin.sowa@polsl.pl
[2] *AGH University of Science and Technology* klaudia.dziedzic04@gmail.com

The study concerns a numerical solver that can be applied in Matlab and Octave. At this stage where the solver is able to solve nonlinear fractional problems - an initial study is made at the attempt to support the inclusion of time delays. The aim is for the solver to be able to solve delay nonlinear fractional differential equations. An example of control theory is brought forth and solved. The error estimation results are presented and a verification of the solution is performed. The verification especially targets the time delay, which is a new element that can be included in problems supported by the solver.

Paper: **4108** **B4L-A**

Fractional-Order Difference Basis Functions a New Modeling Concept for Dynamical Systems

Marcin Gałek[1], **Rafał Stanisławski**[2], **Marek Rydel**[3], **Krzysztof J. Latawiec**[4], **Marian Łukaniszyn**[5]

[1] *Opole University of Technology* galek.marcin@gmail.com
[2] *Opole University of Technology* r.stanislawski@po.opole.pl
[3] *Opole University of Technology* m.rydel@po.opole.pl
[4] *Opole University of Technology* k.latawiec@po.opole.pl
[5] *Opole University of Technology* m.lukaniszyn@po.opole.pl

This paper presents a new concept for modeling of linear fractional-order dynamical systems. The proposed model is based on specific basis functions, the so called Fractional-order Difference Basis Functions, which are a generalization of the delayed filters used in

the FIR model. In the paper, we show elementary properties of the model and present a method for model implementation. Simulation example shows that the model can be effective in modeling of a class of dynamical systems.

Path Planning & Trajectory Tracking, B4L-B

Day: Tuesday, August 27, 2019
Time: 11:20 - 13:00
Room: Vasco da Gamma
Chair: Wojciech Hunek

Paper: **4073** **B4L-B**

Robotic Manipulator Path-Planning: Cost-Function Approximation with Fuzzy Inference System

Dániel Szabó[1], Emese Gincsainé Szádeczky-Kardoss[2]

[1] *Budapest University of Technology and Economics* szabo.daniel0604@gmail.com
[2] *Budapest University of Technology and Economics* szadeczky@iit.bme.hu

This paper presents an offline path-planning method for robotic manipulators in static environment. The framework is based on the Transition-based Rapidly-exploring Random Tree (T-RRT) algorithm that requires a cost for each configurations. In this work, the calculation of this cost-function is based on the distance between the position and configurations that cause collisions. This function is evaluated with fuzzy function approximation which lead to an efficient way to determine the cost all over the configuration space. The method is general, the only restriction is that the segments of the robot and the obstacles are modelled as convex polyhedrons. The approach is validated through simulations in MATLAB Simulink environment with Mitsubishi RV-2F-Q manipulator.

Paper: **4059** **B4L-B**

Dynamic Trajectory Planning for Autonomous Driving Based on Fluid Simulation

Tomasz Sułkowski[1], Paulina Bugiel[2], Jacek Izydorczyk[3]

[1] *Aptiv Services Poland S.A.* tomasz_sulkowski@wp.pl
[2] *Aptiv Services Poland S.A.* bugiel.paulina@gmail.com
[3] *Silesian University of Technology* jacek.izydorczyk@ieee.org

This paper describes the use of Lattice Boltzmann Method for dynamic autonomous driving trajectory planning. By simulating fluid flow on roads as a two-dimensional tubes in a small area around ego car, a vector map is created which can be used as a direct basis for driving trajectory. To tailor the phenomena of fluid flow for legal driving trajectory, the simulated fluid source is placed at an offset angle while dynamically following target car and road borders generate additional potential field. Simulation experiments have

shown that fluid simulation needs to propagate relatively to car driven distance for the algorithm to be feasible. During evaluation such ratio has been found and approximated.

Paper: **4098** **B4L-B**

Trajectory Control of the Wheeled Mobile Robots in Dynamic Environment

Botao Zhang[1], Aleksandr Krasnov[2], Aleksey Chepinskiy[3], Valery Grigoriev[4], Kirill Artemov[5], Duzhesheng Liao[6], Shengyi Zhang[7], Jian Wang[8]

[1]*Hangzhou Dianzi University* billow@hdu.edu.cn
[2]*ITMO University* krasnov.aleksander@gmail.com
[3]*ITMO University* chepinsky_s@hotmail.com
[4]*ITMO University* grigvv@yandex.ru
[5]*ITMO University* kaartemov@corp.ifmo.ru
[6]*ITMO University* ldzs2015@gmail.com
[7]*ITMO University* 1242033174@qq.com
[8]*Hangzhou Dianzi University* wangjian@hdu.edu.cn

This article deals with the problem of the trajectory control of wheeled mobile robots in presence of moving external objects. A procedure of the controllers design based on stabilisation of geometric manifolds using transformation of the mathematical model to the task-oriented basis without velocities measure is proposed. Efficiency of proposed algorithms is proven by numerical simulation results and experimental implementation on wheeled mobile robot.

Paper: **4049** **B4L-B**

Formation of Two-Wheeled Mobile Robots Moving in the Task Space with Static Obstacles - Numerical Verification for Bounded Controls

Wojciech Kowalczyk[1], Krzysztof Kozłowski[2]

[1]*Poznań University of Technology* wojciech.kowalczyk@put.poznan.pl
[2]*Poznań University of Technology* krzysztof.kozlowski@put.poznan.pl

This paper presents control algorithm for formation of multiple non-holonomic mobile robots. It combines persistent excitation trajectory tracking algorithm and collision avoidance based on artificial potential functions. The robots avoid collision with each other and static obstacles existing in the task-space. Stability analysis of the closed-loop system based on Lyapunov-like function is presented. Effectiveness of the proposed method is illustrated by simulation results. They include also case of bounded wheel controls.

Paper: **4024** **B4L-B**

Trajectory Tracking of a Tri-Wheel Mobile Robot Using the Castor Wheel's Twist Angle

Ryszard Beniak[1], **Tomasz Pyka**[2]

[1] *Opole University of Technology* r.beniak@po.opole.pl
[2] *Opole University of Technology* t.pyka@po.opole.pl

This paper presents an advanced control algorithm, which accounts for an additional impact of a castor wheel on a tri-wheel robot's trajectory. It demonstrates how to use the information on the angle of twist in order to limit the errors stemming from odometry. Thanks to applying the proven relationship between the trajectory's curvature and the angle of twist of a castor free wheel, we reduced the driving wheels' rotation errors in the robot's motion along the desired trajectory.

Control Applications, B4L-C

Day: Tuesday, August 27, 2019
Time: 11:20 - 13:00
Room: Ferdinand Magellan
Chair: Andreas Rauh

Paper: **4012** **B4L-C**

A Simple Heuristic Approach for Attitude/Altitude Control of a Quadrotor with Uncertain Parameters

Amit Ailon[1], **Shai Arogeti**[2]

[1] *Ben Gurion University of the Negev* amit@ee.bgu.ac.il
[2] *Ben Gurion University of the Negev* arogeti@bgu.ac.il

In this article we present a simple control procedure for a quadrotor that ensures convergence to a required altitude and attitude set-points under conditions of unknown physical parameters. The quadrotor model is highly nonlinear. The altitude set-point strategy is based on a two-mode control strategy: coarse and the fine motion modes and a sort of huristic process. In the first control mode we apply piecewise control functions. In the attitude regulation the design procedure is based on the passivity-based approach and in particular the controller is independent of the system physical parameters. The considered control strategy might be useful in various aerial missions in which stable hovering is required as for example in reconnaissance and aerial photography flights. The control design complies with the system structure which restricts the thrust force to act in one direction. Simulation results demonstrate the controller performance.

Paper: **4153** **B4L-C**

On the First Single-Nonlinearity Seven-Term Memristor-Based Chaotic Snap System: a Line Equilibrium and Coexisting Hidden Attractors

Irfan Ahmad[1], **Banlue Srisuchinwong**[2]

[1] *Thammasat University* irfan.ahmad2691@gmail.com
[2] *Thammasat University* banlue@siit.tu.ac.th

A novel simple single-nonlinearity seven-term memristor-based chaotic snap system is proposed. The system exhibits a line equilibrium and coexisting hidden attractors, and is simpler than three existing memristor-based chaotic snap systems in the sense that it comprises (i) only seven algebraic terms and (ii) a single term of (intrinsic memristive) nonlinearity. In some regions of parameter space, a chaotic attractor coexists with a line equilibrium or with a limit cycle of different periods. Basin boundaries of limit cycles and chaotic attractors have an intricate fractal structure. In some other regions, two limit cycles are coexisting. The proposed simple chaotic snap system offers potential applications to e.g. chaos-based secure communications and control applications.

Paper: **4155** **B4L-C**

Multicriteria Coordination of Flood Control in Water Reservoir Systems

Andrzej Skulimowski[1]

[1] *AGH University of Science and Technology* ams@agh.edu.pl

This paper presents an application of reference multifunction method to design decision support systems dedicated to selecting optimal reservoir control strategies in the situation of flood emergency. A system of water reservoirs with separate directions, economical goals, and protection subregions is situated on feeders while the flood wave on the recipient between and beneath the feeder mouths is controlled by a coordinated release of water from the reservoirs. The flood damage is minimized by a suitable dynamic multicriteria coordination with the environmental, financial and human life protection related criteria. The coordinating decision center assures that the values of the individual reservoirs' criteria are nondominated and belong to a given set of acceptable values of criteria on certain subinterval of the control period. We provide an architecture of the decision support system capable of solving the coordination problem in real-time with a real-life example from the reservoir system in the Upper Vistula basin, Poland

SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles I, B5L-A

Day: Tuesday, August 27, 2019
Time: 15:00 - 16:20
Room: Marco Polo
Chair: Paweł Skruch

Paper: **4021** **B5L-A**

Calculation of Descriptive Statistics by Devices with Low Computational Resources for Use in Calibration of V2I System

Katarzyna Kubiak[1], Marzena Banach[2], Rafał Długosz[3]

[1] *Adam Mickiewicz University* kbkubiak45@gmail.com
[2] *Poznań University of Technology* marzena.banach@erba.com
[3] *Aptiv Services Poland S.A.* rafal.dlugosz@aptiv.com

In this work we present modified iterative methods for computing basic statistical quantities (mean, variance), for the use in the calibration process of a system based on V2I (vehicle-to-infrastructure) communication devices. Such devices, mounted in road and urban infrastructure (RSU - road side equipment) may be used as a support for autonomous vehicles moving in urban environment. The calibration is necessary to determine the positions of the RSUs in global coordinate system (GCS) and to record this information in their internal memory. The proposed modifications to conventional iterative algorithms are aimed at adapting these methods to the application in devices with low computational abilities or directly at the transistor level in specialized integrated circuits.

Paper: **4158** **B5L-A**

Techniques to Facilitate the Use of V2I Communication System As Support for Traffic Sign Recognition Algorithms

Marzena Banach[1], Rafał Długosz[2]

[1] *Poznań University of Technology* marzena.banach@erba.com
[2] *Aptiv Services Poland S.A.* rafal.dlugosz@aptiv.com

Solutions proposed in this work are related to development of vehicle-to-infrastructure (V2I) communication in the context of its support for Traffic Sign Recognition (TSR) algorithms used in advanced driver assistance systems (ADAS). One of the ideas of the application of the V2I communication, proposed in the literature, is to equip traffic signs (TS) with devices, capable of communicating their meaning to passing vehicles equipped with ADAS functions or autonomous vehicles. We propose grouping TSs and covering groups with single road side unit (RSU) devices. it will facilitate implementation and maintenance of the overall system. This will also reduce the amount of data sent over the network.

Paper: **4037** **B5L-A**

Camera Model for Lens with Strong Distortion in Automotive Application

Kamil Lelowicz[1]

[1] *AGH University of Science and Technology* lelowicz@agh.edu.pl

Document presents mathematical model of camera with strong lens distortion that can be used in calibration process and in a computer vision algorithms. Camera distortion is a significant problem in computer vision. Both radial and tangential aberration are taken into consideration. Moreover, a comparison of the use of the division and Brown-Conrady models has been presented.

Control & Systems Theory II, B5L-B

Day: Tuesday, August 27, 2019
Time: 15:00 - 16:20
Room: Vasco da Gamma
Chair: Harald Aschemann

Paper: **4127** **B5L-B**

An Application of the Induced Matrix Norm in the Minimum-Energy Design of Perfect Control Algorithm

Dariusz Pączko[1], **Wojciech Hunek**[2]

[1] *Opole University of Technology* d.paczko@po.opole.pl
[2] *Opole University of Technology* w.hunek@po.opole.pl

In the previous research study it has been pointed out that employing the approximation of the induced matrix norm can be useful during design of minimum-energy perfect control law for LTI MIMO discrete-time state-space plants. It has also been shown that this scenario was related to the case involving the closed-loop control matrix norm being less than unity, which was preserved by proper selection of applied non-unique inverses. This paper focuses on the systems which have been excluded from our past considerations. The methodology of minimum-energy approach for plants with norm greater than one is postulated here and some peculiarities in this matter additionally are given. This innovative method allows to predefine in a simple way a minimum-energy behavior of this intriguing control procedure.

Paper: **4087** **B5L-B**

Relative Degree One and Two Sliding Variables for Multi-Input Discrete-Time Systems

Paweł Latosiński[1], **Andrzej Bartoszewicz**[2]

[1] *Łódź University of Technology* pawel.latosinski@p.lodz.pl
[2] *Łódź University of Technology* andrzej.bartoszewicz@p.lodz.pl

In this paper we consider sliding mode control of multi-input discrete-time plants. For such plants, we propose the use of relative degree two sliding variables, which are known to improve robustness of single-input plants compared to their relative degree one equivalent. We investigate the design procedure of relative degree two sliding variables for multi-input systems. Then, we present two sliding mode control strategies obtained with the reaching law approach, using relative degree one and two sliding variables, respectively. We demonstrate that both reaching laws ensure desirable properties of the system sliding motion and that the method using relative degree two sliding variables ensures better robustness of the system than the one with relative degree one variables. We further show that the proposed reaching law based strategies enable independent tuning of individual inputs.

Paper: **4134** **B5L-B**

Periodic Regimes of Motion of a Body with a Moving Internal Mass

Tatiana Figurina[1], **Dmitri Knyazkov**[2]

[1] *Ishlinsky Institute for Problems in Mechanics RAS* t_figurina@mail.ru
[2] *Ishlinsky Institute for Problems in Mechanics RAS* knyaz@ipmnet.ru

We consider motion of a body with an internal mass, that moves periodically without velocity jumps. The body moves in a resistive environment. We investigate regimes, when the body's velocity is also periodic. We prove that the periodic regime exists, is unique and exponentially stable for the majority of resistances. A two-sided estimate of the periodic regime initial velocity is obtained. For linear and piecewise linear resistances, a periodic regime is constructed; the rate of the exponential convergence to this regime is found. The general results are illustrated by simulations for parameters of a physical prototype of a capsule robot.

Paper: **4047** **B5L-B**

Discrete-Time Design of Model Reference Learning Control System

Edi Kurniawan[1], Bambang Widiyatmoko[2], Dwi Bayuwati[3], M. Imam Afandi[4], Suryadi Suryadi[5], Mefina Y. Rofianingrum[6]

[1] *Indonesian Institute of Sciences* edi.kurniawan@lipi.go.id
[2] *Indonesian Institute of Sciences* bamb039@lipi.go.id
[3] *Indonesian Institute of Sciences* dwib001@lipi.go.id
[4] *Indonesian Institute of Sciences* mohamad.imam.afandi@lipi.go.id
[5] *Indonesian Institute of Sciences* sury011@lipi.go.id
[6] *Indonesian Institute of Sciences* mefi001@lipi.go.id

This paper presents the design of discrete-time model reference learning control of linear system for tracking aperiodic signal while rejecting periodic disturbance. The design integrates Model Reference Control (MRC) and Iterative Learning Control (ILC) in order to achieve the desired objective. The use of MRC makes tracking any reference signal is possible, while ILC is used to eliminate the periodic disturbance. The proposed design is simulated on LTI system with repetitive output disturbance. Model reference learning control with several ILC learning gains are simulated. It is shown that ILC learning gain can be tuned to determine the convergence rate and stability of the whole system. Simulation results indicate that the accurate tracking of aperiodic reference can be achieved as long as the plant and disturbance models are accurately known.

Optimization, B5L-C

Day: Tuesday, August 27, 2019
Time: 15:00 - 16:20
Room: Ferdinand Magellan
Chair: Czesław Smutnicki

Paper: **4055** **B5L-C**

Parameter Optimization of Control with Feedback Linearization for a Model of Thermoelectric Processes in Cylindrical Bodies

Alexander Gavrikov[1], Georgy Kostin[2], Dmitri Knyazkov[3], Andreas Rauh[4], Harald Aschemann[5]

[1] *Ishlinsky Institute for Problems in Mechanics RAS* gavrikov@ipmnet.ru
[2] *Ishlinsky Institute for Problems in Mechanics RAS* kostin@ipmnet.ru
[3] *Ishlinsky Institute for Problems in Mechanics RAS* knyaz@ipmnet.ru
[4] *University of Rostock* andreas.rauh@uni-rostock.de
[5] *University of Rostock* harald.aschemann@uni-rostock.de

In this paper, mathematical modeling of transient processes and parameter optimization of control laws for heat transfer in a conductive solid structure are considered. In accordance

with an implementation of an experimental setup, a nonlinear model is proposed for the thermoelectric process in a Peltier element arranged in between of two metal cylinders. The method of separation of variables is applied to reduce the spatially three-dimensional system to a finite set of ordinary differential equations. The nonlinearity of the resulting equations with respect to the temperature state is eliminated by introducing feedback control in the form of a voltage proportional to the temperature drop on the Peltier element. Additionally, a feedforward control law defined by a piecewise constant function of time is optimized to bring the system, which is still nonlinear with respect to this voltage input, as closely as possible to a prescribed terminal steady state.

Paper: **4071** **B5L-C**

Optimizing Consumer-Side Electricity Usage in a Smart Household

Salma Taik[1], Bálint Kiss[2]

[1]*Budapest University of Technology and Economics* staik@iit.bme.hu
[2]*Budapest University of Technology and Economics* bkiss@iit.bme.hu

In this paper, we discuss the energy consumption of a smart household containing smart electric appliances. The optimal household consumption pattern is the result of two optimization levels when the Time of Use (ToU) tariffs are proposed by the utility company. First, we schedule the smart appliances by solving a Mixed Integer Programming (MIP) optimization problem. The second level is reserved to control the electric heating system with a Model Predictive Controller (MPC) using the output of the first optimization level as energy constraints. Simulation shows the energy efficiency and an optimal electricity cost of the framework proposed.

Paper: **4076** **B5L-C**

Optimization of Traffic Signal Control Based on Game Theoretical Framework

Jian Guo[1], Istvan Harmati[2]

[1]*Budapest University of Technology and Economics* guojian@iit.bme.hu
[2]*Budapest University of Technology and Economics* harmati@iit.bme.hu

This paper presents a model of traffic signal control using a game theoretical framework based on decision-making operations, which aims at finding an optimal solution to reduce traffic congestion. In this game, incoming links (i.e. sections) are regarded as players and the status of signal light (green or red) can be considered as the decisions made by players. The effectiveness of the global optimal strategy and Nash equilibrium strategy produced from a game theoretical framework and constant strategy (i.e. the time interval of red and green lights is always constant and periodical) are compared in the later research.

Paper: **4107** **B5L-C**

An Improved Reinforcement Learning Control Strategy for Batch Processes

Peng Zhang[1], Jie Zhang[2], Yang Long[3], Bingzhang Hu[4]

[1]*Newcastle University* p.zhang9@newcastle.ac.uk
[2]*Newcastle University* jie.zhang@newcastle.ac.uk
[3]*Duram University* Yang.Long@ieee.org
[4]*Newcastle University* Bingzhang.Hu@newcastle.ac.uk

Batch processes are significant and essential manufacturing route for the agile manufacturing of high value added products and they are typically difficult to control . To overcome these issues and difficulties, a modified multi-step action Q-learning algorithm (MMSA) based on multiple step action Q-learning (MSA) is proposed in this paper. For MSA, the action space is divided into some periods of same time steps and the same action is explored with fixed greedy policy being applied continuously during a period. Compared with MSA, the modification of MMSA is that the exploration and selection of action will follow an improved and various greedy policy in the whole system time which can improve the flexibility and speed of the learning algorithm. The proposed algorithm is applied to a highly nonlinear batch process and it is shown giving better control performance than the traditional one-step reinforcement learning and MSA.

Wednesday
August 28th, 2019

Plenary 3: Jeff S. Shamma, C1L-A

Day: Wednesday, August 28, 2019
Time: 09:00 - 10:00
Room: Marco Polo
Chair: Andrzej Bartoszewicz

Paper: **4162** **C1L-A**

Game Theory and Distributed Control

Jeff S. Shamma[1]

[1] *King Abdullah University of Science and Technology* jeff.shamma@kaust.edu.sa

Observers, C2L-A

Day: Wednesday, August 28, 2019
Time: 10:00 - 11:00
Room: Marco Polo
Chair: Wojciech Hunek

Paper: **4051** **C2L-A**

Robust Unknown Input Observer Design for Simultaneous Actuator and Sensor Faults

Marcin Pazera[1], **Marcin Witczak**[2], **Norbert Kukurowski**[3]

[1] *University of Zielona Góra* M.Pazera@issi.uz.zgora.pl
[2] *University of Zielona Góra* M.Witczak@issi.uz.zgora.pl
[3] *University of Zielona Góra* N.Kukurowski@issi.uz.zgora.pl

The paper deals with the problem of simultaneous estimation of the state as well as the sensor and actuator faults. The proposed approach is developed in such a way that it allows decoupling the actuator faults from the state. In a similar fashion, the sensor fault is derived directly from the output. Moreover, the quadratic boundedness approach is utilised for guaranteeing the robust stability of the observer. It supposes that the uncertainty are limited within an ellipsoidal set. The final part of the paper shows the illustrative example with the implementation to the laboratory multi-tank system.

Paper: **4096** **C2L-A**

Interval Observer-Based Controller Design for Systems with State Constraints: Application to Solid Oxide Fuel Cells Stacks

Sara Ifqir[1], Andreas Rauh[2], Julia Kersten[3], Dalil Ichalal[4], Naima Ait-Oufroukh[5], Saïd Mammar[6]

[1] *Université Paris-Sud / Université d'Évry Val-d'Essonne* ifqirsara@gmail.com
[2] *University of Rostock* andreas.rauh@uni-rostock.de
[3] *University of Rostock* julia.kersten@uni-rostock.de
[4] *Université Paris-Sud / Université d'Évry Val-d'Essonne* dalil.ichalal@univ-evry.fr
[5] *Université Paris-Sud / Université d'Évry Val-d'Essonne* naima.aitoufroukh@univ-evry.fr
[6] *Université Paris-Sud / Université d'Évry Val-d'Essonne* said.mammar@univ-evry.fr

For many practical applications, it is necessary to design controllers that are, one the one hand, robust against bounded uncertainty in selected parameters and external disturbances. On the other hand, it is also quite common for such systems, that state constraints need to be accounted for which must not be exceeded for any possible parameter value. Although the task is quite challenging, several robust control design procedures were designed in recent years which allow for solving these problems, especially with respect to the latter aspect. In this paper, such robust control procedures are combined in a novel manner with an interval observer to additionally handle the influence of unknown but bounded measurement noise and to prevent the violation of state constraints in a provable fashion.

Paper: **4101** **C2L-A**

Design of a Takagi-Sugeno State and Disturbance Observer for a Torque-Controlled Hydrostatic Transmission

Dang Ngoc Danh[1], Harald Aschemann[2]

[1] *University of Rostock* Ngoc.Dang@uni-rostock.de
[2] *University of Rostock* Harald.Aschemann@uni-rostock.de

In this paper, a Takagi-Sugeno (TS) state and disturbance observer is designed. The corresponding estimates are employed in a decentralized control approach for the normalized tilt angle of the hydraulic motor as well as the motor torque of a hydrostatic transmission. For the observer design, a nonlinear state-space model is written in quasi-linear form and extended by two integrator disturbance models. The observer gain matrix is derived by an exact interpolation of optimal designs at the vertices of a polytopic description using corresponding membership functions. Asymptotic stability of the observer error dynamics is guaranteed by solving a set of linear matrix inequalities (LMIs) resulting in a joint Lyapunov function. For an accurate trajectory tracking, feedback control is extended by feedforward control. The estimated disturbances from the TS observer are used for a subsequent disturbance rejection. The performance of the observer-based control structure is shown by simulations based on a validated model of a dedicated test rig which is available at the Chair of Mechatronics, University of Rostock.

Robotics III, C2L-B

Day: Wednesday, August 28, 2019
Time: 10:00 - 11:00
Room: Vasco da Gamma
Chair: Krzysztof Kozłowski

Paper: **4114** **C2L-B**

Explicit Interpolating Control of Unmanned Aerial Vehicle

Zdeněk Bouček[1], Miroslav Flídr[2]

[1] *University of West Bohemia* zboucek@ntis.zcu.cz
[2] *University of West Bohemia* flidr@ntis.zcu.cz

The paper deals with the constrained suboptimal control of a quadrotor Unmanned Aerial Vehicle (UAV). First the Optimal Control Problem (OCP) with constraints is formulated and afterwards two methodologies that provide an approximate solution to the OCP are introduced. The first one is called a Model Predictive Control (MPC) which is standard methodology used in this field and it deals with the OCP on the shorter receding horizon. The second one is an Interpolating Control (IC) that uses interpolation of two controllers with different properties, the optimal LQ controller and vertex controller for the unconstrained and constrained cases, respectively. Both methodologies are implemented and compared in the simulation on a planar nonlinear model of the UAV.

Paper: **4138** **C2L-B**

Computation Complexity Evaluation of FastSLAM Algorithm for Unmanned Ground Vehicles

Ahmed E. Al-Tarras[1], Mostafa I. Yacoub[2], Mostafa Asfoor[3], Al-Hussein Sharaf[4]

[1] *Military Technical College* ahmadaltrass@gmail.com
[2] *Military Technical College* mostafa.yacoub@mtc.edu.eg
[3] *Military Technical College* asfoor@mtc.edu.eg
[4] *Military Technical College* a.m.sharaf@mtc.edu.eg

FastSLAM algorithm is commonly used in Unmanned Ground Vehicles (UGVs) recently. One of the main problems under research is the computation cost of this probabilistic algorithm. Since the speed of the UGV is limited by the latency of the algorithm, the computation complexity and its effect on the step time of the FastSLAM needs to be investigated. The present work addresses the effects of the number of particles and number of map features on the computation complexity of the FastSLAM algorithm. The study included the prediction, the observation, data association and resampling phase's complexities. Also, the correlation between the uncertainty of the UGV location and the number of particles was addressed. The simulation study was validated experimentally using hardware in the loop (HIL) setup. The analysis showed that when there is a prior

knowledge of the average number of map features, an optimum number of particle filters could be set for that UGV in the given environment while maintaining an improved performance of the algorithm.

Poster Session III, C3P-D

Day: Wednesday, August 28, 2019
Time: 10:00 - 12:30
Room: Poster Area
Chair: Paweł Dworak

Paper: **4016** **C3P-D**

Overheating of Underground Power Cable Line Due to its Partial Exposition to Solar Radiation

Stanislaw Czapp[1], Filip Ratkowski[2], Seweryn Szultka[3], Adam Tomaszewski[4]

[1] *Gdansk University of Technology* stanislaw.czapp@pg.edu.pl
[2] *Gdansk University of Technology* filip.ratkowski@pg.edu.pl
[3] *Gdansk University of Technology* seweryn.szultka@pg.edu.pl
[4] *Polish Academy of Sciences* atomaszewski@imp.gda.pl

Current-carrying capacity of underground power cable lines depends, among others, on thermal resistivity of the soil and cables layout: trefoil formation, flat formation with or without spacing. If conditions for heat transfer in the ground are favorable, the current-carrying capacity is relatively high. Therefore, it generates risk of the power cables overheating, if part of the cable line is located vertically in the air, to be connected with an overhead power line at its pole. Risk of the overheating is very high especially during strong solar radiation. The maximum permissible cable load for underground thermal condition is too optimistic for part of the cable line placed in the air. This paper presents computer modelling and simulations of thermal conditions of an underground low-voltage cable line, which part is located at the pole of the overhead line. Results of simulations indicate that part of the cables in the air can be strongly overheated.

Paper: **4040** **C3P-D**

Action Recognition by Weighted Averaged Hidden Markov Models

Aleksandra Postawka[1], Przemysław Śliwiński[2]

[1] *Wrocław University of Science and Technology* aleksandra.postawka@pwr.edu.pl
[2] *Wrocław University of Science and Technology* przemyslaw.sliwinski@pwr.edu.pl

In the paper the problem of action recognition with the help of Markov models is considered. We propose an algorithm aiming at reduction of the false positive rate. We state a hypothesis that these errors are caused by learning gesture sequences representing rare movements and not that containing popular ones. Our algorithm translates the sequence

of gestures into the corresponding Markov models which are used for a preliminary classification. The obtained evaluation coefficients (numbers of proper classifications) are then used to determine the best weights in a combined model composed of these models. In order to find a compromise between the number of true positives and the number of false positives, the power function of weights is examined.

Paper: **4043** **C3P-D**

Application of an Adaptive Golomb Block Code Using Asymmetric Inter-Channel Dependencies

Cezary Wernik[1], **Grzegorz Ulacha**[2]

[1] *West Pomeranian University of Technology Szczecin* cwernik@wi.zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* gulacha@wi.zut.edu.pl

In this paper the lossless block encoder application using the adaptive Golomb code and asymmetric inter-channel dependencies are presented. Using the sets of settings obtained from the study of inter-channel dependencies, the lowest bit averages were found within the channels. In the next step the algorithm was improved by adaptation within the blocks, what allowed to improving the degree of compression.

Paper: **4092** **C3P-D**

System Identification and Model Comparison of a Tension Leg Platform for Floating Offshore Wind Turbines

Thomas Hansen[1], **Maria Jørgensen**[2], **Van Roy Tran**[3], **Kasper Jessen**[4], **Mohsen Soltani**[5]

[1] *Aalborg University* th15@student.aau.dk
[2] *Aalborg University* mjorge15@student.aau.dk
[3] *Aalborg University* vtran15@student.aau.dk
[4] *Aalborg University* kje@et.aau.dk
[5] *Aalborg University* sms@et.aau.dk

This paper focuses on using System Identification for identifying a model for a floating offshore wind turbine for a 1:35 scaled model of the 5 MW NREL turbine. To obtain such a model, an examination of the response due to the hydrodynamic loads will be conducted on the TLP foundation of the FOWT. The examination will be based on generated irregular Pierson-Moskowitz waves. System Identification is used to analyze the data obtained from experiments to determine different models describing the floating offshore wind turbine. The paper concludes that the ARMAX model is the most accurate model at describing it.

Paper: **4112** **C3P-D**

A New Classification and Aerial Manipulation Q-PRR Design

Kamel Bouzgou[1], Laredj Benchikh[2], Lydie Nouveliere[3], Yasmina Bestaoui[4], Zoubir Ahmed-Foitih[5]

[1] *Université Paris-Sud / Université d'Évry Val-d'Essonne* kamel.bouzgou@univ-usto.dz
[2] *Université Paris-Sud / Université d'Évry Val-d'Essonne* laredj.benchikh@univ-evry.fr
[3] *Université Paris-Sud / Université d'Évry Val-d'Essonne* lydie.nouveliere@univ-evry.fr
[4] *Université Paris-Sud / Université d'Évry Val-d'Essonne* yasmina.bestaoui@univ-evry.fr
[5] *Oran University of Science and Technology - Mohamed Boudiaf* zoubir.foitih@univ-usto.dz

This paper presents a new designation and classification of the UAV and robot manipulator systems where a new nomenclature is recognized as being the first contribution in the design and system bibliography. Several papers deal a problem of manipulation with a different unmanned aerial vehicle, robot arms and also with different naming of their systems, where the difficulty in locating and finding items and a good paper with its title or even by keywords,The multirotor equipped with the n-DoF robotic arm is one of the most widely used expression to describe such a structure. The aerial manipulation formula is presented and proved with a large example in the literature.

Paper: **4121** **C3P-D**

Motor Failure Tolerant Control System with Self Diagnostics for Unmanned Multirotors

Leszek Ambroziak[1], Ashutosh Simha[2], Ewa Pawłuszewicz[3], Ulle Kotta[4], Arkadiusz Bożko[5], Mirosław Kondratiuk[6]

[1] *Bialystok University of Technology* l.ambroziak@pb.edu.pl
[2] *Tallinn University of Technology* ashutosh.iisc@gmail.com
[3] *Bialystok University of Technology* e.pawluszewicz@pb.edu.pl
[4] *Tallinn University of Technology* kotta@cc.ioc.ee
[5] *Bialystok University of Technology* a.bozko@pb.edu.pl
[6] *Bialystok University of Technology* m.kondratiuk@pb.edu.pl

The paper presents a method for rotor failure detection and control system reconfiguration in case of unmanned multirotor propulsion system breakdown. The proposed algorithm uses onboard IMU orientation information for failure detection and isolation. An adaptive fault tolerant control is designed for detecting and correcting partial or complete rotor failures. In case of a complete failure, the center of mass is reconfigured and control system is switched to a tri-rotor configuration. It has been demonstrated through simulations that the adaptive parameters converge to the true values of rotor efficiency. Further, in-flight experiments were conducted to demonstrate the failure detection and fault tolerant controller on a MAV quadrotor. Obtained results validate the effectiveness of the proposed motor failure tolerant control method to effectively compensate for complete loss of one rotor, leading to a resilient flight control mechanism.

Paper: **4131** **C3P-D**

Design, Modeling and Simulation of PID Control for DC/AC Inverters

Marian Blachuta[1], Zbigniew Rymarski[2], Robert Bieda[3], Krzysztof Bernacki[4], Rafal Grygiel[5]

[1] *Silesian University of Technology* blachuta@polsl.pl
[2] *Silesian University of Technology* zbigniew.rymarski@polsl.pl
[3] *Silesian University of Technology* robert.bieda@polsl.pl
[4] *Silesian University of Technology* krzysztof.bernacki@polsl.pl
[5] *Silesian University of Technology* rafal.grygiel@polsl.pl

The paper presents modeling and simulation of DC/AC inverters with PID controllers tuned so as to induce time-scale separation between fast mode of controller and slow mode of the output signal. The sampled data PWM system is modeled using its quasi-continuous time representation. SIMULINK models are used to verify approximations used. The results are compared with a real inverter.

Paper: **4133** **C3P-D**

Constrained Kalman Filtering: Improving Fused Information Retention During Constraining

Felix Baker[1], Suresh Thennadil[2]

[1] *Charles Darwin University* felixmatthew.baker@cdu.edu.au
[2] *Charles Darwin University* suresh.thennadil@cdu.edu.au

Kalman filtering can produce unrealistic values and can prevent accurate convergence as the technique does not naturally include safeguards that exclude unphysical states. It can be demonstrated that without implementing constraints, or even some existing constraint strategies, that the filter could converge incorrectly. Currently available approaches to constraining the estimated state variables are arbitrary. For example, a simple way to constrain a violating state variable, is to reset its value to the constraint limit, the effect of which is a reduction of the importance of the measurement. The proposed constraining method attempts to preserve the importance of the observation/measurement in the fused estimate. This method compensates the changes in the constrained state variables by adjusting the non-constrained state variables in order to force the net change in measurement estimate to zero.

Paper: **4136** **C3P-D**

Speed Control Modeling for in-Wheel Permanent Magnet Brushless DC Motors for Electric Vehicles

Hossam T. Al-Fiky[1], Mostafa Asfoor[2], Mostafa I. Yacoub[3], Al-Hussein Sharaf[4]

[1] *Military Technical College* hossamalfiky2020@gmail.com
[2] *Military Technical College* asfoor@mtc.edu.eg
[3] *Military Technical College* mostafa.yacoub@mtc.edu.eg
[4] *Military Technical College* a.m.sharaf@mtc.edu.eg

In this decade, modern Battery Electric Vehicles (BEVs) had witnessed the intervention of in-wheel BLDC motors which led to improved overall efficiency due to the absence of both; the mechanical powertrain and the brushes. In the present work, a detailed parameterized model of a PM-BLDC motor was considered to estimate its torque-speed characteristics accurately. Three differential equations were simultaneously solved to estimate the motor characteristics. Additionally, an electric drive system was fully modeled including: Li-ion battery, six-step voltage inverters and Hall sensors in the presence of disturbance load torque. For the complete motor parameters to be fed to the model, experimental system identification was implemented. The steady-state response behavior of the motor was validated. In order to control the motor's rotational speed with enhanced transient response, a PID speed controller was implemented. The controlled BLDC motor model results included the speed, back EMF, motor torque and armature phase currents. The results showed that, the proposed in-wheel PM-BLDC motor model could be reliably employed as a tool for BEVs modeling.

Paper: **4140** **C3P-D**

Neural Data Processing in Scanner of Static Elements

Marcin Kaminski[1], Mateusz Malarczyk[2]

[1] *Wrocław University of Science and Technology* marcin.kaminski@pwr.edu.pl
[2] *Wrocław University of Science and Technology* 227532@student.pwr.edu.pl

This article presents design and subsequent implementation stages for the low-cost shape scanner of relatively small elements. The main concept of hardware and data processing algorithm are described. Special software for managing work of the scanner and collecting measurement data was prepared using the Processing programming language. Assuming cost reduction and simple device construction, limited precision of the shape scanning is expected. In order to improve the obtained results, reduce the disturbances and increase the resolution (the number of points describing shape), additional data conversions performed using the neural network were used.

Fractional Order Systems II, C4L-A

Day: Wednesday, August 28, 2019
Time: 11:20 - 13:00
Room: Marco Polo
Chair: Piotr Ostalczyk

Paper: **4020** **C4L-A**

Parameter Identification for the Fractional Order, State Space Model of Heat Transfer Process Using Atangana-Baleanu Operator

Krzysztof Oprzędkiewicz[1], **Wojciech Mitkowski**[2]

[1] *AGH University of Science and Technology* kop@agh.edu.pl
[2] *AGH University of Science and Technology* wojciech.mitkowski@agh.edu.pl

In the paper the parameters identification problem for a new, non integer order, state space model of heat transfer process is presented. The proposed model uses Atangana-Baleanu derivative operator. The analytical formula of step response is proposed. The parameters of the model are estimated via numerical minimization of the Mean Square Error (MSE) cost function. Finally the proposed model is compared to fractional order models using Caputo (C) and Caputo-Fabrizio (CF) operators. Results of numerical tests show, that the accuracy of the proposed model is better than accuracy of CF model, but worse, than accuracy of the C model.

Paper: **4118** **C4L-A**

Markov Parameters of the Input-Output Map for Discrete-Time Order Systems with Grunvald-Letnikov h-Differece Operator

Ewa Pawłuszewicz[1], **Andrzej Koszewnik**[2]

[1] *Bialystok University of Technology* e.pawluszewicz@pb.edu.pl
[2] *Bialystok University of Technology* a.koszewnik@pb.edu.pl

The realization problem of a fractional order discrete-time linear control systems defined by the Grunwald- Letnikov operator is consider. To this aim properties of a Markovtype sequence are studied. It is shown that an abstract inputoutput map has a state-space fractional order realization in finite number of steps if and only if the Markov-type parameters satisfy a linear recursion relation.

Paper: **4144** **C4L-A**

A Digital PID Controller Based on Grünwald-Letnikov Fractional-, Variable-Order Operator

Piotr Oziabło[1], Dorota Mozyrska[2], Malgorzata Wyrwas[3]

[1] *Bialystok University of Technology* p.oziablo@student.pb.edu.pl
[2] *Bialystok University of Technology* d.mozyrska@pb.edu.pl
[3] *Bialystok University of Technology* m.wyrwas@pb.edu.pl

The paper presents an example of implementation of a digital PID controller with Grunwald-Letnikov fractional-, variable-order summations and differences. The method of finding values of orders and parameters K_p, K_i, K_d of such controller for considered plant model is presented. Two summation performance criteria are used to evaluate the results achieved with the usage of fractional-, variable-order PID controller tuned by proposed algorithm. Mentioned criteria are integral squared time weighted error (ISTE) and integral squared time-squared weighted error (IST2E). Additionally the results are compared with the ones obtained with PID controller tuned using Ziegler-Nichols method, PID controller tuned with Matlab 'pidtune' function and PID controller which coefficients were tuned by minimising mentioned ISTE and IST2E errors with Nelder-Mead method (implemented by Matlab 'fminsearch' function).

Paper: **4146** **C4L-A**

Nonlinear Fractional-Order Impedance Control for Knee Rehabilitation

Anake Pomprapa[1], Mohamed Kastouri[2], Lin Liu[3], Steffen Leonhardt[4]

[1] *RWTH Aachen University* pomprapa@hia.rwth-aachen.de
[2] *RWTH Aachen University* mohamed.kastouri@rwth-aachen.de
[3] *RWTH Aachen University* liu@hia.rwth-aachen.de
[4] *RWTH Aachen University* leonhardt@hia.rwth-aachen.de

This article deals with a design of impedance control for 1-DOF knee rehabilitation based on an unconventional form of nonlinear fractional-order proportional-derivative (NL-FOPD) controller. Extremum seeking algorithm is subsequently applied to synthesize the tuning parameters, in order to extremize a cost function and to ensure the optimal solution for this particular application. The simulative results demonstrate system stability and robust performance in the presence of stiffness variation, parametric uncertainty of load dynamics, and torque disturbance that replicates an interaction between a patient and a robot.

Paper: **4147** **C4L-A**

Digital and Analog Design of Fractional PD Controller for a Servo System

Waldemar Bauer[1], **Jerzy Baranowski**[2], **Stavroula Kapoulea**[3], **Costas Psychalinos**[4]

[1] *AGH University of Science and Technology* bauer@agh.edu.pl
[2] *AGH University of Science and Technology* jb@agh.edu.pl
[3] *University of Patras* skapoulea@upnet.gr
[4] *University of Patras* cpsychal@upatras.gr

Paper presents two implementations of a fractional-order proportional-derivative (PD) controller for a position servo system. The first one is an analog one with the offered attractive benefit of using only one second-generation current conveyor (CCII) as an active element, minimizing the active component count compared to the conventional way of implementation where It requires three CCIIs for this purpose. The behavior of the controller is evaluated using the Cadence software and MOS transistor models. The second approach uses a digital implementation of Oustaloup filter in a time domain version.

Identification, C4L-B

Day: Wednesday, August 28, 2019
Time: 11:20 - 13:00
Room: Vasco da Gamma
Chair: Jacek Kabziński

Paper: **4038** **C4L-B**

Parametric Identification of PMSM Mathematical Model

Lukasz Zawarczyński[1], **Tadeusz Stefański**[2]

[1] *Kielce University of Technology* l.zawarczynski@tu.kielce.pl
[2] *Kielce University of Technology* t.stefanski@tu.kielce.pl

The problems of mathematical modelling and parameter identification of PMSM mathematical model were analysed. The numerical Box's method of static optimisation was applied in off-line parametric identification. Parameters of the mathematical models were determined according to minimisation of the mean-square error of the stator current and of the angular velocity. In laboratory tests the influence of the excitation signals and the plan of the experiments on the values of identified parameters were shown. The experimental verification was carried out for the laboratory model of the inverter drive system with PMSM of rated power 2.5 kW.

Paper: **4062** **C4L-B**

Duality-Based Approach to Identification of Linear Time-Varying Hamiltonian Systems with RKHS As Data Descriptors

Joe Alan Roman-Flores[1], **Paolo Rapisarda**[2], **Luis Montesdeoca**[3]

[1] *University of Southampton* joe_alan_k@outlook.com
[2] *University of Southampton* pr3@soton.ac.uk
[3] *University of Southampton* ljm1e14@soton.ac.uk

In this paper we develop a duality based approach for the identification of linear time-varying systems. We exploit the fact that external structures at the level of the inputs and outputs are reflected in the internal structure at the level of the state. Our approach first computes state trajectories from matrices of input-output data. We then develop a factorization of the state trajectories from the input-output data matrices. Then a state space representation compatible with the data is computed. We do not impose conditions in the time variation properties of the to-be-identified system. We exploit the fact that linear time-varying systems as well as nonlinear systems are self-adjoint if they have a internal representation as a linear Hamiltonian. Finally, we utilise reproducing kernel Hilbert spaces (RKHS) to formalize the building of time functions for data and embed it into the duality-based approach.

Paper: **4124** **C4L-B**

Optimization Techniques for the Design of Identification Procedures for the Electro-Chemical Dynamics of High-Temperature Fuel Cells

Wiebke Frenkel[1], **Andreas Rauh**[2], **Julia Kersten**[3], **Harald Aschemann**[4]

[1] *University of Rostock* wiebke.frenkel@uni-rostock.de
[2] *University of Rostock* andreas.rauh@uni-rostock.de
[3] *University of Rostock* julia.kersten@uni-rostock.de
[4] *University of Rostock* harald.aschemann@uni-rostock.de

This paper presents a methodology to design an optimal open-loop control sequence for the electro-chemical subsystem of a high-temperature fuel cell. This control input helps to improve the parameter identifiability and simultaneously acts on both a nominal and disturbed system model. For this purpose, a quadratic distance measure between the respective output variables is maximized with the help of Pontryagin's Maximum Principle. To compute the trajectory for the manipulated variable in terms of a reasonably smooth (respectively, continuous) electric current signal, the system is augmented by an additional state, which represents a linear low-pass filter for the physical input. Furthermore, the parameters of the dynamic system under consideration can then be identified reliably with the help of this optimal control signal. Due to nonlinear couplings between some of the system parameters, the subsequent identification is performed by a two-stage pro-

cedure. As a result, the identified parameters reconstruct the nominal system dynamics with high accuracy, while the advantages of this methodological approach are verified in comparison with naive heuristics.

Paper: **4013** **C4L-B**

Identification of Multichannel Nonlinear Systems Excited by Realisations of Mutivariate Orthogonal Multisine Random Time-Series

Jarosław Figwer[1]

[1] *Silesian University of Technology* Jaroslaw.Figwer@polsl.pl

In the paper nonlinear transformations of multivariate orthogonal multisine random time-series are discussed. A focus on transformations that preserves orthogonality of transformed multivariate orthogonal multisine random time-series elements is given and the following from this property decomposition of multichannel nonlinear dynamic system identification problem into separate single-channel nonlinear dynamic system identification problems is described. This decomposition is illustrated by simulation examples devoted to identification of two-input single-output nonlinear dynamic systems based on observed mixtures of single-channel nonlinear block-oriented dynamic system outputs and the corresponding samples of the used bivariate orthogonal white multisine random excitations.

Paper: **4150** **C4L-B**

FEM Modeling and Parameter Identification of Thermoelectrical Processes in Cylindrical Bodies

Dmitri Knyazkov[1], **Georgy Kostin**[2], **Alexander Gavrikov**[3], **Harald Aschemann**[4], **Andreas Rauh**[5]

[1] *Ishlinsky Institute for Problems in Mechanics RAS* knyaz@ipmnet.ru
[2] *Ishlinsky Institute for Problems in Mechanics RAS* kostin@ipmnet.ru
[3] *Ishlinsky Institute for Problems in Mechanics RAS* gavrikov@ipmnet.ru
[4] *University of Rostock* Harald.Aschemann@uni-rostock.de
[5] *University of Rostock* Andreas.Rauh@uni-rostock.de

The paper considers a test rig available at the University of Rostock that consists of two co-axial aluminum cylinders heated by a Peltier element (PE) located in between them. Both the outer ends of the cylinders are thermally insulated. For the assessment of control structures, an accurate finite element model for the complete system is derived including a detailed thermoelectric model for the PE. Parameters of the PE - the Seebeck coefficient and the Ohmic resistance - are identified from the experimental data. Validation of the resulting model shows that the simulation results are in good agreement with experimental data.

Modelling & Simulation, C4L-C

Day: Wednesday, August 28, 2019
Time: 11:20 - 13:00
Room: Ferdinand Magellan
Chair: Stefan Siegmund

Paper: **4083** **C4L-C**

Integrated Maintenance Decision Making Platform for Gantry Cranes in Container Terminal

Janusz Szpytko[1], Yorlandys Salgado Duarte[2]

[1] *AGH University of Science and Technology* szpytko@agh.edu.pl
[2] *AGH University of Science and Technology* salgado@agh.edu.pl

The paper presents a risk-based model to coordinate the predictive-preventive maintenance process of gantry cranes in a container terminal with vessels high demand. The model coordinates the predictive-preventive maintenance minimizing the risk of Gantry Cranes Inefficiency (GCI). The risk is estimated with a sequential Markov Chain Monte Carlo (MCMC) simulation model. In this paper, the Predictive-Preventive Maintenance Scheduling (PPMS) of gantry cranes is non-linear stochastic optimization problem and it is efficiently solved with the algorithms Particle Swarm Optimization (PSO). The model allows the terminal container operators to obtain a maintenance schedule that minimizes the risk of GCI, as much as possible in a container terminal; as well as establishing the desired level of risk. The paper demonstrates the proposed model effectiveness with data of a real container terminal.

Paper: **4100** **C4L-C**

Approximation State-Space Model for 22 Hyperbolic Systems with Collocated Boundary Inputs

Krzysztof Bartecki[1]

[1] *Opole University of Technology* k.bartecki@po.opole.pl

The paper discusses an approximation model developed for linear hyperbolic DPS with two state variables and two collocated boundary inputs, expressed in classical, finite-dimensional state space framework. Using the method of lines approach with the backward difference scheme, the original PDEs are transformed into a set of ODEs and expressed in the form of the state-space equations with matrix-valued state, input and output operators. The eigenvalues and the steady-state solutions of the approximation model are analyzed. The considerations are illustrated with a parallel-flow double-pipe heat exchanger. Steady-state and frequency-domain responses obtained from its original PDE model are compared with those calculated from its ODE approximations of different orders.

Paper: **4122** **C4L-C**

Simulation Platform for Wireless Data Communication Using a New Signal Reconstruction Method

Paweł Majewski[1], **Wojciech Hunek**[2]

[1] *Opole University of Technology* p.majewski@po.opole.pl
[2] *Opole University of Technology* w.hunek@po.opole.pl

A platform for simulation of MIMO wireless data transmission processes is presented in this paper. The innovative tool implements authors' solution based on the polynomial approach related to the nonsquare matrices. Through an application of some nonunique inverses of nonsquare propagation matrices it is possible to increase an efficiency of signal recovery, which is confirmed by the theoretical background and a number of simulation instances. Thus, the useful environment can compete with other platforms employing different techniques. This statement is discussed in this paper.

Paper: **4132** **C4L-C**

Modelling of a Highly-Viscous, Non-Isothermal Fluid with Free Surface Using Model Reduction

Edmond Skeli[1], **Dimitri Harder**[2], **Dirk Weidemann**[3], **Klaus Panreck**[4]

[1] *University of Applied Sciences Bielefeld* edmond.skeli@fh-bielefeld.de
[2] *University of Applied Sciences Bielefeld* dimitri.harder@fh-bielefeld.de
[3] *University of Applied Sciences Bielefeld* dirk.weidemann@fh-bielefeld.de
[4] *University of Applied Sciences Bielefeld* klaus.panreck@fh-bielefeld.de

The inflow of a highly viscous fluid into the gap between two counter-rotating cylinders is considered, which is an unsteady process modelled by time-dependent incompressible Navier-Stokes equations. While the gap is being filled a limited bulging occurs in front of the gap. The free surface of the bulge has to be determined to solve the Navier-Stokes equation. Using perturbation theory it is shown that the velocities and the temperature of the fluid evolve at different time scales indicating that two reduced models can be used instead of the complete model, which significantly decreases the computational effort.

Paper: **4149** **C4L-C**

Games with Resources and Their Use in Modeling Control Processes in Heterogeneous Populations

Andrzej Swierniak[1], **Michal Krzeslak**[2], **Damian Borys**[3]

[1] *Silesian university of Technology* andrzej.swierniak@polsl.pl
[2] *Silesian University of Technology* krzeslak.michal@gmail.com
[3] *Silesian University of Technology* damian.borys@polsl.pl

We propose to endow evolutionary game models with changes of the phenotypes adjustment during the transient generations performed by the parameters in the payoff matrix

which determine the fitness resulting from different interactions between players. These changes represent alteration of access to external resources which, in turn, may describe control actions for the populations. For non-spatial games it leads to time-varying reproduction dynamics and the same to time-varying asymptotics. In the case of spatial games, these functions are represented by an additional lattice where another and parallel game based on cellular automata is performed.

Thursday
August 29th, 2019

SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles II, D1L-A

Day: Thursday, August 29, 2019
Time: 09:00 - 10:20
Room: Marco Polo
Chair: Paweł Skruch

Paper: **4022** **D1L-A**

Static Camera Calibration for Advanced Driver Assistance System Used in Trucks – Robust Detector of Calibration Points

Rafał Długosz[1], Waldemar Dworakowski[2], Piotr Suliga[3]

[1] *Aptiv Services Poland S.A.* rafal.dlugosz@gmail.com
[2] *Aptiv Services Poland S.A.* waldemar.dworakowski@aptiv.com
[3] *Aptiv Services Poland S.A.* piotr.suliga@aptiv.com

The work presents factory calibration procedure of the camera, for the use in Advanced Driver Assistance Systems (ADAS) mounted in trucks. It is a commercial project implemented for production and already used in vehicles. For this reason, special emphasis was placed on the reliability of the proposed solutions. At the same time, limited hardware resources were an important requirement here. For this reason, it was necessary to optimize the algorithms used so that their execution time was within the assumed time limits. One of the problems encountered during the calibration procedure were various objects located around the calibration pattern, for example, in the factory. In some situations these objects were classified by the system as calibration points, resulting in false outcomes of the overall calibration procedure. We developed methods that allow for distinguishing these points and removing them from the list of detected points. The procedure has been carefully tested under various unfavorable conditions with more than 500,000 tests.

Paper: **4048** **D1L-A**

The Application of Virtual Logic Models to Simulate Real Environment for Testing Advanced Driving-Assistance Systems

Michal Pikus[1], Jaroslaw Was[2]

[1] *AGH University of Science and Technology* mpikus@agh.edu.pl
[2] *AGH University of Science and Technology* jarek@agh.edu.pl

Advanced driving-assistance systems (ADAS) have become more popular and received more aid in automotive business. ADAS systems evolution requires more efforts to prepare efficient and reliable systems. Because of safety restrictions we need to validate systems by driving over several million kilometers in different conditions. That is why research, development and verification processes are highly required. The best solution to solve this problem are computer simulation. The use of digital scenarios saves time,

money and human resources. There are many simulators which are developed by automotive companies. In our paper we would like to present set of simulators which are used to simulate and validate camera sensors, control and path planning algorithms for ADAS. Our tools are able to simulate/emulate vehicle components and road environment elements. However, mainly in case of ADAS systems this is a difficult task. Our paper presents approaches the methodology of virtual simulations

Paper: **4057** **D1L-A**

Lean Systems Engineering for Automotive Perception Systems

Aleksander Buczacki[1], Dariusz Cieślar[2], Bohdan Oppenheim[3], Mateusz Stachnik[4]

[1] *Warsaw University of Technology* a.buczacki@wip.pw.edu.pl
[2] *Aptiv Services Poland S.A.* dariusz.cieslar@aptiv.com
[3] *Loyola Marymount University* bohdan.oppenheim@lmu.edu
[4] *Aptiv Services Poland S.A.* mateusz.stachnik@aptiv.com

The paper discusses elements in the design and development process of sensing and perception systems. These systems form the basis of the autonomous vehicle architecture in which uncertainties must be taken into account for efficient and effective development process. The Lean Systems Engineering methodology supports proper definition and description of system interfaces. A novel approach for development, verification and evaluation of perception algorithms is presented where inputs, states and outputs of the systems are in general considered as stochastic processes. An illustrative example is presented to verify theoretical analysis and mathematical formulation.

Nonlinear Systems & Control, D1L-B

Day: Thursday, August 29, 2019
Time: 09:00 - 10:20
Room: Vasco da Gamma
Chair: Wiesław Krajewski

Paper: **4041** **D1L-B**

Modeling of Switching-Mode Nonlinear System by Exponentially Weighted Aggregation

Paweł Wachel[1], Przemysław Śliwiński[2], Zygmunt Hasiewicz[3]

[1] *Wrocław University of Science and Technology* pawel.wachel@pwr.edu.pl
[2] *Wrocław University of Science and Technology* przemyslaw.sliwinski@pwr.edu.pl
[3] *Wrocław University of Science and Technology* zygmunt.hasiewicz@pwr.edu.pl

We consider a class of non-linear dynamic systems with finite memory and nonlinear characteristic that reveals time-varying behavior. It is assumed that the considered systems can change their mode in the a priori known range of modes but the switching moments

are unknown and cannot be directly detected. In the considered approach, based on the noisy measurements of the system output, we apply exponentially weighted aggregation techniques to estimate noise-free counterparts of the possessed output observations. Theoretical properties of the method as well as exemplary numerical simulations are also described and discussed in the paper.

Paper: **4056** **D1L-B**

Experimental Validation of a Nonlinear Model for Controlled Thermoelectric Processes in Cylindrical Bodies

Alexander Gavrikov[1], Georgy Kostin[2], Dmitri Knyazkov[3], Andreas Rauh[4], Harald Aschemann[5]

[1] *Ishlinsky Institute for Problems in Mechanics RAS* gavrikov@ipmnet.ru
[2] *Ishlinsky Institute for Problems in Mechanics RAS* kostin@ipmnet.ru
[3] *Ishlinsky Institute for Problems in Mechanics RAS* knyaz@ipmnet.ru
[4] *University of Rostock* andreas.rauh@uni-rostock.de
[5] *University of Rostock* harald.aschemann@uni-rostock.de

A nonlinear model of controlled thermoelectric processes in heat-conductive bodies is experimentally validated. The model describes heat transfer occurring in a cylindrical structure due to an electric voltage supplied to a thermoelectric converter. The corresponding test rig consists of two aluminum bodies with a thin Peltier element arranged in between. The model takes into account both the heat flux due to the Peltier effect and Joule heating in the converter itself. Several experiments are conducted at a dedicated test setup, where a piecewise constant voltage is employed and the resulting temperature is measured at selected points on the surface of the structure. The physical parameters of the model are identified first in one of the experiments, and the overall model is validated by using data from the remaining experiments. The governing equations describing thermoelectric processes are linearized approximately w.r.t. the temperature. The obtained equations still depend in a nonlinear way on the input voltage. Nevertheless, a Fourier analysis allows for constructing the eigenmodes symbolically and using them for calculations afterwards.

Paper: **4102** **D1L-B**

Self-Tuning Control for Nonlinear Systems Using a State-Dependent Riccati Equation Approach

Alexander Wache[1], Harald Aschemann[2]

[1] *University of Rostock* alexander.wache@uni-rostock.de
[2] *University of Rostock* harald.aschemann@uni-rostock.de

This paper presents a self-tuning algorithm for a nonlinear spring-mass-damper system that uses a quasi-linear state-space representation and allows for automatic optimisation of design parameters, w.r.t. a chosen objective cost function. This algorithm is developed

in the framework of a nonlinear system model with only approximately known system parameters. Using extended linearisation techniques, an equivalent quasi-linear system representation is established first. Based on this linear model representation, an optimal controller is calculated by solving state-dependent Riccati equations (SDREs). Using a modified Nelder-Mead algorithm, the proposed self-tuning algorithm for optimisation of weighting parameters in the performance cost function is presented. The algorithm is applied to a nonlinear spring-mass-damper system and the main advantages of this approach are demonstrated in simulations. Moreover, the influence of model uncertainties as well as additional sensor noise and unknown disturbances on the optimisation routine is evaluated. Finally, the simulation results are compared to each other – showing clearly the efficiency and the benefits of the overall approach.

Paper: **4109** **D1L-B**

Model-Based Nonlinear Control of the Cathode Pressure of a PEM Fuel Cell System Using a VTG

Dmitrij Schitz[1], **Harald Aschemann**[2]

[1] *University of Rostock* Dmitrij.Schitz@gmail.com
[2] *University of Rostock* Harald.Aschemann@uni-rostock.de

Fuel cells are in risk of starvation due to a possible drop of the oxygen partial pressure during a dynamic operation. Therefore, feedback control of the cathode pressure plays an important role towards an efficient operation of a polymer electrolyte membrane (PEM) fuel cell system. In this paper, hence, a model-based nonlinear pressure control approach using a variable turbine geometry (VTG) is presented. The system model is derived from physical considerations in symbolic form, and parametrized by a least-squares parameter identification. As the derived dynamic model of the cathode subsystem is highly nonlinear, appropriate techniques using differential flatness are applied. Moreover, a sigma-point Kalman filter (SPKF) provides accurate estimates for the state variables and a lumped disturbance. Simulation results show the effectiveness and illustrate the achieved control performance.

Intelligent Systems & Methods, D1L-C

Day: Thursday, August 29, 2019
Time: 09:00 - 10:20
Room: Ferdinand Magellan
Chair: Andrzej Świerniak

Paper: **4050** **D1L-C**

Automotive Ethernet Applications Using Scalable Service-Oriented Middleware Over IP: Service Discovery

Teodor-Constantin Nichițelea[1], Maria-Geanina Unguritu[2]

[1] *University of Craiova* teodor@automation.ucv.ro
[2] *University of Craiova* geanina@automation.ucv.ro

This paper presents a simulated distributed embedded system consisting of two Automotive Ethernet applications based on the SOME/IP-SD (Scalable Service-Oriented Middleware over IP – Service Discovery) concept: angular position control of a DC motor actuator for an automobile's trunk lid and interior lights control based on the vehicle's doors state. The paper also proposes a different in-vehicle E/E (Electric and Electronic) architecture which contains only the scalable Ethernet network. For this reason, the paper motivates the need for Ethernet in Automotive and makes a comparison to conventional busses.

Paper: **4077** **D1L-C**

Development of an Agent-Based System for Decentralized Control of District Energy Systems

Jakob Fritz[1], André Xhonneux[2], Dirk Müller[3]

[1] *Forschungszentrum Jülich* j.fritz@fz-juelich.de
[2] *Forschungszentrum Jülich* a.xhonneux@fz-juelich.de
[3] *Forschungszentrum Jülich & RWTH Aachen University* dmueller@eonerc.rwth-aachen.de

This contribution introduces a new system for distributed model predictive control of energy systems. This system uses multiple agents where each agents optimizes a subsystem. A central instance coordinates the individual agents and takes care of feasibility of the combination of the single solutions. The advantages of this approach are increased maintainability and privacy for the individual agents, thus increasing applicability to real-world systems where often multiple parties are involved in a single energy system. Where adequate, the agents perform MPC to control their subsystems. The system and method can be chosen for each agent individually.

Paper: **4105** **D1L-C**

Software Framework for Fast Image Retrieval

Rafał Grycuk[1], **Rafał Scherer**[2]

[1] *Częstochowa University of Technology* rafal.grycuk@iisi.pcz.pl
[2] *Częstochowa University of Technology* rafal.scherer@iisi.pcz.pl

In the paper we describe a system for retrieving images by their features. The software components are built around a multi-layer architecture. We propose also an idea of finding similar images by the CEDD descriptor and vector similarity. We test the proposed method on the Pascal VOC dataset. We published the sources of the system in a public repository.

Paper: **4120** **D1L-C**

Process Fault Detection and Reconstruction by Principal Component Analysis

Ruosen Qi[1], **Jie Zhang**[2]

[1] *Newcastle University* r.qi2@newcastle.ac.uk
[2] *Newcastle University* jie.zhang@newcastle.ac.uk

Existing fault reconstruction methods are very effective in dealing with sensor faults where the fault direction is usually easy to determine. However, implementing fault reconstruction methods for process faults is quite challenging as the fault direction vectors are usually difficult to specify. Process faults usually affect a number of process variables with various extents. This paper introduces a principal component analysis (PCA) based fault reconstruction method. PCA is used to analyze historical process data with faults to extract fault directions, which are then used for fault reconstruction. The proposed method is demonstrated on a simulated continuous stirred-tank reactor.

SPECIAL SESSION: Artificial Intelligence and Autonomous Vehicles III, D2L-A

Day: Thursday, August 29, 2019
Time: 10:40 - 12:00
Room: Marco Polo
Chair: Paweł Skruch

Paper: **4093** **D2L-A**

Performance of LiDAR Object Detection Deep Learning Architectures Based on Artificially Generated Point Cloud Data from CARLA Simulator

Daniel Dworak[1], Filip Ciepiela[2], Jakub Derbisz[3], Izzat Izzat[4], Mateusz Komorkiewicz[5], Mateusz Wójcik[6]

[1] *AGH University of Science and Technology* ddworak@agh.edu.pl
[2] *Aptiv Services Poland S.A.* filip.ciepiela@aptiv.com
[3] *Aptiv Services Poland S.A.* jakub.derbisz@aptiv.com
[4] *Aptiv Services US, LLC* izzat.izzat@aptiv.com
[5] *Aptiv Services Poland S.A.* mateusz.komorkiewicz@aptiv.com
[6] *Aptiv Services Poland S.A.* mateusz.wojcik@aptiv.com

Training deep neural network algorithms for LiDAR based object detection for autonomous cars requires huge amount of labeled data. Both data collection and labeling requires a lot of effort, money and time. Therefore, the use of simulation software for virtual data generation environments is gaining wide interest from both researchers and engineers. The big question remains how well artificially generated data resembles the data gathered by real sensors and how the differences affects the final algorithms performance. The article is trying to make a quantitative answer to the above question. Selected state-of-the-art algorithms for LiDAR point cloud object detection were trained on both real and artificially generated data sets. Their performance on different test sets were evaluated. The main focus was to determinate how well artificially trained networks perform on real data and if combined train sets can achieve better results overall.

Paper: **4103** **D2L-A**

Uncertainty Propagation for Vehicle Detections in Experimentally Validated Radar Model for Automotive Application

Adam Martowicz[1], Alberto Gallina[2], Grzegorz Karpiel[3]

[1] *AGH University of Science and Technology* adam.martowicz@agh.edu.pl
[2] *AGH University of Science and Technology* agallina@agh.edu.pl
[3] *AGH University of Science and Technology* gkarpiel@agh.edu.pl

The paper is devoted to the development and experimental validation of a radar model elaborated for an automotive application. The described numerical model takes into ac-

count the physical properties of a typical automotive radar, the environmental conditions as well as the properties of targeted objects. Moreover, a dedicated, very efficient algorithm of geometric transformations – implemented in the radar model for simulation of wave scattering phenomena – is presented. A phenomenological model of uncertainty is enclosed to the algorithm to represent more effectively radar detections. The solution presented by the authors is thus ready to be used in hardware-in-the-loop simulations of various road traffic scenarios.

Paper: **4125** **D2L-A**

A Generic Validation Scheme for Real-Time Capable Automotive Radar Sensor Models Integrated Into an Autonomous Driving Simulator

Michał Jasiński[1]

[1] *AGH University of Science and Technology* michal.jasinski@agh.edu.pl

Since Advanced Driver Assistance Systems are getting more and more complex a strong effort is put into the development of open-source autonomous driving simulators. However a robust virtual environment should not only be assessed by its realistic physics or 3D assets variety, but it also has to incorporate highly accurate and real-time capable sensor models. The research presented in this paper introduces a robust method for validating radar sensor models enabling a simple proof of their reliability in the virtual scenario. This paper shows also an exemplary radar sensor model integrated into CARLA simulator.

Paper: **4064** **D2L-A**

Full State Proportional Controller for Adaptive Cruise Control System

Marek Długosz[1], **Guangming Zhang**[2]

[1] *AGH University of Science and Technology* mdlugosz@agh.edu.pl
[2] *Liverpool John Moores University* G.Zhang@ljmu.ac.uk

The paper presents a proposal of using a full state proportional controller in Adaptive Cruise Control (ACC) systems. A full state proportional controller is one of the simplest controllers used in automation systems. Its advantage is based on the fact that there is no additional dynamics, which makes the state of a closed system unchanged. The article proposes a method of a numerical search for optimum parameters of the controller to ensure asymptotic stability of a closed system. The correctness of the proposed solutions was verified via computer simulations.

Signal Processing & Communication, D2L-B

Day: Thursday, August 29, 2019
Time: 10:40 - 12:00
Room: Vasco da Gamma
Chair: Witold Byrski

Paper: **4006** **D2L-B**

Stress Analysis Recorded in the EEG Signal Based on Mathematical Markers

Magda Żołubak[1], Barbara Grochowicz[2], Mariusz Pelc[3], Aleksandra Kawala-Sterniuk[4]

[1] *Opole University of Technology* magda.zolubak@gmail.com
[2] *Opole University of Technology* b.grochowicz@po.opole.pl
[3] *University of Greenwich* m.pelc@po.opole.pl
[4] *Opole University of Technology* kawala84@gmail.com

Stress is an increasingly common problem. Thanks to the use of various mathematical methods, it can be described mathematically based on the EEG signal. Generally, the stress in mathematical analysis can be divided into several models. To determine the variability in the stress-related EEG signal, the periodograms used for the overall assessment are checked. Our results suggest the occurrence of three models describing chronic stress.

Paper: **4143** **D2L-B**

Embedded Heart Rate Analysis Based on Sound Sensing

Maciej Rosół[1], Łukasz Więckowski[2]

[1] *AGH University of Science and Technology* mr@agh.edu.pl
[2] *AGH University of Science and Technology* wieckow@agh.edu.pl

In this article, we present a low-cost system of location and classification of heart sounds in S1 and S2 based on a single-chip microcontroller and MEMS microphone. The experimental data analysis methods in time and frequency domains are also presented. The heartbeat segmentation process includes autocorrelation to predict the time of the heartbeat cycle. The time-frequency characteristics are extracted with a Fast Fourier Transform to analyze diastole and systole heart cycles.

Paper: **4157** **D2L-B**

Soft Real-Time Communication with WebSocket and WebRTC Protocols Performance Analysis for Web-Based Control Loops

Tomasz Karla[1], **Jarosław Tarnawski**[2]

[1] *Gdańsk University of Technology* tomasz.karla@pg.edu.pl
[2] *Gdańsk University of Technology* jaroslaw.tarnawski@pg.edu.pl

The web browser has become an access window for content and services. Current applications in the field of automation include, for example, the implementation of user interfaces to present the state of the process and to accept operators' instructions in the form of web pages. The article considers network services and web browser as elements of the control loop. At least soft real-time (RT) work is needed for such applications. With the development of network protocols, the issue of providing RT transmission has appeared. There are currently two leading protocols taking into account the time aspects: WebSocket and WebRTC. The article compares their properties (mainly communication delays) in various network configurations and assess their suitability as an infrastructure of control systems. Selected techniques allowing to handle with delays in control loops are presented. Two control loops (simple PID loop and a multidimensional DMC) on web platform case studies with simple are presented.

Paper: **4065** **D2L-B**

Remote Receiver Control in MPTCP Networks in Uncertain Operating Conditions

Przemysław Ignaciuk[1], **Michał Morawski**[2]

[1] *Łódź University of Technology* przemyslaw.ignaciuk@p.lodz.pl
[2] *Łódź University of Technology* michal.morawski@p.lodz.pl

The use of parallel channels to transfer the data promises numerous advantages from the application point of view. It also opens new research perspectives concerning data flow optimization. In this paper, a new flow controller, designed for the communication of multihome systems that exchange data using MPTCP protocol is presented. The controller operates on the top of other protocol components and responds properly to the fluctuations observed beneath, e.g., uncertain throughput and delays on the paths and non-optimal stream split ratio. The control algorithm establishes a feasible (non-negative and bounded) input signal and prevents both exhausting and overflowing the receiver buffer despite fluctuating networking conditions. It is executed at the sender side and it does not require any changes at the receiver.

Robotics IV, D2L-C

Day: Thursday, August 29, 2019
Time: 10:40 - 12:00
Room: Ferdinand Magellan
Chair: Przemysław Herman

Paper: **4010** **D2L-C**

Kinematic Predictive Imaging Technique for Telerobotic Surgery with Time Delay Using Model Predictive Control

Jasmeet Singh Ladoiye[1], Dan Necsulescu[2], Jurek Sasiadek[3]

[1] *University of Ottawa* jlado023@uottawa.ca
[2] *University of Ottawa* necsu@uottawa.ca
[3] *Carleton University* jurek.sasiadek@carleton.ca

Minimum invasive robotic surgery is one of the most desired applications required with the advancement of medical technologies. Surgeons rely on the visual feedback solely from the laparoscopic camera to get the information about the operation to make further decisions. The control gets harder due to the presence of the latency in the network that can make the system unstable. The synchronization between the hand to eye of the surgeon is affected due to random behavior of the latency. In this paper, a novel approach is proposed by using the model predictive control to develop a predictive imaging technique that will provide the surgeon simplified imaging during the condition when delayed perception could occur. The ability of the model predictive control to predict the future will help to handle the randomness of the latency providing a better hand to eye coordination to the surgeon. A comparison is provided with the current techniques showing the effectiveness of the suggested approach.

Paper: **4088** **D2L-C**

Social Robot in Diagnosis of Autism Among Preschool Children

Krzysztof Arent[1], Joanna Kruk-Lasocka[2], Tomasz Niemiec[3], Remigiusz Szczepanowski[4]

[1] *Wrocław University of Science and Technology* krzysztof.arent@pwr.edu.pl
[2] *University of Lower Silesia* joanna.kruk-lasocka@dsw.edu.pl
[3] *University of Lower Silesia* tomasz.niemiec@dsw.edu.pl
[4] *University of Lower Silesia* remigiusz.szczepanowski@dsw.edu.pl

Current research on autism raises an important methodological issue concerning reliable measurement tools to diagnose abnormal social interactions within autistic children. Here we presents proposal of an interdisciplinary approach combining psychology and robotics yielding human-robot interaction to recognize autism symptoms based on a pre-schoolers' play with the social robot. The observational measures combined with competent raters technique indicated abnormal interaction patterns in children with autism during inter-

active games with NAO robot. Our research provides promising preliminary results on application of robot to diagnose autism and results regarding user's requirements and evaluation's criteria for a robot design.

Paper: **4053** **D2L-C**

Development of a High-Efficiency Pitch/Roll Inertial Measurement Unit Based on a Low-Cost Accelerometer and Gyroscope Sensors

Michał Okulski[1], **Maciej Ławryńczuk**[2]

[1] *Warsaw University of Technology* mikkichz2@gmail.com
[2] *Warsaw University of Technology* M.Lawrynczuk@ia.pw.edu.pl

This paper describes an original pitch/roll IMU (Inertial Measurement Unit) for Unmanned Aerial Vehicles (UAV) and general robotics applications. The development process is reported and the obtained results of experiments are discussed. The IMU has two key advantages: a) high quality output data is produced at high frequency (1 kHz), b) low cost accelerometer and gyroscope sensors are used. A dedicated 3-axis gimbal has been built to calibrate and test the sensors and later to tune the parameters of the Kalman Filter.

Paper: **4060** **D2L-C**

Features Matching Based Merging of 3D Maps in Multi-Robot Systems

Michał Drwięga[1]

[1] *Wrocław University of Science and Technology* drwiega.michal@gmail.com

The paper focuses on the feature matching based merging of 3D maps in a multi-robot system. The presented approach works globally what means that an initial transformation is not necessary for a proper integration of maps. The only one assumption is that the maps have a common part that can be used during a features detection, description and a matching process to compute a transformation between them. Then the found initial solution is corrected by a variation of an ICP based method. The maps are stored in the octree based representation (octomaps) but during transformation estimation a point cloud representation is used as well. In addition, the presented method was verified in various experiments, both in a simulation, with Turtlebots robots and with publicly available datasets. The solution can be applied to many robotic applications such as underwater robots, aerial robots or robots equipped with manipulators. However, so far it was mostly tested in groups of wheeled robots.

Index

Ż

What to see at Międzyzdroje?

Międzyzdroje is a popular charming seaside holiday resort located on the Wolin Island in the north-western corner of Poland (ca. 100 km north of Szczecin, ca. 250 km northeast of Berlin and ca. 600 km north-west of Warsaw) between the Wolin National Park Forest and sandy beach with a steep cliff shoreline. The beauty of Międzyzdroje lies in its fine architecture and natural environment. Together with the adjoining Wolin National Park, which houses one of the very few bison reserves in the world, and offers a series of awe-inspiring hiking trails, it is a place of unique scenic, cultural and tourist value.

Places particularly worth visiting:

Kawcza Góra, a hill in the eastern part of the town. A nice walking path leads to the top, where two rocks commemorate two congresses of foresters; stairs go down to the sea.

The Międzyzdroje cliff, the highest sea shore in Poland, rising up to 95 meters above sea level, is damaged by marine erosion - up to one meter of land is cut by waves every year.

The Parish Church of St. Peter the Apostle, built in 1862, was designed by the famous architect Stüler and co-designed by King of Prussia Frederic William IV, who covered most of the construction costs. The International Choir Song Festival and concerts of organ music are held in the church.

The Stella Matutina (Morning Star) Chapel built in 1902, houses a hospice run by the Borromean Nuns.

The fishing harbour in the eastern part of the town.

The bison reserve, established in 1976, it is also inhabited by other animal species, e.g. the wild boar and the roe-deer.

The marked path in the National Park: the red trail along the sea coast, the green trail to Lake Czajcze near Warnowo, and the blue trail to Zielonka hill at Lubin pass by many vantage points and nature reserves.

Zielonka hill at Lubin, the most beautiful panoramic view of the Old Swina river marshes and the Szczecin Lagoon.

Lake Czajcze near Warnowo, a picturesque postglacial water reservoir shaped like a horseshoe. The peninsula in the middle was a site of a 14th-c. settlement.

Lake Turkusowe at Wapnica hides a flooded chalk mine. Its turquoise water and picturesque steep shores are an attraction of this landscape reserve.

Wolin, the legendary 9th/11th-c. port town of Vineta. It has an archaeological museum and other ancient sites, including the 9th-c. burial ground with barrows.