WELCOME from the MMAR 2018 Organizing Committee

I would like to invite you to Międzyzdroje, Poland for the 23rd International Conference on Methods and Models in Automation and Robotics. Over 218 draft papers have been submitted, from which the International Program Committee, chaired by Professor Tadeusz Kaczorek, has selected 173 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, 27 August 2018. The first three days of the conference begin with a plenary lecture delivered by a distinguished scientist. All other papers will be presented in four parallel regular sessions. Furthermore, several poster sessions will take place. Moreover, all the MMAR 2018 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 2018 Organizing Committee
Faculty of Electrical Engineering
West Pomeranian University of Technology, Szczecin

Organizer

Faculty of Electrical Engineering,
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of Technology,
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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 2018 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 23rd in a series which started in 1994.

Venue and dates

The Conference will be held at the Amber Baltic Hotel in Miedzyzdroje, from Monday, 27 August till Thursday, 30 August 2018. The Conference registration desk in Amber Baltic Hotel will be opened on the Monday morning, 27 August and during each day of the Conference. The Conference will start on Monday, 27 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 2018 and their efforts in coordinating the review process.

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In the name of all the authors we would like to thank the trackchairs for their dedicated work during the review process of MMAR 2018:

Control and Systems Theory	Jacek Kabziński Andrzej Dzieliński Wiesław Krajewski
Control Applications	Harald Aschemann Paweł Dworak
Intelligent Systems and Methods	Jacek Piskorowski Roman Kaszyński
Robotics	Ahmed Chemori Krzysztof Kozłowski Cezary Zieliński Jurek Sasiadek
Modelling, Identification and Simulation	Wojciech Hunek Krzysztof Latawiec Andreas Rauh
Signal Processing and Networked Control Systems	Roman Kaszyński Krzysztof Okarma
Discrete Events and Hybrid Systems	Jacek Piskorowski

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We would like to thank the following individuals for their efforts in the review process of MMAR 2018:

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Monday, Aug 27th, 2018

	Casino	Kalman	Lehar	Strauss
11.00	Registration opens (Amber hotel main hall)			
15.00-15.10	Conference Opening (Casino)			
15.10-16.10	Plenary Lecture (Casino), Chair: *Tadeusz Kaczorek* , page 16 **An Intelligent Decision-Making System for Autonomous Units Based on the Mind Model** speaker: Zdzislaw Kowalczuk			
16.10-16.30	*Coffee break* (in front of Kalman/Lehar)			
16.30-17.20	A2P-E, page 16 **Poster Session I** *Paweł Dworak*			
16.30-17.50	A3L-A, page 20 **Optimal Control** *Andrzej Dzieliński*	A3L-B, page 21 **Identification I** *Zdzisław Kowalczuk*	A3L-C, page 23 **Fractional Order Systems I** *Tadeusz Kaczorek*	A3L-D, page 25 **Mobile Robotics I** *Elżbieta Roszkowska*
19.00	Welcome Party (Amber, Chopin room)			

Tuesday, Aug 28th, 2018

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Zbigniew Emirsajłow* , page 28 **Model Predictive Control and Estimation of Linear Transport-Reaction Distributed Parameter Systems** speaker: Stevan Dubljevic			
10.00-11.00	B2L-A, page 28 **Distributed Parameter Systems** *Miguel E. Vázquez-Méndez*	B2L-B, page 30 **AI Methods I** *Marius Baban*	B2L-C, page 31 **Modelling & Simulation I** *Ali Hajnayeb*	B2L-D, page 33 **Control & Systems Theory I** *Wiesław Krajewski*
10.00-12.00	B3P-E, page 34 **Poster Session II** *Przemysław Mazurek*			
11.00-11.20	*Coffee break* (in front of Kalman/Lehar)			
11.20-13.00	B4L-A, page 38 **Fractional Order Systems II** *Piotr Ostalczyk*	B4L-B, page 40 **Control Applications I** *Georgy Kostin*	B4L-C, page 42 **Modelling & Simulation II** *Stevan Dubljevic*	B4L-D, page 45 **Sliding Mode Control** *Jacek Kabziński*
13.00-15.00	*Lunch* (Amber hotel)			
15.00-16.20	B5L-A, page 47 **Optimization** *Sebastian Engell*	B5L-B, page 49 **Image Processing** *Krzysztof Okarma*	B5L-C, page 51 **Identification II** *Jarosław Figwer*	B5L-D, page 53 **UAV** *Kemao Peng*
15.00-16.20	B6P-E, page 55 **Poster Session III** *Wojciech Grega*			
19.00	Conference Banquet (Międzyzdroje International House of Culture)			

Wednesday, Aug 29th, 2018

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Harald Aschemann* , page 62 **Autonomous Flight of Flapping Wing Robots - the Relation Between Body and Mind** speaker: Guido de Croon			
10.00-11.00	C2L-A, page 62 **Adaptive & Robust Control** *Dirk Weidemann*	C2L-B, page 64 **Signal Processing** *Przemysław Ignaciuk*	C2L-C, page 65 **Fractional Order Systems III** *Małgorzata Klimek*	C2L-D, page 66 **Control Applications II** *Paolo Mercorelli*
10.00-12.00	C3P-E, page 68 **Poster Session IV** *Grzegorz Mzyk*			
11.00-11.20	*Coffee break* (in front of Kalman/Lehar)			
11.20-13.00	C4L-A, page 72 **Control & Systems Theory II** *Andrzej Bartoszewicz*	C4L-B, page 74 **Control Applications III** *Andreas Rauh*	C4L-C, page 76 **Robotics I** *Ignacy Dulęba*	C4L-D, page 78 **Modelling & Simulation III** *Johannes Reuter*
13.00-15.00	*Lunch*			
16.30	Touristic Programme Grill Party at the Golf Course (bus is leaving from the front of the Amber Hotel)			

Thursday, Aug 30th, 2018

	Casino	**Kalman**	**Lehar**	**Strauss**
9.00- 10.20	D1L-A, page 82 **Measurement** *Wojciech Hunek*	D1L-B, page 84 **Mobile Robotics II** *Adam Krzyżak*	D1L-C, page 86 **Control & Systems Theory III** *Krzysztof Latawiec*	D1L-D, page 88 **Fault Detection** *Marian Błachuta*
9.30- 11.30	D2P-E, page 89 **Poster Session V** *Krzysztof Okarma*			
10.20- 10.40	*Coffee break* (in front of Kalman/Lehar)			
10.40- 12.00	D3L-A, page 93 **AI Methods II** *Andrzej Świerniak*	D3L-B, page 95 **Robotics II** *Krzysztof Kozłowski*	D3L-C, page 97 **Scheduling** *Adam Kowalewski*	D3L-D, page 99 **Modelling & Simulation IV** *Rafał Stanisławski*
12.30- 13.00	Conference Program Committee Meeting *Young Author Prize*			
13.00- 13.15	Young Author Award Ceremony (in the Chopin room)			
13.15	Farewell Lunch (at the Amber hotel)			

Monday
August 27th, 2018

Plenary 1: Zdzislaw Kowalczuk, A1L-A

Day: Monday, August 27, 2018
Time: 15:10 - 16:10
Room: Casino
Chair: Tadeusz Kaczorek

Paper: **4216** **A1L-A**

An Intelligent Decision-Making System for Autonomous Units Based on the Mind Model

Zdzisław Kowalczuk[1], Michał Czubenko[2]

[1] *Gdańsk University of Technology* kova@pg.edu.pl
[2] *Gdańsk University of Technology* micczube@pg.edu.pl

This article presents a specific part of current trends in autonomous robotics. It pays special attention to the basic aspects of cognitive architecture. After a brief introduction, we shortly describe the Intelligent System of Decision-making developed at the Gdansk University of Technology.

Poster Session I, A2P-E

Day: Monday, August 27, 2018
Time: 16:30 - 17:50
Room: Poster Area
Chair: Paweł Dworak

Paper: **4008** **A2P-E**

Sample Time Optimization for the Discrete Approximation of the Fractional Order Charef Transfer Function

Krzysztof Oprzędkiewicz[1], Klaudia Dziedzic[2]

[1] *AGH University of Science and Technology* kop@agh.edu.pl
[2] *AGH University of Science and Technology* klaudia.dziedzic04@gmail.com

In the paper the sample time optimization problem for discrete Charef approximation is presented. The sample time assuring the best accuracy of discrete model is assigned numerically with the use of PSO algorithm. Results of experiments show that the PSO method allows to find optimal value of sample time with sensible time of calculations.

Paper: **4031** **A2P-E**

Local Controllability of Discrete Semilinear Time-Varying Fractional Order Systems with Constant Delay

Artur Babiarz[1]

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

The presented paper considers an unconstrained local controllability problem of semilinear fractional order discrete-time systems with constant delay in control. By the general formula of solution of difference state equation we present a sufficient condition for local unconstrained controllability. At the end, an illustrative example is presented.

Paper: **4053** **A2P-E**

On the Existence of Optimal Solutions for Optimal Control Problems Involving the Caputo Fractional Derivatives with Nonsingular Kernels

Rafał Kamocki[1], **Kamil Pajek**[2]

[1] *University of Łódź* rafkam@math.uni.lodz.pl
[2] *University of Łódź* kamil.pajek@gmail.com

The paper concerns linear autonomic continuous control systems involving the Caputo fractional derivatives with exponential and Mittag-Leffler nonsingular kernels. In the first part, a thorem on the existence of a unique solution to such systems is proved. Next, based on the existence result, continuous dependence of solutions on controls is studied. Finally, a theorem on the existence of optimal solutions to investigated systems with a nonlinear integral performance index is proved.

Paper: **4106** **A2P-E**

Minimum Energy Control of Fractional Linear Systems

Jerzy Klamka[1]

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

In the paper linear fractional finite-dimensional stationary damped dynamical control systems are considered. Under controllability assumption minimum energy control problem is formulated and analytically solved using properties of scalar product and norm in the finite dimensional space. The possible extensions are also pointed out.

Paper: **4147** **A2P-E**

Improvement of the Torque Control Dynamics of the PMSM Drive Using the FOC-Controlled Simple Boost QZSDMC Converter

Przemysław Siwek[1], **Konrad Urbanski**[2]

[1]*Poznań University of Technology* przemyslaw.siwek@put.poznan.pl
[2]*Poznań University of Technology* konrad.urbanski@put.poznan.pl

The following paper presents a method for improving the dynamics of a PMSM drive torque control loop by using Quasi Z-Source Direct Matrix Converter. In recent research Quasi Z-Source, which is a boost converter, was connected with the Matrix Converter in order to allow operation with unity voltage transfer ratio. In this paper voltage boost of the mentioned device was used to speed up the increase and decrease of the current in motor coils. A Field Oriented Control for Matrix Converter method is presented, which is adapted to operate with Quasi Z-Source controlled by the Simple Boost. The simulation research comparing the traditional Matrix Converter with the proposed system was performed. The following were analysed: motor current rise time, power grid THD, spectrum and power consumption of both devices. Quasi Z-Source Direct Matrix Converter turned out to have higher torque control loop dynamics and lower values of the current control error integral but at the cost of an increase of power consumption and THD.

Paper: **4149** **A2P-E**

Input Filter Optimisation for a DTC Driven Matrix Converter-Fed PMSM Drive

Przemysław Siwek[1]

[1]*Poznań University of Technology* przemyslaw.siwek@put.poznan.pl

This paper presents optimisation results of input filter parameters for a Direct Torque Control driven Matrix Converter-fed PMSM drive. The main objective of performed research was to achieve better quality indicators of input filter as compared to the analytic method. DTC method is based on controlling the length and angle of a stator flux linkage vector with MC states chosen from a Switching Table. Therefore, presented method has a variable switching frequency, which makes it difficult to analytically appoint a suitable filter. The optimization was performed using one of the newest metaheuristic algorithms - Cuckoo Search. In the article author proposes an objective function, optimization restrictions and filter quality indicators connected with the power factor, electromagnetic torque error, current drawn from the grid, voltage THD and grid current. As a result of this analysis, best filters were chosen, whose performances were then compared in simulation research. Eventually, a filter appointed by mentioned optimization achieved better results for power factor and grid current distortion indicators. Remaining parameters were similar to those of analytic filter.

Paper: **4155** **A2P-E**

Terminal Sliding Mode Control with Control Signal and Velocity Constraints

Mateusz Pietrala[1], **Marek Jaskuła**[2]

[1] *Lodz University of Technology* 800904@edu.p.lodz.pl
[2] *Lodz University of Technology* 800903@edu.p.lodz.pl

In this paper the time optimal sliding mode controller for the second order systems with uncertainties is introduced. A time-varying sliding line is proposed, in order to eliminate the influence of perturbations for the whole regulation process. Moreover, it is selected to ensure the finite-time convergence of the regulation error to zero. The regulation time is minimized with respect to the control signal and velocity constraints.

Paper: **4189** **A2P-E**

Model Reference Control for 2-D System

Jerzy Kurek[1]

[1] *Warsaw University of Technology* jkurek@nchtr.pw.edu.pl

The Model Reference Control algorithm for SISO 2-D system is presented. The control algorithm is simple one and can be easily used in practice. It enables simple design of 2-D system. The proposed approach is illustrated by numerical example.

Paper: **4194** **A2P-E**

Adaptive Gradient-Based Luenberger Observer Implemented for Electric Drive with Elastic Joint

Marcin Kaminski[1]

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

In this paper work of the Luenberger observer applied for electric drive with complex mechanical part is analyzed. Comparing to classical solution, additional adaptation of gain matrix was introduced. Starting point for gradient-based on-line parameter recalculation is determined using metaheuristic algorithm - Grey Wolf Optimizer. Two state variables, the most often used in control structures applied for two-mass system, are estimated: load speed and shaft torque. Mentioned methods lead to precise calculations of signals and improvement of results after time constants changes. Model of the adaptive observer was tested in simulations and experiment.

Optimal Control, A3L-A

Day: Monday, August 27, 2018
Time: 16:30 - 17:50
Room: Casino
Chair: Andrzej Dzieliński

Paper: **4055** **A3L-A**

Model Decomposition and Optimal Flux Control for Linear Distributed Heat Transfer Systems

Georgy Kostin[1], **Andreas Rauh**[2], **Harald Aschemann**[3]

[1] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* kostin@ipmnet.ru
[2] *University of Rostock* Andreas.Rauh@uni-rostock.de
[3] *University of Rostock* Harald.Aschemann@uni-rostock.de

An optimal control problem for heat transfer in a steel bar heated and cooled by Peltier elements attached to its lower surface is studied. The bar has a cuboid shape with insulated vertical sides, whereas the heat exchange takes place on the body's upper and lower surfaces. A thermodynamic model accounting for heat capacity of cooling units is considered and an experimental identification of unknown structural parameters is carried out. The problem is additionally to find the feedforward control law for the elements' heat powers leading the system in finite time to a stationary state and minimizing a quadratic cost function. Order reduction and decomposition techniques based on the Fourier method are used to optimize the control signals.

Paper: **4060** **A3L-A**

Optimal PWA Approximation for a Nonlinear Car on the Hill System and Properties of the Hybrid MPC Constrained Time-Optimal Controller

Przemyslaw Orlowski[1]

[1] *West Pomeranian University of Technology Szczecin* orzel@zut.edu.pl

Most of the real control systems are nonlinear, although very often linear models and hybrid PWA models are employed as prognostic models for the synthesis of model predictive control. The main aim of the paper is to analyze the efficiency of the approximation method from the nonlinear discretized into the discrete piece-wise affine model. The system under consideration is the car of the hill system with state nonlinearities and input saturation. Primary motivations are applications in control systems design. Both accuracy and numerical complexity of the piece-wise affine control system grow with the number of polyhedral partitions, describing the system. The efficiency of the proposed PWA approximation method is evaluated on the numerical example.

Paper: **4062** **A3L-A**

An Integro-Differential Approach to LQ-Optimal Control Problems for Heat Transfer in a Cylindrical Body

Alexander Gavrikov[1], **Georgy Kostin**[2]

[1] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences*

gavrikov@ipmnet.ru

[2] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* *kostin@ipmnet.ru*

Optimal boundary control problems with linear-quadratic cost functions are considered for heat transfer processes in a cylindrical body. The method of integro-differential relations is used to reduce the original PDE model to a finite-dimensional controlled system. Three types of linear-quadratic cost functions are studied: the first includes control functions and terminal temperature distribution, the second additionally takes into account the heat flux at the terminal time instant and the third contains a measure of approximation error. Numerical examples are given and discussed.

Identification I, A3L-B

Day: Monday, August 27, 2018
Time: 16:30 - 17:50
Room: Kalman
Chair: Zdzisław Kowalczuk

Paper: **4005** **A3L-B**

Continuous-Time Nonlinear Block-Oriented Dynamic System Identification from Sampled Step and Step-Like Responses

Jarosław Figwer[1]

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

In this paper an approach to continuous-time nonlinear block-oriented dynamic system identification containing unknown time delay is presented. In the presented approach the excitation being a step or step-like signal is generated from D/A converter equipped with zero-order hold filter. Data used for model identification are sampled step or step-like responses. Parameters of the corresponding models are obtained by an optimisation algorithm utilizing ideas of randomized search. The presented discussion is illustrated by simulation experiments devoted to model identification of Wiener, Hammerstein, Hammerstein-Wiener and Wiener-Hammerstein systems.

Paper: **4207** **A3L-B**

Trajectory Tracking and Nonparametric Identification of Flexible Space Robot Manipulators

Jerzy Sąsiadek[1], Steve Ulrich[2], Adam Krzyżak[3]

[1] *Carleton University* JurekSasiadek@cunet.carleton.ca
[2] *Carleton University* sulrich@connect.carleton.ca
[3] *Concordia University* krzyzak@cs.concordia.ca

The paper compares control strategies for four a flexible robot space manipulator. The control strategies include the classical Slotine and Li algorithm, a simple proportional derivative controller, a singular perturbation-based controller and a nonlinear backstepping controller. All strategies are validated in simulations simulations for endpoint target positioning while tracking a square trajectory by a two-link flexible joint space robot, thus providing a common framework to compare the respective performance of the considered control schemes. Simulation results indicate that controlling both nonlinearities and joint flexibility effects improve the closed-loop behavior of the space robot where the control of nonlinearities is of greater importance. The best performance for this particular application is achieved by the nonlinear backstepping control strategy. We also propose Hammerstein nonlinear joint model and introduce its nonparametric kernel identification algorithm and study its convergence.

Paper: **4021** **A3L-B**

Efficient Identification of Hammerstein Systems by Two-Level Optimization with Decomposition

Grzegorz Mzyk[1]

[1] *Wrocław University of Science and Technology* grzegorz.mzyk@pwr.edu.pl

The paper considers popular problem of Hammerstein system identification. It is inspired by the real problem concerning modeling of differential scanning calorimetry for chalcogenide glass properties examination. In spite of variety of identification methods proposed in the literature, none of them can be applied directly, due to specific practical limitations. The most popular approaches, e.g. overparametrization approach, or nonparametric regression estimation, require relatively large number of data or lead to very complicated numerical tasks. The proposed algorithm consists of two steps. Firstly, the impulse response of the linear block is identified by the standard least squares method, assuming i.i.d. input excitation. Next, the coefficients of orthogonal expansion of nonlinear characteristic are estimated independently by iterative optimization, provided that the criterion function is convex. Results of simulation examples give promising results, i.e., satisfactory accuracy and relatively fast computations.

Fractional Order Systems I, A3L-C

Day: Monday, August 27, 2018
Time: 16:30 - 17:50
Room: Lehar
Chair: Tadeusz Kaczorek

Paper: **4213** **A3L-C**

Variable-, Fractional-Order RST/PID Controller Transient Characteristics Calculation

Piotr Ostalczyk[1]

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

In the paper we propose a method of the variablefractional- order (VFO) discrete-time linear system response calculation applied to the VFO RST/PID controllers response. To such a controllers one cannot directly apply the commonly known one-sided Z-Transform method. Treating the VFO-PID controller as a special case of the RST controller we show that using classical methods one can derive the dynamical properties of the VFO-PID controller.

Paper: **4198** **A3L-C**

Logistic Fractional Variable-Order Equation - Numerical Simulations for Fitting Parameters

Dorota Mozyrska[1], **Piotr Oziablo**[2]

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

The work presents variable-, fractional-order backward difference of the Grunwald-Letnikov type. Variable and fractional-order in the name of the operator means that instead of constant, integer order backward difference, the order of the tested operator is a real value function. The focus is put on presenting the method of finding the parameter of the order function (assuming that the general family of the function is known) and constant lambda coefficient in a way that values returned by the operator fit some particular simulated data. Mentioned lambda coefficient is a parameter is the scaling factor of eigenfunction of the tested backward difference operator.

Paper: **4176** **A3L-C**

The Fractional Variable-Order Cucker-Smale Type Model for a Couple of Agents

Ewa Girejko[1], Dorota Mozyrska[2], Malgorzata Wyrwas[3]

[1] *Bialystok University of Technology* e.girejko@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 is devoted to the behaviour of fractional variable-order system with two agents. Interactions between agents are defined like in Cucker-Smale model but the memory is included by using the Grunwald-Letnikov fractional variable-order operator in the equation describing the velocity of agents. The condition for achieving a consensus for the considered model is formulated and the behaviour of the system is supported by numerical analysis.

Paper: **4164** **A3L-C**

Predictive Control of Linear Fractional-Order Systems Based on Discrete-Time Fractional-Order Laguerre Filters

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

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

The paper presents a new prediction algorithm for a new class of fractional-order systems in terms of two-layer discrete-time fractional-order Laguerre-systems. The proposed algorithm is applied to extended horizon model predictive control. Simulation examples confirm the effectiveness of introduced prediction algorithm and usefulness of two-layer Laguerre models in designing the predictive controllers for discrete-time fractional-order systems.

Mobile Robotics I, A3L-D

Day: Monday, August 27, 2018
Time: 16:30 - 17:50
Room: Strauss
Chair: Elżbieta Roszkowska

Paper: **4037** **A3L-D**

Mixed Energy Model for a Differential Guide Mobile Robot

Mauricio Fernando Jaramillo Morales[1], Juan Bernardo Gómez Mendoza[2]

[1] *Universidad Nacional de Colombia* mfjaramillom@unal.edu.co
[2] *Universidad Nacional de Colombia* jbgomezm@unal.edu.co

Energy consumption is an important element in the autonomy of mobile robots, in any application in which the robot carries a source of finite energy. The formulation of an energy model can relate the kinematic movements of mobile robots and energy consumption. In this paper, an energy model is proposed, which takes into account the kinematic and dynamic models for mobile robot as well as the motors, given an energy value close to the real energy consumption.

Paper: **4121** **A3L-D**

Feasible Trajectory Planning Algorithm for a Skid-Steered Tracked Mobile Robot Subject to Skid and Slip Phenomena

Vito Antonio Nardi[1], Alessia Ferraro[2], Valerio Scordamaglia[3]

[1] *Università degli Studi Mediterranea di Reggio Calabria* vitoantonio.nardi@gmail.com
[2] *Università degli Studi Mediterranea di Reggio Calabria* alessiaferraro996@gmail.com
[3] *Università degli Studi Mediterranea di Reggio Calabria* valerio.scordamaglia@unirc.it

This paper proposes an approach for the motion planning of a constrained skid-steered tracked mobile robot under the hypothesis of non-negligible skid and slip phenomena. Operating environment is firstly discretized with a finite dimensional grid. Then, a weighted graph is defined whose nodes are the above mentioned grid points, and whose arcs denote the trajectory segments. A modified shortest path search algorithm is then proposed to find a trajectory, in terms of succession of arcs, connecting starting and ending nodes. Trajectory feasibility is guaranteed by recurring to set-based arguments, some numerical examples are finally discussed.

Application of Iterative Learning Methods to Control of a LEGO Wheeled Mobile Robot

Robert Maniarski[1], **Wojciech Paszke**[2], **Maciej Patan**[3]

[1] *University of Zielona Góra* robert5maniarski@gmail.com
[2] *University of Zielona Góra* w.paszke@issi.uz.zgora.pl
[3] *University of Zielona Góra* m.patan@issi.uz.zgora.pl

Iterative Learning Control (ILC) is a very powerful control technique that iteratively improves the transient behaviour of systems that are repetitive in nature. In this paper it is shown how ILC algorithm is designed and implemented to improve the tracking trajectory performance of mobile robot with a differential drive. Two step design procedure is proposed where a feedback controller is chosen as a classical PID controller and involves some performance specification to attenuate non-repetitive disturbances and noises. Then, as the second step, the learning filter is determined by an appropriate application of a plant inversion method. It turns out that convergence and learning performance of this ILC scheme can be obtained for a physical system and hence practical usefulness of the scheme is verified experimentally on Lego EV3-based mobile robot.

Leader-Follower Control and Collision Avoidance for the Formation of Differentially-Driven Mobile Robots

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 leader-follower formation control algorithm with built-in collision avoidance behavior. The robots are differentially-driven nonholonomic mobile platforms. The only robot that knows the desired trajectory of the formation plays the role of the leader. The rest of robots form a queue in which each robot except the last one (that is only a follower) has a single follower and follows also one robot. The task of the followers is to keep relative offset in both spatial coordinates with respect to preceding robot. In addition the information about the control signals is transmitted from the leader to its follower. Artificial potential functions are used to guarantee interagent collision avoidance. When the safety zone of the agent is violated the reference linear velocity is temporarily suspended to resolve collision avoidance problem which has the higher priority. Stability analysis of the closed-loop system is presented. Numerical simulations that confirm effectiveness of the proposed algorithm are included.

Tuesday
August 28th, 2018

Plenary 2: Stevan Dubljevic, B1L-A

Day: Tuesday, August 28, 2018
Time: 9:00 - 10:00
Room: Casino
Chair: Zbigniew Emirsajłow

Paper: **4217** **B1L-A**

Model Predictive Control and Estimation of Linear Transport-Reaction Distributed Parameter Systems

Stevan Dubljevic[1]

[1] *University of Alberta* stevan.dubljevic@ualberta.ca

A systematic development of linear model predictive control algorithms for linear transport-reaction models emerging from chemical engineering practice is presented. The finite-horizon constrained optimal control problems are addressed for the systems varying from the convection dominated models described by hyperbolic partial differential equations (PDEs) to the diffusion models described by parabolic PDEs. The novelty of the design procedure lies in the fact that spatial discretization and/or any other type of spatial approximation of the process model plant is not considered and the system is completely captured with the proposed Cayley-Tustin transformation, which maps a plant model from a continuous to a discrete state space setting. The issues of optimality and constrained stabilization are addressed within the controller design setting leading to the finite constrained quadratic regulator problem, which is easily realized and is no more computationally intensive than the existing algorithms.

Distributed Parameter Systems, B2L-A

Day: Tuesday, August 28, 2018
Time: 10:00 - 11:00
Room: Casino
Chair: Miguel E. Vázquez-Méndez

Paper: **4150** **B2L-A**

Linear Matrix Inequality Techniques for the Optimization of Interval Observers for Spatially Distributed Heating 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

Interval observers provide the possibility to estimate guaranteed enclosures for the state variables of a dynamic system that are compatible on the one hand with a predefined

mathematical model in which uncertain but bounded parameters may be included. On the other hand, they allow for a correction of the state estimates by a Luenberger-like observer where bounded tolerances of the measured outputs are taken into consideration. Especially for cooperative system models, these interval observers can be implemented in a straightforward manner. Then, two separate bounding systems (one for the lower and one for the upper bounds of the respective state variables) have to be defined. In previous work, an offline parameter identification scheme was interfaced with a fundamental interval observer. There, preserving the property of cooperativity by the observer and guaranteeing asymptotic stability of the error dynamics was in focus. This paper aims at optimizing the observer gains in such a way that the widths of the resulting state estimates can be influenced in a systematic manner. Experimental estimation results for a lab-scale distributed heating system conclude this contribution.

Paper: **4204** **B2L-A**

Remarks on Functional Observers for Distributed Parameter Systems

Zbigniew Emirsajłow[1]

[1] *West Pomeranian University of Technology Szczecin* emirsaj@zut.edu.pl

The paper introduces the basic concepts used in the design of functional observers for distributed parameter systems with bounded input and output operators.

Paper: **4087** **B2L-A**

Actuator Fault Detection and Estimation for a Class of Hyperbolic PDEs Using Filter-Based Observer

Xiaodong Xu[1], **Stevan Dubljevic**[2]

[1] *University of Alberta* xx1@ualberta.ca
[2] *University of Alberta* stevan.dubljevic@ualberta.ca

This paper is concerned with simultaneous actuator fault detection and estimation problems for a class of hyperbolic partial integral-differential equations (PIDEs) with boundary controlled and boundary observation. Based on a Luenberger-type observer, the paper studies fault detectability and gives detectability conditions. In presence of actuator fault, the traditional boundary observer based backstepping techniques can only detect a fault occurrence rather than estimate the fault parameter. In this case, this paper developed two novel plant state observers equipped with corresponding fault parameter estimator (parameter tuning update law). The first observer is designed without consideration of model uncertainties or external disturbances based on the observation error system and the fault parameter tuning update law is developed in cooperation with a simple error target system obtained through backstepping transformation. Moreover, with consideration of bounded model uncertainties and disturbances, this paper also developed a filter-based observer.

AI Methods I, B2L-B

Day: Tuesday, August 28, 2018
Time: 10:00 - 11:00
Room: Kalman
Chair: Marius Baban

Paper: **4066** **B2L-B**

Improving Reliability Through the Product's Life Cycle Management

Irina Makarova[1], Ksenia Shubenkova[2], Anton Pashkevich[3]

[1] *Kazan Federal University* kamivm@mail.ru
[2] *Kazan Federal University* ksenia.shubenkova@gmail.com
[3] *Cracow University of Technology* apashkevich@pk.edu.pl

Each manufacturer is responsible for his product from the beginning of design and development to disposal. Thus, it is important to understand the interconnection between all stages of the life cycle and to develop management considering this. Production and service systems can be connected by logistics system and through creation of the integrated information space. Authors propose the concept of decision support system to organize the interaction of production, service and logistics with simulation models as the intelligent heart. Simulation model of spare parts supply optimization as well as the simulation model of internal logistics management are considered.

Paper: **4089** **B2L-B**

Optimisation-Based Tuning of Dynamic Matrix Control Algorithm for Multiple-Input Multiple-Output Processes

Jakub Sawulski[1], Maciej Ławryńczuk[2]

[1] *Warsaw University of Technology* J.Sawulski@ia.pw.edu.pl
[2] *Warsaw University of Technology* M.Lawrynczuk@ia.pw.edu.pl

The main goal of this work is to present possibility of using global optimisation methods for tuning parameters of Model Predictive Control (MPC) algorithms. For test purposes the Dynamic Matrix Control (DMC) algorithm applied to a Multiple-Input Multiple-Output (MIMO) process with 4 manipulated and 3 controlled variables is considered. The tuned parameters of the MPC algorithms include prediction and control horizons as well as the weights in used in the minimised MPC cost-function. Four global optimisation methods are considered: the Particle Swarm Optimisation method, the Firefly Algorithm, the Grey Wolf Optimiser and the Jaya algorithm. They aremcompared in terms of the ability to find the best solution and convergence. The obtained results show that global optimisation methods can be successfully used in this type of tasks.

Paper: **4093** **B2L-B**

A New Potential Field Inspired Path Planning Algorithm for Ships

Agnieszka Lazarowska[1]

[1] *Gdynia Maritime University* a.lazarowska@we.am.gdynia.pl

The paper introduces a new path planning method for ships. It is applied to calculate a safe trajectory for a ship in a collision situation at sea. The algorithm takes into account both static (lands, shallows) and dynamic obstacles (encountered ships) and returns a solution in near-real time. The algorithm is inspired by the Artificial Potential Field method and uses a general concept of this approach. The paper presents the description of a new method and results of simulation studies concerning simple and more complex navigational situations. Results demonstrate the effectiveness of proposed method for ships path planning.

Modelling & Simulation I, B2L-C

Day: Tuesday, August 28, 2018
Time: 10:00 - 11:00
Room: Lehar
Chair: Ali Hajnayeb

Paper: **4180** **B2L-C**

ReliefF-Based Feature Ranking and Feature Selection for Monitoring Induction Motors

Anna Stief[1], **James Ottewill**[2], **Jerzy Baranowski**[3]

[1] *ABB Corporate Research Center* anna.stief@pl.abb.com
[2] *ABB Corporate Research Center* james.ottewill@pl.abb.com
[3] *AGH University of Science and Technology* jb@agh.edu.pl

A feature is a measured property of a monitored system. Feature extraction in condition monitoring requires domain knowledge about a system and its possible fault cases. To find the most sensitive features for fault patterns, one has to evaluate the relevancy of features. In this paper the authors use ReliefF, which is a K-nearest neighbors-based features selection algorithm, to evaluate the extracted features from an induction motor dataset. The method provides insight into the relevance of features by sensor type and also by signal processing type. The evaluation of similarity among the selected features can help identify similar faults. The results obtained emphasize the importance of domain knowledge in proper design of features. Furthermore, by considering experimental data obtained for multiple loading and noise conditions, the feature selection method indicates features which are best suited for diagnosing specific faults, regardless of external conditions. Such information can support the creation of robust monitoring systems.

Paper: **4181** **B2L-C**

Application of the Wavelet Transform and Lipschitz Exponent for the Evaluation of Sandwich Panel Deformations at the Support

Jolanta Pozorska[1], Zbigniew Pozorski[2]

[1] *Czestochowa University of Technology* jolanta.pozorska@im.pcz.pl
[2] *Poznań University of Technology* zbigniew.pozorski@put.poznan.pl

The paper presents the application of wavelet transform and Lipschitz exponent for the evaluation of the failure of sandwich panels used in civil engineering. The three-layer panels have a thick and susceptible core that suffers significant deformations in the vicinity of local impacts, for example at a support. To assess the level of failure of the panel, the analysis of its displacements caused by static load was performed. The obtained results confirmed the effectiveness of the method.

Paper: **4191** **B2L-C**

Analytical Steady-State Model of the Pipeline Flow Process

Zdzisław Kowalczuk[1], Marek Tatara[2]

[1] *Gdańsk University of Technology* kova@pg.edu.pl
[2] *Gdańsk University of Technology* martatar@pg.edu.pl

The issue of modeling the flow process in transmission pipelines is discussed. Under certain assumptions concerning steady state analysis, the differential equations describing the process are solved analytically for two cases: zero and nonzero inclination angles. These equations describe a constant flow rate and a corresponding distribution of the pressure. The pipe length at which the pipeline is choking (the mass flow is equal zero) for given boundary pressures and inclination angle, is also derived. Convergence of the proposed solution for inclination angle alpha tending to 0 to the zero tilt solution, is proved.

Control & Systems Theory I, B2L-D

Day: Tuesday, August 28, 2018
Time: 10:00 - 11:00
Room: Strauss
Chair: Wiesław Krajewski

Paper: **4115** **B2L-D**

Iterative Learning Control for a Sub-Class of Uncertain 2D Systems

Bartłomiej Sulikowski[1]

[1] *University of Zielona Góra* B.Sulikowski@issi.uz.zgora.pl

In this paper the Iterative Learning Control (ILC) scheme is presented for for a subclass of 2D systems, i.e. spatially interconnected systems. Also, the existence of norm bounded uncertainty in the model is considered. Firstly, the 2D model is transformed into the uncertain 1D equivalent model using the lifting procedure. Next, in order to lead the model output to the prescribed reference signal, the ILC scheme is implemented. It attains the structure of the controlled differential linear repetitive process (LRP), hence assuring the stability along the trial of the underlying LRP automatically leads to the feasible ILC and the convergence to zero of the tracking error for the originally considered model. In what follows, the LMI based approach towards robust ILC controller design is given as a main result of this paper. To present the applicability of the proposed approach is applied for a subclass of spatially interconnected systems, i.e. the particular case of ladder RLC circuits.

Paper: **4063** **B2L-D**

On Leader-Following Consensus Protocol for Positive Discrete-Time Multi-Agent Systems

Ewa Girejko[1], **Agnieszka B. Malinowska**[2]

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

In this paper, we introduce a consensus protocol to reach a leader-following consensus for positive discrete-time multi-agent systems. In order to guarantee the convergence of the proposed algorithm, some general results are proved in the framework of the stability theory. In addition, numerical examples that validate the obtained results show the effectiveness of the designed control strategy.

Paper: **4119** **B2L-D**

Pole-Free Perfect Control: Theory Vs. Simulation Examples

Marek Krok[1], **Wojciech Hunek**[2]

[1] *Opole University of Technology* mar.krok@doktorant.po.edu.pl
[2] *Opole University of Technology* w.hunek@po.opole.pl

The mathematical preliminaries of the pole-free perfect control is discussed in this paper. Also the intriguing differences between the pole-free perfect control theory and presented simulation examples are shown. Although, the pole-free phenomenon is described only for a range of state-space systems so far, the first attempt of generalization of this maximum-speed/maximum-accuracy control algorithm is made in this paper.

Poster Session II, B3P-E

Day: Tuesday, August 28, 2018
Time: 10:00 - 12:00
Room: Poster Area
Chair: Przemysław Mazurek

Paper: **4048** **B3P-E**

Decentralized Microgrid Energy Management System with Market-Based Energy Trade System

Adrian Włodarczyk[1], **Albert Kowalczyk**[2], **Jarosław Tarnawski**[3]

[1] *Gdańsk University of Technology* adrianwd19@gmail.com
[2] *Gdańsk University of Technology* albert.kowalczyk@hotmail.com
[3] *Gdańsk University of Technology* jaroslaw.tarnawski@pg.edu.pl

This paper presents a decentralized energy management system for a power microgrid, which integrates individual users, who own renewable energy sources and energy storages. The purpose of the system is to make optimal use of available resources to cover the electricity needs of the whole microgrid. The developed system uses linear optimization to determine optimal power flows between microgrid's nodes. In order to do that, the system uses forecasted power generation profiles and consumer demand profiles, which come from prediction modules. Full decentralization of the system allowed for practically unlimited scalability compared to centralized systems. Decentralization also means better reliability. The system has been implemented in Python using free tools and libraries so that it can be implemented on any computer with an interpreter of that language.

Paper: **4065** **B3P-E**

Automatic Control of Working Process Parameters As a Condition for Robotisation of Mining Machines

Piotr Cheluszka[1], Piotr Sobota[2]

[1] *Silesian University of Technology* Piotr.Cheluszka@polsl.pl
[2] *Silesian University of Technology* Piotr.Sobota@polsl.pl

Boom-type roadheaders adapted to drilling underground roadways in mines and tunnels in civil engineering. The process course for cutting the rock located in a cross section of the drilled tunnel is decisive for the drilling process efficiency. The article presents selected test results for the automatic control algorithm for controlling the cutting process parameters. The proposed control method was implemented in a roadheader. Based on the dynamic characteristics recorded during experimental studies, the performance of the developed solution was evaluated by comparing the results obtained during working in an automatic mode and manual control by the operator.

Paper: **4074** **B3P-E**

Practical Verification of the Advanced Control Algorithms Based on the Virtual Commissioning Methodology – a Case Study

Patryk Grelewicz[1], Pawel Nowak[2], Michal Fratczak[3], Tomasz Klopot[4]

[1] *Silesian University of Technology* patrgre590@student.polsl.pl
[2] *Silesian University of Technology* pawel.nowak@polsl.pl
[3] *Silesian University of Technology* michal.fratczak@polsl.pl
[4] *Silesian University of Technology* tomasz.klopot@polsl.pl

In this paper the possibility of using the virtual commissioning for developing the advanced controllers for example of electric flow heater is presented. First, based on the process measurement data, the virtual environment is prepared. Then, for selected advanced control algorithms, both virtual and real commissioning were carried out. The results are discussed in the paper and they demonstrate the impact of the applied commissioning method on the control performance provided by each of considered control algorithms.

Paper: **4101** **B3P-E**

Sensitivity Characteristics of Positional Game Ship Control in Different Visibility at Sea

Józef Lisowski[1]

[1] *Gdynia Maritime University* j.lisowski@we.am.gdynia.pl

The paper introduces sensitivity of safe ship control to inaccurate data from the ARPA anti-collision radar system and to changes of the process control parameters. Computer simulations of safe ship trajectories are illustrated. Sensitivity characteristics of cooperative multistage positional game control algorithm on certain example of a navigational situation in the Kattegat Strait at different visibility at sea are determined.

Paper: **4153** **B3P-E**

Implementation of the FOPID Algorithm in the PLC Controller - PWR Thermal Power Control Case Study

Bartosz Puchalski[1], **Tomasz Adam Rutkowski**[2], **Kaziemierz Duzinkiewicz**[3]

[1] *Gdańsk University of Technology* bartosz.puchalski@pg.edu.pl
[2] *Gdańsk University of Technology* tomasz.adam.rutkowski@pg.edu.pl
[3] *Gdańsk University of Technology* kazimierz.duzinkiewicz@pg.edu.pl

The paper describes design and verification of discrete FOPID algorithm for control of PWR reactor thermal power. FOPID algorithm synthesis consists of: off-line optimal tuning of parameters in continuous time-domain with LQ performance index and simplified models of nuclear reactor and control rods drive; transformation into equivalent integer order structure using Oustaloup filters and finally its transformation into equivalent discrete form. Discrete FOPID is further implemented in PLC controller and verified by real-time simulation in HIL structure with non-linear PWR reactor model. Promising results were obtained, which confirm improved flexibility of discrete FOPID algorithm in comparison to classical PID counterpart.

Paper: **4201** **B3P-E**

Grey Wolf Optimizer Applied for Design Process of Off-Road Vehicle

Mateusz Kryszczak[1], **Marcin Kaminski**[2]

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

Presented paper deals with design, modeling and realization of vehicle arranged for work in difficult external conditions. Works described in article can be divided into two main groups, first of them is related to optimization of speed controller used for motor. For this purpose, metaheuristic algorithm – GWO (Grey Wolf Optimizer) was used. Next, project is focused on hardware preparation. Important assumption for real model is construction

based on two independent parts of the chassis. It leads to possibilities of better movement in difficult terrain.

Paper: **4125** **B3P-E**

Experimental Verification of Discrete Linear-Quadratic-Gaussian Control System of Electro-Hydraulic Servodrive

Jakub Mozaryn[1], **Arkadiusz Winnicki**[2], **Michał Micewicz**[3]

[1] *Warsaw University of Technology* j.mozaryn@mchtr.pw.edu.pl
[2] *Warsaw University of Technology* arekwinnicki@wp.pl
[3] *Warsaw University of Technology* micewicz.michal@gmail.com

This paper presents the design of a discrete Linear-Quadratic-Gaussian (LQG) controller for the electro-hydraulic servodrive position control. The controller is based on the identified linear model of the system. There are given experimental results of the proposed control system and a comparison with a control system with Proportional-Derivative (PD) controller.

Paper: **4177** **B3P-E**

Adaptive Controller with Neural Signal Predictor Applied for Two-Mass System

Marcin Kaminski[1]

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

This article presents design, implementation and analysis of results prepared for adaptive control structure based on two neural networks. The first of them is main controller with reconfigurable parameters, the second is applied in training algorithm. The task of additional model is prediction of information about measured signal. That construction of the controller can improve reaction of main neural networks against changes of state variables. Significant part of described work is focused on implementation of proposed model as speed controller of electrical drive. Analyzed control structure is tested in simulations and experiment (using dSPACE card).

Paper: **4084** **B3P-E**

Independent Flight Management System for Unmanned VTOL Aircraft

Adam Sikora[1], **Roman Czyba**[2]

[1] *Silesian University of Technology* adam_s1@interia.pl
[2] *Silesian University of Technology* roman.czyba@polsl.pl

In this paper control strategy for an independent flight management system of unmanned Vertical Take-off and Landing (VTOL) aircraft is taken into consideration. The developed algorithm allows to verify independently the current VTOL aircraft location and on the basis of it, to take appropriate actions in emergency states. Motivation to take up this problem is Medical Express UAV Challenge competition, which is one of the biggest events promoting the idea of autonomous control of Unmanned Aerial Vehicles (UAV). The paper presents assumptions of the project, concept of the system as well as the algorithm independently verifying the location, its software implementation and hardware realization. Finally, tests performed on a real device show that the concept and proposed algorithm with control strategies are satisfactory at this early concept level.

Fractional Order Systems II, B4L-A

Day: Tuesday, August 28, 2018
Time: 11:20 - 13:00
Room: Casino
Chair: Piotr Ostalczyk

Paper: **4018** **B4L-A**

Fractional Opinion Formation Models with Leadership

Ricardo Almeida[1], **Agnieszka B. Malinowska**[2], **Tatiana Odzijewicz**[3]

[1] *University of Aveiro* ricardo.almeida@ua.pt
[2] *Bialystok University of Technology* a.malinowska@pb.edu.pl
[3] *Warsaw School of Economics* tatiana.odzijewicz@sgh.waw.pl

This paper deals with an opinion formation model that obeys a nonlinear system of fractional-order differential equations. We introduce a virtual leader in order to attain a consensus. Sufficient conditions are established to ensure that the opinions of all agents globally asymptotically approach the opinion of the leader. We also address the problem of designing optimal control strategies for the leader so that the followers tend to consensus in the most efficient way. A variational integrator scheme is applied to solve the leader-follower optimal control problem. Finally, in order to verify the theoretical analysis, several particular examples are presented.

Paper: **4019** **B4L-A**

Leader-Following Group Consensus of Discrete Fractional-Order Double-Integrator Multi-Agent Systems

Mohammad Tabatabaei[1], **Erfan Shahamatkhah**[2]

[1] *Islamic Azad University* tabatabaei@iaukhsh.ac.ir
[2] *Islamic Azad University* shahamatkhah@gmail.com

This paper concerns with the leader-following group consensus problem for discrete-time fractional-order multi-agent systems with double-integrator agents. The interconnection between the agents is characterized with a bidirectional fixed graph. Two groups with two-leaders are considered. By considering some assumptions on the interaction graph, it is proved that leader-following group consensus will be realized if the controller parameters lie in a two-dimensional specific region. Simulation results indicate the efficiency of the proposed distributed control structure.

Paper: **4023** **B4L-A**

Simple Case of Fractional Sturm-Liouville Problem with Homogeneous Von Neumann Boundary Conditions

Malgorzata Klimek[1]

[1] *Czestochowa University of Technology* mpklimek@o2.pl

We study a variant of fractional Sturm-Liouvile eigenvalue problem with homogeneous von Neumann boundary conditions and prove that its spectrum is purely discrete. The differential fractional eigenvalue problem is converted to the integral one with the comapact, self-adjoint Hilbert-Schmidt integral operator. Both eigenvalue problems, differential and integral one, are equivalent on the respective subspace of continuous functions. The eigenfunctions are continuous and form an orthogonal basis in the respective Hilbert space.

Paper: **4092** **B4L-A**

Extensions of the Cayley-Hamilton Theorem to Fractional Linear Systems

Tadeusz Kaczorek[1]

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

The classical Cayley-Hamilton theorem is extended to fractional continuous-time linear systems. For single fractional order system the Cayley-Hamilton theorem is extended to basic continuous-time functions determining the solution of the system. The Cayley-Hamilton theorem is also extended to different orders fractional linear systems.

Paper: **4148** **B4L-A**

On the Observablity of Linear Nonstationary Fractional Systems

Zbigniew Zaczkiewicz[1]

[1] *Bialystok University of Technology* z.zaczkiewicz@pb.edu.pl

The paper is deals with a problem of observability of time variant linear fractional systems. We present definition of the estimation of initial conditions from the output of the system. By solutions representation we establish necessary and sufficient conditions for the defined observability. The considerations are illustrated by examples.

Control Applications I, B4L-B

Day: Tuesday, August 28, 2018
Time: 11:20 - 13:00
Room: Kalman
Chair: Georgy Kostin

Paper: **4078** **B4L-B**

A Decoupling Servo Pressure Controller for Pneumatic Muscle Actuators

Mirco Martens[1], **Thomas Seel**[2], **Ivo Boblan**[3]

[1] *Technical University of Berlin* mirco.martens@tu-berlin.de
[2] *Technical University of Berlin* seel@control.tu-berlin.de
[3] *Beuth University of Applied Science Berlin* ivo.boblan@beuth-hochschule.de

A pressure servo controller for pneumatic muscle actuators (PMAs) is presented and tested in three test scenarios. Unlike most previous non-linear control approaches, the cur- rent contribution demonstrated that a linear controller design becomes feasible after a slight reformulation of the non-linear plant dynamics. The controller is designed by pole placement in the discrete-time domain. It is demonstrated experimentally that the controller solves the control task and compensates pneumatic cross-coupling effects between different PMAs connected to a shared kinematic structure with an additional disturbance cancellation.

Paper: **4088** **B4L-B**

Practical Validation of the Reduced-Order Active Disturbance Rejection Controller for the Delay-Dominated Processes

Pawel Nowak[1], **Patryk Grelewicz**[2], **Jacek Czeczot**[3]

[1] *Silesian University of Technology* pawel.nowak@polsl.pl
[2] *Silesian University of Technology* patrgre590@student.polsl.pl
[3] *Silesian University of Technology* jacek.czeczot@polsl.pl

In this paper, the application of Reduced-Order Active Disturbance Rejection Controller (RADRC) for the processes with significant time delay is analysed. First, the analysis of the modified RADRC and of its tuning method is presented. Then a practical verification for temperature control in the electric flow heater is shown. In practical studies, the superiority of RADRC over PI and PI with Smith predictor is presented.

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

A Quasi-Stationary Approach to Control Problems for Hybrid Flexible Systems

Alexander Gavrikov[1], **Leonid Akulenko**[2]

[1] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* gavrikov@ipmnet.ru
[2] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* l.akulenko@bk.ru

A control problem for a string-type inhomogeneous system with boundary loads is considered. It is supposed that boundary and distributed controls are applied to the plant. By using corresponding eigenproblems, the lumped dynamics of a hybrid system is considered. Based on an original numerical technique for eigenvalues computation, a combined approach to vibration control is proposed. At the first stage, the linear-quadratic regulator is used for suppression of some highest eigenmodes. After preliminary damping of the oscillations, an explicit quasi-stationary control law is applied to the main lowest eigenmode. The proposed quasi-stationary control affects only the main eigenmode and almost does not disturb the highest modes. A numerical example is given and discussed.

Paper: **4102** **B4L-B**

Visual Feedback for Control Using Haar-Like Classifier to Identify the Quadcopter Position

Konrad Urbanski[1]

[1] *Poznań University of Technology* konrad.urbanski@put.poznan.pl

In order to precise control of unmanned aerial vehicles (UAV), there is a need to get information about UAV's attitude. In the paper a visual feedback is used in order to determine an altitude of the quadcopter. In a case of measure in range of meters or hundreds of meters, typical methods based on barometric sensor, or radar altimeter are

used. However, in a case of range of centimeters or single meters those methods may fail. Visual feedback allows control in range of centimeters or decimeters, depend of setup of visual control. The Haar-like classifier was created in order to find in a streaming video the quadcopter image. Experimental verification of the visual feedback for control of a quadcopter is presented.

Paper: **4160** **B4L-B**

High Performance Control of a Coupled Tanks System As an Example for Control Teaching

Marian Blachuta[1], Robert Bieda[2], Rafal Grygiel[3]

[1] *Silesian University of Technology* blachuta@polsl.pl
[2] *Silesian University of Technology* robert.bieda@polsl.pl
[3] *Silesian University of Technology* rafal.grygiel@polsl.pl

A detailed analysis of level control in a coupled tanks system is performed with respect to load disturbance attenuation. A nonlinear model of the system based on certain normalized variables that bases on only one parameter is constructed and linearized. A strong dependence of system properties on that parameter is highlighted. A simple method of choosing controller type and its settings is proposed that bases on time scale separation. PI control of the first tank, and PI and/or PID control of the second tank as well as cascade P/PI control system are analyzed. Invariance of the well designed control systems with respect to the changes of working point is highlighted.

Modelling & Simulation II, B4L-C

Day: Tuesday, August 28, 2018
Time: 11:20 - 13:00
Room: Lehar
Chair: Stevan Dubljevic

Paper: **4029** **B4L-C**

Physical Modelling of an Antagonistic Pneumatic Pivot Drive

Florian Winter[1], Daniel Rücker[2], Stefan Landkammer[3], Rüdiger Hornfeck[4], Peter Heß[5], Kristin Paetzold[6]

[1] *Technische Hochschule Nürnberg Georg Simon Ohm* florian.winter@th-nuernberg.de
[2] *Technische Hochschule Nürnberg Georg Simon Ohm* daniel.ruecker@th-nuernberg.de
[345] *Technische Hochschule Nürnberg Georg Simon Ohm*
[6] *Universität der Bundeswehr München*

This work deals with the physical modelling of an antagonistic, pneumatic pivot drive, including time dependencies. The developed system includes two pneumatic actuators to control the joint angle. These are a flexible foldable membrane for extension torque and a McKibben-type artificial muscle for flexion torque. Additionally, there are some non-manipulable elements, whose behaviour depends on the joint angle and their derivations.

The physical description of the active and passive system components is the main part of this paper. The system is divided into five subsystems which are separately described. The evaluation part shows a comparison between model and real system. For this purpose, different experiments are presented and the suitability of the chosen model is discussed.

Paper: **4096** **B4L-C**

Comparison and Identifiability Analysis of Friction Models for the Dither Motion of a Solenoid

Hanna Wenzl[1], Florian Straußberger[2], Tristan Braun[3], Stefan Wirtensohn[4], Lothar Kiltz[5], Johannes Reuter[6], Harald Aschemann[7]

[1] *University of Applied Sciences Konstanz* hwenzl@htwg-konstanz.de
[2] *University of Applied Sciences Konstanz* fstrauss@htwg-konstanz.de
[3] *ZF Friedrichshafen AG* tristan.braun@zf.com
[4] *University of Applied Sciences Konstanz* stwirten@htwg-konstanz.de
[5] *ZF Friedrichshafen AG* lothar.kiltz@zf.com
[6] *University of Applied Sciences Konstanz* jreuter@htwg-konstanz.de
[7] *University of Rostock* Harald.Aschemann@uni-rostock.de

In this paper, the mechanical subsystem of a proportional solenoid excited by a dither signal is considered. The objective is to find a suitable friction model that reflects the characteristic mechanical properties of the dynamic system. Several different friction models from the literature are compared. The friction models are evaluated with respect to their accuracy as well as their practical identifiability, the latter being quantified based on the Fisher information matrix.

Paper: **4127** **B4L-C**

Experimental Modelling of a Floating Offshore Wind Turbine

Christian Lindquist[1], Patrick Nielsen[2], Rikke Pedersen[3], Mohsen Soltani[4]

[1] *Aalborg University* clindq14@student.aau.dk
[2] *Aalborg University* pnni14@student.aau.dk
[3] *Aalborg University* rped14@student.aau.dk
[4] *Aalborg University* sms@et.aau.dk

Leading wind turbine manufacturers are increasingly looking at the possibilities of sending offshore wind turbines to deep seas. This can be done using a Floating Offshore Wind Turbine (FOWT). Therefore FOWT is an interesting and timely field of study. The aim of the paper is to use System Identification (SI) to make a data-driven-based model for the FOWT system, located in Offshore Wind & Wave Laboratory at Aalborg University. This is achieved by conducting experiments and analyzing the data. SI is used to analyze data from the experiments and obtain different models. These models are then evaluated based on the fit, the frequency response, autocorrelation and crosscorrelation. Eventually, an AutoRegressive Moving Average and Extra input (ARMAX) model is shown to be the most accurate amongst the analyzed models.

Paper: **4154** **B4L-C**

ADRC Load Position Controller for Two Mass System with Elastic Joint and Backlash

Bartlomiej Wicher[1]

[1]*Poznań University of Technology* bartlomiej.wicher@put.poznan.pl

The article presents simulation research over the position control of two-mass system with backlash. Author implemented Active Disturbance Rejection Control method for this type of object. The simulation research are preliminary tests before implementation the algorithm on laboratory bench. Detailed description of each block of the control system is presented, then simulation research are conducted, next – proposed performance indexes are calculated, finally conclusions and future works are discussed.

Paper: **4146** **B4L-C**

Structural Sensitivity of Control Models Arising in Combined Chemo-Radiotherapy

Marzena Dolbniak[1], **Jaroslaw Smieja**[2], **Andrzej Swierniak**[3]

[1]*Silesian University of Technology* marzena.dolbniak@polsl.pl
[2]*Silesian University of Technology* jaroslaw.smieja@polsl.pl
[3]*Silesian University of Technology* andrzej.swierniak@polsl.pl

Nowadays, the focus is on personalized oncology, in which treatment strategy is tailored to an individual patient. Simple models with minimal number of parameters can be used to find appropriate treatment strategy. The main idea of this study is to describe effects of combined radio-chemotherapy by two control actions. Comparing Kaplan-Meier survival curves obtained for two different tumor growth models indicates that while Gompertz model is slightly less sensitive to changes in control action than exponential and logistic models, the difference is negligible. The important finding is that the shapes of survival curves are similar in all cases. It suggests that the family of models is structurally insensitive.

Sliding Mode Control, B4L-D

Day: Tuesday, August 28, 2018
Time: 11:20 - 13:00
Room: Strauss
Chair: Jacek Kabziński

Paper: **4095** **B4L-D**

Second-Order Sliding Mode Control with State and Disturbance Estimation for a Permanent Magnet Linear Motor

Harald Aschemann[1], Benedikt Haus[2], Paolo Mercorelli[3]

[1] *University of Rostock* Harald.Aschemann@uni-rostock.de
[2] *Leuphana University of Lueneburg* haus@leuphana.de
[3] *Leuphana University of Lueneburg* mercorelli@leuphana.de

As the drive force depends in a nonlinear way on the currents, tracking control of permanent magnetic actuators requires sophisticated control approaches. In this contribution, a cascaded control strategy is proposed that cancels the effect of the nonlinearity and allows for an accurate trajectory tracking. The strategy involves the combination of an inversion-based current control, a second-order sliding mode control (SMC), and a Kalman filter (KF) that provides estimates for the state variables as well as a lumped disturbance force from noisy measurements. The combination of second-order sliding mode control and estimator-based disturbance compensation contributes to the robustness of the overall control structure, reduces chattering effects significantly and addresses unknown disturbances as well as parametric uncertainties. Successful simulation results indicate the potential of the proposed nonlinear control strategy.

Paper: **4111** **B4L-D**

Sliding Mode Control with Time-Varying Switching Hyperplane for Data Transmission Networks

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

Discrete time sliding mode control systems ensure a high degree of robustness with respect to disturbance by confining the system state to a specified vicinity of the switching hyperplane. However, quickly driving the state towards that vicinity often results in unfeasibly large values of the control signal. In order to ensure that robust quasi-sliding motion of the system begins immediately at the start of the control process while limiting the magnitude of the control signal and state variables, a new time-varying sliding hyperplane is proposed. An additional state variable not present in the original system is specified and the hyperplane is defined in the extended state space. The effect of this new variable on

quasi-sliding motion of the system diminishes over time and eventually reaches zero. The strategy which drives the system representative point onto the time-varying hyperplane is applied to control the flow of data in connection-oriented communication networks. For such plants, it is demonstrated that the proposed approach allows one to impose bounds on the input and output of the system at all stages of the control process.

Paper: **4134** **B4L-D**

Integral Sliding Mode Control and Gain-Scheduled Modified Utkin Observer for an Underground Coal Gasification Energy Conversion Process

Ali Uppal[1], Saif Butt[2], Aamer Bhatti[3], Harald Aschemann[4]

[1] *COMSATS Institute of Information Technology* ali_arshad@comsats.edu.pk
[2] *IAV Development GmbH* saif.siddique.butt@iav.de
[3] *Capital University of Science and Technology* aib@cust.edu.pk
[4] *University of Rostock* harald.aschemann@uni-rostock.de

One of the challenging control problems of an underground coal gasification (UCG) process involves maintaining desired heating value extracted from product gases. In this paper, a model-based control and state estimation of UCG process is described. For the purpose of control and state estimation, a complex partial differential equations based model of the UCG process is approximated with a localized nonlinear control-oriented model. Based on this approximated plant model, a robust integral sliding mode control is designed to track desired heating value. Furthermore, for the estimation of unknown states of the system, a gain-scheduled modified Utkin observer is designed as well. The robustness of the nonlinear control and estimation techniques is exploited by introducing parametric uncertainties in the UCG plant. The simulation results highlight the effectiveness of the proposed nonlinear control and estimation techniques in comparison to a conventional PI controller.

Paper: **4073** **B4L-D**

Discrete Sliding-Mode Control of Multipath TCP Networks Under Input and Output Uncertainty

Przemysław Ignaciuk[1], Michał Morawski[2]

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

A telecommunication network consists of an interconnected set of terminals and intermediate nodes, with multiple path choices available in the mesh topology. While the underlying equipment has been always developed with the redundancy in mind, the endpoints made use of a single active connection, only. In the case of failure, the connection has been broken, or stalled. Recently, in order to ameliorate such inopportune situation, multipath versions of the most common network protocols have been elaborated. This

paper presents a discrete-time model of Mulitpath TCP (MPTCP) data transfer and discusses sliding-mode flow controller design. The properties of the obtained control system, in particular the stability and feasibility of network implementation under both input and output uncertainty, are formally proved and illustrated by simulations.

Paper: **4025** **B4L-D**

Sliding Mode Control of an Electromechanical Solenoid Actuator for Soft Landing

Mehmet Polat Kuntuz[1], Muhammad Sarmad Qureshi[2], Ozkan Bebek[3]

[1] *Ozyegin University* mehmet.kuntuz@ozu.edu.tr
[2] *Ozyegin University* sarmad.qureshi@ozu.edu.tr
[3] *Ozyegin University* ozkan.bebek@ozyegin.edu.tr

In this paper two different control techniques have been applied i.e. Proportional Integral Derivative (PID) control algorithm and the Sliding Mode Control (SMC) algorithm, on the hardware model for the position control of Electromagnetic (EM) actuator using a position feedback sensor. Moreover, to avoid the electromagnetic actuator from high velocity impacts which may cause excessively loud noise and create unnecessary wear and tear of the mechanical parts of the actuator, different input reference profiles are designed which when followed can reduce the magnitude of aforesaid impacts, which facilitates the soft landing along with the high speed switching. The accurate and unbiased comparison between the aforesaid two control algorithms has been done.

Optimization, B5L-A

Day: Tuesday, August 28, 2018
Time: 15:00 - 16:20
Room: Casino
Chair: Sebastian Engell

Paper: **4211** **B5L-A**

Optimality and Sensitivity of Least-Distance and Avoidance Solutions in Multicriteria Optimization

Andrzej Maciej Skulimowski[1]

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

This paper investigates the sensitivity and optimality of distance scalarizing solutions in multicriteria problems with reference sets. The reference sets arise often from relaxed criteria space constraint problems and are non-precisely defined. Therefore we provide sufficient conditions ensuring the stability of solutions with respect to the perturbations of reference sets. For various reasons, including a trajectory safety, the above problem may be particularly relevant in case of avoidance values which are usually defined with a

native uncertainty. An application to solving optimal control and uncertain time decision problems is outlined in the final part of this paper

Paper: **4076** **B5L-A**

Optimization of Robot Tasks by Intelligent Objects Using RFID Technology

Christian Thormann[1], **Alexander Winkler**[2]

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

The paper investigates useful applications of RFID (Radio Frequency Identification) technology in combination with industrial robots, because these automation devices are very important in the context of the term Industry 4.0. In industrial automation, RFID transponders can be placed on tools and workpieces. Besides, the identification of objects, it is also possible to store information locally on the object. Such an object may be regarded as an intelligent object, because its supports the decentralization of decisions. The paper makes proposals about what kind of data can be stored in workpieces and how this information can be used to optimize the robot task. Room for improvement is found with respect to, e.g., the path accuracy of the robot motion, force/torque control and collision avoidance. Selected algorithms relating to the proposals are verified successfully by practical experiments.

Paper: **4109** **B5L-A**

Approximate Criteria for the Evaluation of Truly Multi-Dimensional Optimization Problems

Zdzisław Kowalczuk[1], **Tomasz Białaszewski**[2]

[1] *Gdańsk University of Technology* kova@pg.edu.pl
[2] *Gdańsk University of Technology* tombiala@pg.edu.pl

In this paper we propose new improved approximate quality criteria useful in assessing the efficiency of evolutionary multi-objective optimization (EMO). In the performed comparative study we take into account the various EMO algorithms of the state-of-the-art, in order to objectively assess the EMO performance in highly dimensional spaces. It is well known that useful executive criteria, such as those based on the true Pareto front in highly multidimensional spaces, can be tedious or even impossible to calculate. On the other hand, the proposed synthetic quality criteria are easy to implement, computationally inexpensive, and sufficiently informative and effective.

Paper: **4130** **B5L-A**

1st Order Nonstationary Element Optimization Using PSO Algorithm

Katarzyna Wiechetek[1], Roman Kaszyński[2]

[1] *West Pomeranian University of Technology Szczecin* katarzyna.wiechetek@zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* roman.kaszynski@zut.edu.pl

The paper presents a new concept of establishing the varying function parameters in order to reduce the duration of the transition processes. The optimization was conducted using particle swarm optimization algorithm (PSO). The main object of the research was 1st order element with two outputs: a low-pass and a high-pass. By selecting the right values of the parameters a better operation and considerably shorter settling times were achieved. After applying multiobjective optimization algorithm the system could adapt to more requirements at once.

Image Processing, B5L-B

Day: Tuesday, August 28, 2018
Time: 15:00 - 16:20
Room: Kalman
Chair: Krzysztof Okarma

Paper: **4034** **B5L-B**

Performance Analysis of the Image Fusion Methods of the Proposed 2D Acoustic Camera

Jaroslaw Rzepecki[1], Sebastian Budzan[2], Stanislaw Wrona[3], Marek Pawelczyk[4]

[1] *Silesian University of Technology* jaroslaw.rzepecki@polsl.pl
[2] *Silesian University of Technology* sebastian.budzan@polsl.pl
[3] *Silesian University of Technology* stanislaw.wrona@polsl.pl
[4] *Silesian University of Technology* marek.pawelczyk@polsl.pl

In this paper authors described in details some fundamental issues related to the acoustic camera construction. The experiments have been concentrated on the evaluation of the different image fusion algorithms performance. In result, for the specific purposes, especially for noisy spaces and non-stationary sound sources, some alternative method of the image fusion might be more efficient than standard algorithm.

Paper: **4035** **B5L-B**

On Impulsive Noise Suppression Techniques in Color Images

Łukasz Maliński[1], Bogdan Smołka[2]

[1]*Silesian University of Technology* lukasz.malinski@polsl.pl
[2]*Silesian University of Technology* bogdan.smolka@polsl.pl

In the paper the impulsive noise suppression algorithms based on arithmetic mean and vector median scheme are concerned. Usually, the performance of the entire filtering process, which includes noisy pixels detection and noise replacement, is presented. However, the aim of the research presented here, is to focus on the noise replacement step alone. The analyzed algorithms process the corrupted images using external knowledge about locations of noisy pixels in two variants: with maps containing true information about noise and those obtained from very efficient impulsive noise detection scheme.

Paper: **4067** **B5L-B**

Research of the Equipment Calibration Methods for Fertilizers Particles Distribution by Size Using Image Processing Measurement Method

Andrius Laucka[1], Vaida Adaskeviciute[2], Algimantas Valinevicius[3], Darius Andriukaitis[4]

[1]*Kaunas University of Technology* andrius.laucka@ktu.edu
[2]*Vytautas Magnus University* vaida.adaskeviciute@gmail.com
[3]*Kaunas University of Technology* algimantas.valinevicius@ktu.lt
[4]*Kaunas University of Technology* darius.andriukaitis@ktu.lt

Image processing technologies nowadays are widely used in quality control. A new automated quality control system saves resources. Quality control in the fertilizer industry is carried out without interruption. Only indirect measurements can achieve the required quality production efficiency. This article presents the methodology for calibrating indirect particle measurement methods. Particle analysis is performed by processing digital images. Correction of results is carried out with a sieve correction factor. In this work, studies have been carried out using linear regression polynomial function and artificial neural network. With the latter, the best results are achieved with sufficient data for training.

Paper: **4173** **B5L-B**

Classification of Vehicles in Aerial Imagery Using Deep Convolutional Neural Networks

Przemyslaw Mazurek[1], **Dorota Oszutowska-Mazurek**[2]

[1] *West Pomeranian University of Technology Szczecin* przemyslaw.mazurek@zut.edu.pl
[2] *Pomeranian Medical University in Szczecin* adorotta@op.pl

Aerial imagery is important for delivery of spatial information from large surface areas. The detection and classification of vehicles in use or parked is important for the analysis of road traffic or agricultural analyzes. Modified VEDAI database with reduced number to 9 classes of vehicles is used. Deep convolutional neural network is tested for the classification purposes and the influence of number of kernels in the first layer is investigated. Achieved results show similarity between kernels for different setups. Most kernels are radial and classification results are related to the number of the used classes.

Identification II, B5L-C

Day: Tuesday, August 28, 2018
Time: 15:00 - 16:20
Room: Lehar
Chair: Jarosław Figwer

Paper: **4108** **B5L-C**

Nonparametric Identification of the Surgeon's Hand Vibration in Haptic Devices

Ali Hajnayeb[1], **Ahmad Ghasemloonia**[2]

[1] *Shahid Chamran University of Ahvaz* a.nayeb@scu.ac.ir
[2] *University of Calgary* Ahmad.Ghasemloonia@ucalgary.ca

In this study, an experimental setup is developed to investigate a dynamic model of the grasping point of the haptic endeffectors. The system was modeled by its frequency response with a non-parametric identification method. The amplitude and phase of the frequency response of the operator's hand are plotted as a function of frequency. The natural frequency of the hand model is in agreement with the assumed SDOF model. The phase difference and the coherence spectrum is analyzed to investigate the natural frequencies and amplitude ratios at different grasping configurations and finger styles. The results showed changes in the natural frequencies and amplitude ratios for different hand configurations and finger styles. The developed model in this study can be used in conjunction with the vibration generators in haptic handcontrollers to more accurately render the developed vibration at surgical corridors at the end-user hand.

Paper: **4126** **B5L-C**

Modeling and Identification of Cylindrical Bodies with Free Convection and Peltier Elements As Sources for Active Heating

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

[1] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* knyaz@ipmnet.ru
[2] *University of Rostock* Harald.Aschemann@uni-rostock.de
[3] *University of Rostock* Julia.Kersten@uni-rostock.de
[4] *Ishlinsky Institute for Problems in Mechanics of the Russian Academy of Sciences* kostin@ipmnet.ru
[5] *University of Rostock* Andreas.Rauh@uni-rostock.de

The paper considers the modeling of active heating or natural cooling of a cylindrical body, - either vertically or horizontally arranged. The position dependency of the coefficient of convective heat transfer along the surface of the body on this process is investigated in detail. It turned out that its nonuniformity must be taken into account when solving problems of controlled heating for bodies with low thermal conductivity. An identification of the model parameters leads to results that are in good agreement with values from the literature for the experimental setup - a cylindrical body heated from both ends by two Peltier elements.

Paper: **4026** **B5L-C**

Least Squares and Instrumental Variables Identification of Polynomial Wiener Systems

Andrzej Janczak[1]

[1] *University of Zielona Góra* A.Janczak@issi.uz.zgora.pl

The paper is addressed to a combined least squares (LS) and instrumental variables (IV) approach to identification of polynomial Wiener systems. It is assumed that the inverse nonlinear element can be described by a polynomial. It is shown that LS parameter estimates of polynomial Wiener system are non-consistent and to circumvent the consistency problem, the well-known IV method is used. To avoid the parameter redundancy, three different methods of calculation inverse nonlinear function parameters from the transformed model parameters are proposed. The simulation results are included that confirm the practical feasibility of the proposed approach. The highest parameter estimation accuracy has been obtained via solving an overdetermined system of equations, only insignificantly lower accuracy has been obtained using the mean value approach, and the lowest one calculating the inverse nonlinear function parameters from the sums of transformed Wiener model parameters.

Paper: **4007** **B5L-C**

Parameter Identification for Non Integer Order, Discrete, State Space Model of Heat Transfer Process Using CFE Approximation

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 a new, non integer order, discrete state space model of heat transfer process is presented. The proposed model employes CFE approximation what assures good accuracy with relatively low order and short memory length. The parameters of the model were estimated via minimization the MSE (Mean Square Error) cost function. The proposed model is compared to discrete model using PSE approximation. Results of comparison show, that the proposed model employing CFE approximation is able to assure the same accuracy using significantly smaller memory length than model employing PSE approximation.

UAV, B5L-D

Day: Tuesday, August 28, 2018
Time: 15:00 - 16:20
Room: Strauss
Chair: Kemao Peng

Paper: **4017** **B5L-D**

Guidance and Control of Autonomous, Flexible Wing UAV with Advanced Vision System

Malik Al-Isawi[1], **Jurek Sasiadek**[2]

[1] *Carleton University* malikgts@hotmail.com
[2] *Carleton University* Jurek.Sasiadek@carleton.ca

This paper presents a new methodology to guide and control flexible wings UAV based on a stereo vision system with advanced fuzzy logic algorithms. This system allows to detect wing's deflections and shapes by using the novel Deflection-Detection Vision System(DDVS).This methodology has three different steps. First, the shape of the wing was identified by the determinant the deflection points on the wing using the stereo camera. Second, the Fuzzy Logic Algorithm was used to classify the shapes of the wing and to determine the flight parameters such as, speed, angle of attack and roll angle. Finally, an autopilot controller based on intelligent, adaptive, neuro-fuzzy system (ANFIS) algorithm was designed. Extensive, experimental studies were performed in wind tunnel to determine the characteristics of the flexible wing. The testing were performed for wind speeds ranging from 11 to 31 km/h, angles of attack ranging from -20 deg to +20

deg. The experimental results were extended and verified with simulation experiments for wider ranges of velocities and angle of attack

Paper: **4033** **B5L-D**

MARAAL: a Low Altitude Long Endurance Solar Powered UAV for Surveillance and Mapping Applications

Vijay Shankar Dwivedi[1], Jay Patrikar[2], Amulya Addamane[3], Ajoy Kanti Ghosh[4]

[1]*Indian Institute of Technology Kanpur* vijayd@iitk.ac.in
[2]*Indian Institute of Technology Kanpur* jaypat@iitk.ac.in
[3]*Indian Institute of Technology Kanpur* amulya@iitk.ac.in
[4]*Indian Institute of Technology Kanpur* akg@iitk.ac.in

This paper constitutes the detailed design, fabrication and flight tests of MARAAL: A low altitude long endurance UAV to be operated day-night in a subtropical region.The Solar UAV prototype fabricated at Unmanned Aerial Laboratory IIT Kanpur has a wing span of 5.35m, maximum endurance of 16 hours and a maximum payload capacity of 6 kgs.A detailed conceptual design process is established with a set of constraints which are used to generate parameters for 6DOF simulation. Developments in solar cell encapsulation process ensure a superior aerodynamic performance. The paper also highlights the construction efforts and details of the hardware and onboard electronics including surveillance equipment

Paper: **4080** **B5L-D**

Obstacle Detection and Avoidance System for Unmanned Multirotors

Adam Stulgis[1], Leszek Ambroziak[2], Mirosław Kondratiuk[3]

[1]*Bialystok University of Technology* astulgis95@gmail.com
[2]*Bialystok University of Technology* l.ambroziak@pb.edu.pl
[3]*Bialystok University of Technology* m.kondratiuk@pb.edu.pl

The paper presents the simple method for obstacle detection and avoidance designed for small unmanned multi-rotors. The system is using laser scanner information and supports the pilot during the manual flights. The proposed obstacle avoidance algorithm was described in details. The main aim of the work were the in-flight test. The tests were divided into two stages – with static obstacle and with dynamic one. The results were presented in the UAV trajectories plot and PWM control signal time plots. Obtained results validate the effectiveness of the proposed collision avoidance method. Described approach helps to ensure collision free conditions for UAV operators. Also the proposed anti-collision system could be easily used in autonomous flight stages of UAVs.

Paper: **4143** **B5L-D**

Development of an Unmanned Vertical Take-Off and Landing Aircraft for Medical Express UAV Challenge

Roman Czyba[1], Marcin Lemanowicz[2], Michał Simon[3], Tomasz Kudala[4], Zbigniew Gorol[5], Maciej Galeja[6], Karol Hanke[7], Adam Sikora[8], Wojciech Grabowski[9]

[1] *Silesian University of Technology* roman.czyba@polsl.pl
[2] *Silesian University of Technology* Marcin.Lemanowicz@polsl.pl
[3] *Silesian University of Technology* 1michal.simon1995@gmail.com
[4] *Silesian University of Technology* tk96pl@gmail.com
[5] *Silesian University of Technology* zbigniew.gorol@gmail.com
[6] *Silesian University of Technology* maciej.galeja@o2.pl
[7] *Silesian University of Technology* karol.hanke@interia.pl
[8] *Silesian University of Technology* adam_s1@interia.pl
[9] *Silesian University of Technology* wgrabowski.highflyers@gmail.com

This paper presents a design process of unmanned vertical take-off and landing aircraft, developed by the High Flyers team from Silesian University of Technology, who decided to participate in the Medical Express UAV Challenge competition. The designed system is described as a hybrid platform, where different operating modes correspond to the vertical flight, transition and spatial flight in the airframe system. Explanation of an iterative design process with the contribution of CAD design, CFD analysis and control system design in particular flight modes is presented. Simulation results are carried out to corroborate the design control system. Finally, the fast prototyping of proposed control strategy as well as manufacturing process is shown.

Poster Session III, B6P-E

Day: Tuesday, August 28, 2018
Time: 15:00 - 16:20
Room: Poster Area
Chair: Wojciech Grega

Paper: **4016** **B6P-E**

Fuzzy-Genetic Approach to Solving Clustering Problem

Krzysztof Pytel[1]

[1] *University of Łódź* kpytel@uni.lodz.pl

The article presents the idea of the hybrid Fuzzy Logic-Genetic Algorithm system that supports solving clustering problems. The Genetic Algorithm realizes the process of multi-objective optimization - it aims at optimal distribution of clusters and correctly assigns each object to a cluster. The Fuzzy Logic Controller is used for setting the number of clusters. Experiments show that the proposed algorithm is an efficient tool for the clustering problem. The algorithm can be also used for solving similar optimization

problems, for example to predict cardiovascular diseases, based predictors like Blood Pressure or Body Mass Index.

Paper: **4099** **B6P-E**

Designing Social Robot Interaction System for Conversational Turn-Taking

Mateusz Żarkowski[1]

[1] *Wrocław University of Science and Technology* mateusz.zarkowski@pwr.edu.pl

This paper is a proof of concept for implementing turn-taking behavior into the architecture of a social robot. Firstly, we discuss the phenomenon of turn-taking from the psychological perspective, then assess the computational turn-taking models and identify their strengths and flaws for implementation onto a social robot. Afterwards, we derive the architecture for social robot turn-taking system that, basing on the behavior of the user, is able to detect the turn-taking cues, determine turn transitions and, in result, provide natural communication respecting social norms in regard to turn-taking mechanisms. Lastly, we evaluate the feasibility of the proposed approach taking into consideration available technical solutions and their limitations.

Paper: **4112** **B6P-E**

Artificial Neural Network Capability for Human Being Identification Based on ECG

Volodymyr Khoma[1], **Mariusz Pelc**[2], **Yuriy Khoma**[3]

[1] *Opole University of Technology* v.khoma@po.opole.pl
[2] *Opole University of Technology / University of Greenwich* m.pelc@po.opole.pl
[3] *Opole University of Technology* khoma.yuriy@gmail.com

In this paper we presented a method for human being identification based on ECG supported by Artificial Neural Networks. We also propose structure of such identification system with description of its functional elements. To provide an insight into efficiency of the proposed methodology we compare it to alternative approaches based on Logistic Regression and K-Nearest Neighbour. All experiments were performed on several representative data (existing ECG records of real patients).

Paper: **4113** **B6P-E**

A Fuzzy Logic-Based Approach for Predictive Maintenance of Grinding Wheels of Automated Grinding Lines

Marius Baban[1], **Calin Florin Baban**[2], **Beniamin Moisi**[3]

[1] *University of Oradea* mbaban@uoradea.ro
[2] *University of Oradea* cbaban@uoradea.ro
[3] *University of Oradea* beni_moisi17@yahoo.com

The state of grinding wheels of automated grinding lines can be evaluated by monitoring their vibration and temperature, so that a condition-based approach can be used for their maintenance. However, there are some limitations of condition monitoring, which may conduct to some uncertainty or vagueness in accomplishing diagnostics. Within this framework, the aim of this study is the employment of a fuzzy logic for planning the maintenance policy of the grinding wheels of automated grinding lines.

Paper: **4145** **B6P-E**

Efficient Integration of Octree Based Maps in Multi-Robot System

Michał Drwięga[1]

[1] *Wrocław University of Science and Technology* michal.drwiega@pwr.edu.pl

The paper presents an approach for integration of three-dimensional world models (octree based maps) in multi-robot systems. The process of maps integration is based on ICP (Iterative Closest Point) algorithm which has been adapted and optimized to operate on octomaps. The presented approach has been verified in numerous experiments both in simulation and with publicly available datasets captured from robots. The solution can be applied to various robotic applications such as underwater robots, flying robots or robots equipped with manipulators - wherever 3D maps are needed and a task is performed by group of mobile robots.

Paper: **4042** **B6P-E**

Installation and Control of Building Automation Systems Using Human-Robot-Interaction

Mattes Ohlenbusch[1], Niklas Bartner[2], Sarah Vöge[3], Jan Vox[4], Jannik Fleßner[5], Melina Frenken[6], Frank Wallhoff[7]

[1] *Jade University of Applied Sciences* mattes.ohlenbusch@student.jade-hs.de
[2] *Jade University of Applied Sciences* niklas.bartner@student.jade-hs.de
[3] *Jade University of Applied Sciences* sarah.voege@student.jade-hs.de
[4] *Jade University of Applied Sciences* jan.vox@jade-hs.de
[5] *Jade University of Applied Sciences* jannik.flessner@jade-hs.de
[6] *Jade University of Applied Sciences* melina.frenken@jade-hs.de
[7] *Jade University of Applied Sciences* frank.wallhoff@jade-hs.de

In this work, an implementation of a building automation system extendable in a dialog with a robot counterpart is designed and evaluated. The system enables its users to integrate new building automation devices into an existing configuration and control them using only voice control. Key findings of this work are that users of the developed system find it more desirable to be able to extend their building automation by themselves. Moreover they perceive the interaction scheme to integrate new automation components as mostly positive. The study was conducted with a group consisting of 13 subjects. The acceptance and usability determined by questionnaires is shown. The presented study underpins the superiority of voice driven interaction within an installation and parametrization setting.

Paper: **4009** **B6P-E**

Accuracy Control Studies of Engineer Robot Manipulator of Serial-to-Parralel Kinematic Structure

Piotr Krogul[1], Stanisław Konopka[2], Marian Łopatka[3]

[1] *Military University of Technology* piotr.krogul@wat.edu.pl
[2] *Military University of Technology* stanislaw.konopka@wat.edu.pl
[3] *Military University of Technology* marian.lopatka@wat.edu.pl

The improvement of intuitive control of engineer robot manipulators caused the development of special control lever mechanisms. This approach has reduced the psycho-physical fatigue of the operator. The article presents experimental accuracy control for one of the typical kinematic structures of engineer robot's manipulator using lever mechanism. Taking into consideration, a model of such a mechanism and a control algorithm that uses the operation of typical regulators were developed and made. Based on the movement of the manipulator's working tool along the assumed horizontal trajectory for different speeds of movement the errors in running working tool were determined.

Paper: **4182** **B6P-E**

Development of a Model Predictive Controller for an Unstable Heavy Self-Balancing Robot

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 development of a control system for a heavy self-balancing two-wheeled robot. The development process includes: model identification, model tuning, design and tuning of a Model Predictive Control (MPC) algorithm. Although a simple linear state-space model with only two state variables is used, the results of laboratory experiments clearly indicate that the MPC algorithm based on such a model works well, i.e. the algorithm is able to effectively stabilise the robot.

Paper: **4184** **B6P-E**

Integrated Drive System of Robotic Arm Joint Used in a Mobile Robot

Piotr Tomaszuk[1], **Aneta Łukowska**[2], **Maciej Rećko**[3], **Kazimierz Dzierżek**[4]

[1] *Bialystok University of Technology* ptom9515@gmail.com
[2] *Bialystok University of Technology* aalukowska@gmail.com
[3] *Bialystok University of Technology* m.recko@outlook.com
[4] *Bialystok University of Technology* k.dzierzek@pb.edu.pl

The objective of the article is the description of the design process of compact cycloidal gear with built-in brushless motor and integrated driver. The assumption of the project is to create a lightweight joint with high ratio and durability to use in a mobile robot's arm or other movable parts. The primary purpose of the project is cost-effective construction using mainly off the shelf parts and own design cycloidal gear.

Paper: **4215** **B6P-E**

A Novel Approach for Invasive Weeds and Vegetation Surveys Using UAS and Artificial Intelligence

Juan Sandino[1], **Felipe Gonzalez**[2]

[1] *Queensland University of Technology* sandinoj@qut.edu.au
[2] *Queensland University of Technology* felipe.gonzalez@qut.edu.au

Surveillance tasks of weeds and vegetation in arid lands is a complex, difficult and time-consuming task. In this article we present a framework to detect and map invasive grasses, combining UAVs and high-resolution RGB technologies and machine learning for data processing. This approach is illustrated by segmenting Buffel Grass (Cenchrus ciliaris) and Spinifex (Triodia sp.). Segmentation results produced individual detection rates of 97

Wednesday
August 29th, 2018

Plenary 3: Guido de Croon, C1L-A

Day: Wednesday, August 29, 2018
Time: 9:00 - 10:00
Room: Casino
Chair: Harald Aschemann

Paper: **4218** **C1L-A**

Autonomous Flight of Flapping Wing Robots - the Relation Between Body and Mind

Guido de Croon[1]

[1] *Delft University of Technology* g.c.h.e.decroon@tudelft.nl

Tiny fruit flies are a great inspiration for autonomously flying robots. With a mere 100,000 neurons they are able to fly, navigate, find food and shelter, and even socially interact with each other. In my presentation, I will talk about my dream to endow small flying robots with similar capabilities. Specifically, I will talk about the DelFly family of flapping wing robots, developed at TU Delft, and how the DelFly has "evolved" over the years from a purely telecommanded drone to the 20-gram fully autonomous DelFly Explorer. I will delve into the developments in hardware (the robot's body) and into the Artificial Intelligence algorithms (the robot's mind) that underly the success of the Explorer, arguing that for such small and light-weight flying robots, body and mind should be carefully designed together. I will also discuss the challenges ahead, i.e., how to make such light-weight drones work together in a swarm or how to navigate over longer distances.

Adaptive & Robust Control, C2L-A

Day: Wednesday, August 29, 2018
Time: 10:00 - 11:00
Room: Casino
Chair: Dirk Weidemann

Paper: **4057** **C2L-A**

Robust and Adaptive Ship Path-Following Control System Design

Zenon Zwierzewicz[1]

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

The paper considers the problem of ship path-following system design based on robust and adaptive control methods. The ship under consideration is an underactuated, nonlinear object with unknown model parameters subjected to hard environmental disturbances.

For this reason the applied design procedures attempt to combine the disturbances attenuation, function approximation and adaptive control techniques. The whole control system is able to ensure tracking performance on the Hinf optimal attenuation level. Simulations of the ship path-following process have confirmed a good performance of the proposed controller.

Paper: **4165** **C2L-A**

Model-Free Control Approach for Fixed-Wing UAVs with Uncertain Parameters Analysis

Jacson Miguel O. Barth[1], Jean-Philippe Condomines[2], Jean-Marc Moschetta[3], Cédric Join[4], Michel Fliess[5]

[1] *École Nationale de l'Aviation Civile* jacson-miguel.olszanecki-barth@enac.fr
[2] *École Nationale de l'Aviation Civile* jean-philippe.condomines@enac.fr
[3] *Institut Supérieur de l'Aéronautique et de l'Espace* jean-marc.moschetta@isae-supaero.fr
[4] *Université de Lorraine* cedric.join@univ-lorraine.fr
[5] *LIX-CNRS École Polytechnique* Michel.Fliess@polytechnique.edu

This paper presents first results of an innovative Model Free Control (MFC) architecture applied to fixed-wing UAVs. MFC is an algorithm dedicated to systems with poor modeling knowledge. Indeed, the costs to derive a reliable and representative aerodynamic model for UAVs motivated the use of such a controller. By exploiting a purely numerical model, this algorithm provides an intuitive method to tune the control loop without any information about the controlled system. We propose to extend the MFC architecture to the case of fixed-wing UAVs and study the MFC properties in terms of uncertain parameters. As a first result, our designed MFC architecture provides an continuous controller able to stabilize the entire flight envelope of two different fixed-wing UAVs. These results show promising adaptive perspectives and demonstrate that MFC presents robust properties for both uncertain parameters and disturbance rejection.

Paper: **4122** **C2L-A**

On Initialization of Adaptation in Active Noise Control

Jarosław Figwer[1], Malgorzata Michalczyk[2]

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

In this paper properties of adaptive feedforward active noise control systems with adaptation based on LMS algorithm are discussed from the point of view of initialization of adaptation. A focus on average rate of convergence of resulting active noise control algorithms is given. The presented ideas are illustrated by simulation examples in which mixed spectrum and wide-band noises are attenuated.

Signal Processing, C2L-B

Day: Wednesday, August 29, 2018
Time: 10:00 - 11:00
Room: Kalman
Chair: Przemysław Ignaciuk

Paper: **4059** **C2L-B**

Control Loop Performance Improvement for OPC Implementation

Wojciech Grega[1]

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

The OPC (OLE for Process Control) protocol was developed as a solution which fulfils the requirements of open data integration architecture for industrial control. The OPC standard was primarily not intended for feedback control with real-time requirements. The main complication of this control architecture is the presence of variable time delays. There are several ways to reduce the negative impact of the delays which OPC introduces into the control loop. The Smith predictor turns out to be a simple and effective compensator that rejects the time delays from the control loop.

Paper: **4011** **C2L-B**

Amplitude Modulation and Convolutional Encoder Techinques for Gait Speed Classification

Abdulhakim Elkurdi[1], **Ipek Caliskanelli**[2], **Samia Nefti-Meziani**[3]

[1] *University of Salford* a.elkurdi@edu.salford.ac.uk
[2] *University of Salford* i.caliskanellis@salford.ac.uk
[3] *University of Salford* s.Nefti-Meziani@salford.ac.uk

Human gait analysis can provide vital information especially with optical sensor to track and asses the changes in gait pattern. In this paper, the Kinect v2 based system is used for classifying a several walk speeds and Convolutional Encoder (CE) technique is validated. Positional skeletal data is collected from the lower body's joints and Amplitude Modulation (AM) is used to modify gait signal for extracting the gait features namely baseband frequency and modulation index. The obtained results show that 97.8

Paper: **4205** **C2L-B**

Multitasking Filtration Network

Adrian Sztandera[1], **Roman Kaszyński**[2]

[1] *West Pomeranian University of Technology Szczecin* adrian.sztandera@zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* Roman.Kaszynski@zut.edu.pl

In the paper a concept of creating a filtering network based on filtering sockets is presented.

The basic parallel and serial structures was described. Shaping frequency response was achieved by minimizing the cost function using firefly algorithm. Replacing gain coefficient k and time constant T with gain function and time function reduced the duration of the transition processes. The results are presented and compared with the stationary counterpart.

Fractional Order Systems III, C2L-C

Day: Wednesday, August 29, 2018
Time: 10:00 - 11:00
Room: Lehar
Chair: Małgorzata Klimek

Paper: **4075** **C2L-C**

Performance Assessment of the Tilt Fractional Order Integral Derivative Regulator for Control Flow Rate in Festo MPS® PA Compact Workstation

Andrzej Koszewnik[1], Michał Ostaszewski[2], Ewa Pawłuszewicz[3], Piotr Radgowski[4]

[1] *Bialystok University of Technology* a.koszewnik@pb.edu.pl
[2] *Bialystok University of Technology* m.ostaszewski@pb.edu.pl
[3] *Bialystok University of Technology* e.pawluszewicz@pb.edu.pl
[4] *Bialystok University of Technology* piotr.radgowski@gmail.com

The aim of this paper is to study the behavior of the tilt fractional order integral derivative regulator (TFOID) controller. The design regulator was applied for control flow rate in the laboratory stand Festo MPS PA Compact Workstation. The obtained simulation and experimental results are discussed.

Paper: **4104** **C2L-C**

Transfer Matrices with Positive Coefficients for Standard and Fractional Positive Linear Systems

Tadeusz Kaczorek[1], Łukasz Sajewski[2]

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

Standard and fractional positive 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 transfer matrix has only positive coefficients. Some invariant properties of positive standard and fractional linear systems are discussed.

Paper: **4157** **C2L-C**

Discrepancy Between Derivative Orders in Fractional Supercapacitor Models for Charging and Discharging Cycles

Ryszard Kopka[1]

[1] *Opole University of Technology* r.kopka@po.opole.pl

This paper presents results of research related to estimating a fractional order of supercapacitor models governed by non-integer differential equations. The results are determined on the basis of supercapacitors responses to voltage and current steps of different values, separately for charging and discharging cycles. The use of fractional order models makes it possible to reduce the complexity of the model and, at the same time, ensures very good compliance with the real system response. It is well known that the fractional order of the differential equations corresponds to the physicochemical properties of the supercapacitor. Three widely available supercapacitors are examined. The tests are carried out for five different values of voltage and current steps. The obtained results indicate an important dependence of the estimated non-integer order also on the conditions of their use.

Control Applications II, C2L-D

Day: Wednesday, August 29, 2018
Time: 10:00 - 11:00
Room: Strauss
Chair: Paolo Mercorelli

Paper: **4107** **C2L-D**

Feedforward Position Control Concepts for Radial Pneumatic Engines

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 an innovative design of a pneumatic drive as well as two corresponding feedforward position control concepts. Pneumatic drives are favoured in the context of clinical applications due to several advantages. Drawbacks, nevertheless, exist due to the compressibility of the working fluid – mostly air – and nonlinear friction inside the pneumatic drives. Technical applications require typically feedback control, and the use of position sensors. The use of such electric sensors, however, represents a severe issue when developing medical robots for research in magnet resonance imaging (MRI) or other medical equipment, which prevent the use of any metallic components as well as electrical signals. Thus, a new concept for a pneumatic rotary drive is presented that does not require position sensors. Three single acting pneumatic pistons are arranged in a favourable

geometrical relation to each other. By means of nonlinear pressure tracking control, the drive positions meet the accuracy requirements regarding the desired position. Realistic simulations show that an accurate tracking is achievable despite nonlinear friction.

Paper: **4138** **C2L-D**

Computationally Efficient Implementation of Dynamic Matrix Control Algorithm for Very Fast Processes Using Programmable Logic Controller

Andrzej Wojtulewicz[1], **Maciej Ławryńczuk**[2]

[1] *Warsaw University of Technology* A.Wojtulewicz@elka.pw.edu.pl
[2] *Warsaw University of Technology* M.Lawrynczuk@ia.pw.edu.pl

This work reports implementation of the Dynamic Matrix Control (DMC) algorithm using a Programmable Logic Controller (PLC). In contrast to other implementations of the DMC algorithm in control of industrial processes with relatively long time constants (and sampling times), in this work very fast processes are considered, characterised by very short sampling times. The DMC algorithm is implemented in its most computationally efficient version in which the values of the manipulated variables are calculated from explicit formulas. Thanks to that it is shown that the DMC algorithm is able to successfully control a laboratory process with the sampling time equal to 5 ms.

Paper: **4162** **C2L-D**

A Comparative Study on the Nonlinear Control of Ball and Plate

Büşra Şen[1], **Türker Türker**[2]

[1] *Yildiz Technical University* busra.sen@std.yildiz.edu.tr
[2] *Yildiz Technical University* turker.ytu@gmail.com

Two different nonlinear controller design techniques are presented and compared for ball and plate system. Firstly, a cascaded controller is designed consisting of inner and outer loop controllers separately. In this design procedure, the inner loop controller provides the tracking of a trajectory by the plate while the outer loop controller generates the reference trajectory for the plate with respect to the command input for the ball. Secondly, a backstepping controller is developed for the same system. Linear dynamics is obtained in the closed loop system with both of the control structures. Finally, numerical simulations are implemented for different reference signals with controller gains providing the closed loop dynamics having the same eigenvalues for both of the designed controllers, and the responses are compared comprehensively.

Poster Session IV, C3P-E

Day: Wednesday, August 29, 2018
Time: 10:00 - 12:00
Room: Poster Area
Chair: Grzegorz Mzyk

Paper: **4068** **C3P-E**

Evaluation of Packet Delay Effect on Control Quality in Networked Control Systems

Tomasz Stach[1], Mariusz Pelc[2], Jacek Korniak[3]

[1] *Opole University of Technology* stach.tomasz@gmail.com
[2] *Opole University of Technology / University of Greenwich* m.pelc@po.opole.pl
[3] *Opole University of Technology* j.korniak@po.opole.pl

The aim of this paper is to review and classify typical disturbances that occur in the computer/wireless networks and discuss the impact that some of them may have on the control quality in the networked control systems. We will demonstrate that even not a very complex control task involving programmable PID-type controller and an inertia system will may convert into a non-trivial task when performed not in a traditional closed-loop hard-wired system but rather a system when the control loop closes over a communication network.

Paper: **4079** **C3P-E**

Improving the Measurement Accuracy of the Static IR Triangulation System Through Apparent Beacon Position Estimation

Adam Wolniakowski[1], Maciej Ciężkowski[2]

[1] *Bialystok University of Technology* a.wolniakowski@pb.edu.pl
[2] *Bialystok University of Technology* m.ciezkowski@pb.edu.pl

The ever more dynamic development of autonomous systems in many areas of industry cause the precise indoor navigation to be an important issue. Unfortunately, the influence of walls and other obstacles that interfere with the measurement signals make the indoor navigation systems less accurate – such disturbances introduce so-called signal multipathing. Multipathing is often reduced by creating error maps, which is a labor-intensive task. Another problem in navigation is the precise determination of the position of the navigation reference points called beacons. In this paper, we present an ABPE method (Apparent Beacon Position Estimation) to improve the accuracy of the indoor triangulation positioning system by estimating the apparent beacons positions that does not require a-priori knowledge of beacon positions. The proposed method has been verified experimentally and additionally it has been compared with the methods based on mapping using a second order polynomial.

Paper: **4159** **C3P-E**

New Approach to Audio Lossless Block Encoding

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 basics of data modeling and the method of minimization mean square error for lossless audio compression are presented. The described research focuses on presentation of more flexible saving prediction factors effective method. Using the proposed method (MMSE) for the universal parameter set the bit average for the test database was better by 7.73

Paper: **4178** **C3P-E**

Implementation of Non-Integer Order Filtering for the Purpose of Disparities Detection in Beta Frequencies – a Pilot Study

Aleksandra Kawala-Janik[1], **Magda Zolubak**[2], **Waldemar Bauer**[3], **Bartosz Nazimek**[4], **Tomasz Sobolewski**[5], **Radek Martinek**[6], **Marcin Sowa**[7], **Mariusz Pelc**[8]

[1] *Opole University of Technology* kawala84@gmail.com
[2] *Opole University of Technology* magda.zolubak@gmail.com
[3] *AGH University of Science and Technology* bauer@agh.edu.pl
[4] *University Hospital in Opole* nazim76@tlen.pl
[5] *University Hospital in Opole* sobolak83@wp.pl
[6] *Technical University of Ostrava* radek.martinek@vsb.cz
[7] *Silesian University of Technology* marcin.sowa@polsl.pl
[8] *Opole University of Technology / University of Greenwich* m.pelc@greenwich.ac.uk

In this work the authors of the hereof paper describe pilot study on implementation of fractional order filtering applied for the purpose of disparities detection in Beta Frequencies. The Beta waves frequency range can be split into three sections, where the information provided by particular section enables more accurate medical diagnosis. Spectral analysis used in this study allowed appropriate isolation of the Beta waves. Implementation of non-integer order filtering in such study is innovative and provided some promising results.

Paper: **4192** **C3P-E**

Fast Two-Level Image Indexing Based on Local Interest Points

Patryk Najgebauer[1], **Rafal Grycuk**[2], **Rafal Scherer**[3]

[1] *Czestochowa University of Technology* patryk.najgebauer@iisi.pcz.pl
[2] *Czestochowa University of Technology* rafal.grycuk@iisi.pcz.pl
[3] *Czestochowa University of Technology* rafal.scherer@iisi.pcz.pl

In this article, we present a method to speed up image content similarity search based on the SURF algorithm in large sets of images. The method stores SURF extracted

keypoints in an ordered way based on descriptor indexing. This approach significantly reduces the number of unnecessary comparisons between sets of image keypoints during matching. The method is based on descriptor dual-hashing to preserve the information of descriptors that are close to the boundary between different hashes. The presented structure is also optimized to be stored in a file and to search without pre-loading to avoid image feature extraction in each search process.

Paper: **4206** **C3P-E**

Head Motion Synthesis of Human–Like Virtual Person in an Inactive Mode

Maja Kocoń[1]

[1] *West Pomeranian University of Technology Szczecin* maja.kocon@zut.edu.pl

At present, in human–machine interaction systems, communication may be realized with the visual representation of a person. The use of human visualization requires human mechanisms of movement and social behaviour analysis. Naturally, the human body is in subtle motion. These small changes in body position are unintentional and in most cases involuntary. In the simulation of a virtual person, this type of motion can provide pseudo human behaviour. Therefore the paper addresses the problem of simulating human head idle gestures for avatars. The idle mode is introduced in order to increase the realism of the avatar's behaviour. The proposed mode involves the situation when the avatar is waiting for external events and can eliminate the frozen state of the character.

Paper: **4124** **C3P-E**

The Torque Distribution Analysis for Dual Motor - Single Shaft Electric Drive

Arkadiusz Hajduga[1]

[1] *Warsaw University of Technology* arkadiusz.hajduga@simr.pw.edu.pl

The application of Automated Manual Transmission in electric drive gives a significant benefit in electric energy consumption saving, especially in the case of city exploitation. The interruption of electric machine operation during gear shifting may be removed thanks to the proper drive structure. The dual motor single shaft powertrain is one of them. The usage of two motors gives the additional possibility of output torque composition. In the paper the analyses of both motor torque distribution analyses influence on electric energy consumption were carried out for a wide range of output speed and torque.

Paper: **4131** **C3P-E**

Fractional Differential Equation Solvers in Octave/MATLAB

Marcin Sowa[1], Aleksandra Kawala-Janik[2], Waldemar Bauer[3]

[1] *Silesian University of Technology* marcin.sowa@polsl.pl
[2] *Opole University of Technology* kawala84@gmail.com
[3] *AGH University of Science and Technology* bauer@agh.edu.pl

This paper concerns solvers for time fractional differential equations in Matlab and Octave. The main analysis revolves around a time step size adaptive solver basing on the numerical method called SubIval. The basis of SubIval is explained and formulae for the step size adaptivity are given. The solver is compared with others basing on: fractional linear multistep methods, product integration rules and the Grunwald-Letnikov approximation.

Paper: **4208** **C3P-E**

Linear Time-Varying Multi-Notch FIR Filter for Fast EMG Measurements

Piotr Okoniewski[1], Sławomir Kocon[2], Jacek Piskorowski[3]

[1] *West Pomeranian University of Technology Szczecin* piotr.okoniewski@zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* slawomir.kocon@zut.edu.pl
[3] *West Pomeranian University of Technology Szczecin* jacek.piskorowski@zut.edu.pl

This paper presents a concept of implementing time-varying FIR narrow multi-band-stop filter for fast EMG measurements. The proposed system consists of a notch type filter with a predefined time-varying coefficients and an IMU-based trigger to start the measurement of the muscle movement. The coefficients of the time-varying filter are calculated according to the selected time-varying function in the selected time span. The use of an external trigger, which signals the moment of the muscle movement, allows to use the time-varying filter not only in the beginning of the measurement but also further during the test. The paper is an extension of the previous research in the field of time-varying filtering structures.

Paper: **4209** **C3P-E**

Allpass Based Multi-Notch IIR Filter with Equalized Group Delay

Piotr Okoniewski[1], Sławomir Kocon[2], Jacek Piskorowski[3]

[1] *West Pomeranian University of Technology Szczecin* piotr.okoniewski@zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* slawomir.kocon@zut.edu.pl
[3] *West Pomeranian University of Technology Szczecin* jacek.piskorowski@zut.edu.pl

This paper presents a concept of time-varying IIR multi-band-stop filter with equalized group delay characteristic in the steady state. The ECG signal is used to test the proposed structure. As the group delay equalizer we used the constrained Newton-type algorithm

provided by Matlab. To confirm the robustness of the proposed solutions we also present the experimental results with the aid of noise frequency estimator.

Control & Systems Theory II, C4L-A

Day: Wednesday, August 29, 2018
Time: 11:20 - 13:00
Room: Casino
Chair: Andrzej Bartoszewicz

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

Further Towards the Analytical Solution of Minimum-Energy Perfect Control Design Problem

Wojciech Hunek[1], **Tomasz Feliks**[2]

[1] *Opole University of Technology* w.hunek@po.opole.pl
[2] *Opole University of Technology* tomasz.feliks@doktorant.po.edu.pl

In this paper an analytical calculation of the minimum-energy perfect control for LTI discrete-time state-space systems with different number of input and output variables is presented. Recent publications have confirmed that the so-called right (sigma)-inverse outperforms the minimum-norm T-inverse in terms of minimum-energy perfect control design, this fact has only been shown in heuristic studies, so far. Following the obtained issues a new material concerning the optimal control problem is presented here. Notwithstanding, the solution is only valid for special chosen systems thus giving rise to reliable exploration in the future.

Paper: **4014** **C4L-A**

On Polynomial Zero Exclusion from an RHP Sector

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

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

Simple conditions based on generalisations of the Routh–Hurwitz and Mikhailov criteria that ensure the absence of polynomial roots in an RHP sector straddling the positive real semi–axis (S–stability) are presented. In particular, it is shown that S–stability is ensured if the phase variation of a suitable power of the original nth–degree characteristic polynomial is equal to pi/2, which implies that the zeros of the real and imaginary parts of this power must satisfy an interlacing property similar to the interlacing property satisfied by Hurwitz polynomials according to the classic Hermite–Biehler theorem. The condition can be checked by means of Sturm sequences. Examples show how the proposed methods operate.

Paper: **4116** **C4L-A**

A New Nonunique PSVD-Based Inverse of Nonsquare Polynomial Matrices

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

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

A new nonunique inverse of nonsqure polynomial matrices is introduced in this paper. Following the new given definitions of T-, (tau)-, (sigma)-, S- and H-inverse a new issue concerning the HM-inverse of plants having different number of input and output variables is presented. It is noted that a new method can be applied to the different nonsquare systems finally to obtain the inverse model control schemes known as the IMC structures. Additionally, it is emphasized that the authors' approach can be useful during design of perfect control strategy dedicated to LTI MIMO right-invertible objects. After some assumption the technique taken from perfect signal reconstruction tasks could be implemented in the minimum variance/perfect control problem and, crucially, stands as a counterpart to existing methods of signal recovery.

Paper: **4072** **C4L-A**

Application of a Frequency-Discretization Technique for Stability and Control of Uncertain Differential Linear Repetitive Processes

Marcin Boski[1], **Wojciech Paszke**[2], **Eric Rogers**[3]

[1] *University of Zielona Góra* m.boski@issi.uz.zgora.pl
[2] *University of Zielona Góra* w.paszke@issi.uz.zgora.pl
[3] *University of Southampton* etar@ecs.soton.ac.uk

The paper investigates the problem of stability analysis of differential linear repetitive processes with norm-bounded uncertainties. By applying a version of the Kalman-Yakubovich-Popov (KYP) Lemma, relaxed conditions for stability along the pass are proposed in terms of linear matrix inequalities (LMIs), which can be easily solved via standard numerical software. In particular, the conservatism of the resulting condition for stability along the pass can be significantly reduced by dividing the entire frequency domain into several sub-intervals and by applying KYP Lemma to each frequency sub-interval. Moreover, the obtained stability result is suitable for extension to robust control law design for processes with norm bounded uncertainty. Finally, a numerical example is provided to illustrate the application of the developed results.

Paper: **4024** **C4L-A**

A Characterization of the Distance Between Controllable and Uncontrollable LTI Systems

Doan Thai Son[1], **Joseph Páez Chávez**[2], **Stefan Siegmund**[3]

[1] *Vietnam Academy of Science and Technology* dtson@math.ac.vn
[2] *Escuela Superior Politécnica del Litoral* jpaez@espol.edu.ec
[3] *Technische Universität Dresden* stefan.siegmund@tu-dresden.de

The controllability distance for a linear time- invariant (LTI) system is defined as the norm of the smallest perturbation rendering the system uncontrollable. This is a widely used concept in control theory and provides a measure of the robustness of a system. Previous investigations have shown that the controllability distance can be characterized by a optimization problem involving singular values of extended matrices. This characterization has been established for general first-order systems and a certain class of higher-order systems. In this paper, we develop an analogous characterization of the controllability distance for a more general family of LTI systems, where controllability is formulated in a behavioral framework.

Control Applications III, C4L-B

Day: Wednesday, August 29, 2018
Time: 11:20 - 13:00
Room: Kalman
Chair: Andreas Rauh

Paper: **4197** **C4L-B**

A Lyapunov Function Based Nonlinear Controller Design for PVTOL Aircraft

Evren Subaşı[1], **Türker Türker**[2]

[1] *Yildiz Technical University* evren1subasi@gmail.com
[2] *Yildiz Technical University* turker.ytu@gmail.com

An alternative stabilization procedure based on a Lyapunov function is presented for PVTOL aircraft. The rotational dynamics of the aircraft is represented with complex numbers, and the controller design procedure is given based on this model. Almost global asymptotic stability of the desired position for the aircraft is shown with a Lyapunov function and by the utilization of LaSalle's invariant set principle. The performance of the developed controller is tested via numerical simulations and the results are presented.

Paper: **4195** **C4L-B**

Combining an Internal SMC with an External MTPA Control Loop for an Interior PMSM

Tanja Zwerger[1], Paolo Mercorelli[2]

[1] *MTU Friedrichshafen GmbH* Tanja.Zwerger@mtu-online.com
[2] *Leuphana University of Lueneburg* mercorelli@uni.leuphana.de

This paper deals with control strategies in Permanent Magnet Synchronous Machines (PMSMs). An internal loop control is proposed in which a Sliding Mode Control (SMC) works to control the optimal desired current calculated by the Maximum Torque per Ampere (MTPA) strategy which works in the external loop of control. The main contribution of the paper is to show how disturbance rejection is provided together with a load compensation. Simulation results are shown comparing, with the same control scheme, the performances obtained with SMC and Proportional-Integral controllers (PI).

Paper: **4200** **C4L-B**

Study on Controller Embedding Stage Using Model-Based-Design for a Bike with CMG

Maciej Różewicz[1], Akademia Górniczo-Hutnicza[2], Adam Piłat[3]

[1] *Akademia Górniczo-Hutnicza im. Stanisława Staszica* rozewicz@agh.edu.pl
[2] *Akademia Górniczo-Hutnicza im. Stanisława Staszica* unknown@mail.com
[3] *Akademia Górniczo-Hutnicza im. Stanisława Staszica* ap@agh.edu.pl

In previous works, authors presented some methods for mathematical modelling of dynamics and robust control approach to stabilization of a bicycle with usage of Control Moment Gyro (CMG). In this paper, the next step in the control system design and verification are presented. The model based approach is applied in forms of model in the loop, software in the loop, and processor in the loop to practically test the considered controller before final implementation in the real-device. The considered methods are illustrated with experimental data and compared.

Paper: **4175** **C4L-B**

Effects of Pharmacokinetics and DNA Repair on the Structure of Optimal Controls in a Simple Model of Radio-Chemotherapy

Piotr Bajger[1], Krzysztof Fujarewicz[2], Andrzej Swierniak[3]

[1] *University of Warsaw* p.bajger@uw.edu.pl
[2] *Silesian University of Technology* krzysztof.fujarewicz@polsl.pl
[3] *Silesian University of Technology* andrzej.swierniak@polsl.pl

In this study optimal control framework is applied to two models of radiochemotherapy. A base, simple model represented by a first order nonlinear differential equation system adopts a classical log-kill hypothesis for chemotherapy and a linear-quadratic response

for radiotherapy. It is shown that optimal treatment should apply radiotherapy first, while the onset of chemotherapy should be delayed. The second model takes into account the effects of pharmacokinetics and DNA repair. By obtaining full analytical results for chemotherapy control and partial results for radiotherapy it is shown that the structure of optimal control is altered.

Paper: **4169** **C4L-B**

Comparison of Estimator-Based Compensation Schemes for Hydrostatic Transmissions with Uncertainties

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, the achievable tracking performance of a decentralized control scheme of a hydrostatic transmission is investigated for three alternative estimators in combination with output feedback linearization: a state and disturbance observer, an adaptive parameter estimator and a neural network. All these estimators address the given disturbances and uncertainty in the hydraulic system and contribute to the robustness of the feedback linearization as well the tracking accuracy. Firstly, the three control schemes are evaluated by means of simulations and, secondly, validated by experiments on a dedicated test rig at the Chair of Mechatronics, University of Rostock.

Robotics I, C4L-C

Day: Wednesday, August 29, 2018
Time: 11:20 - 13:00
Room: Lehar
Chair: Ignacy Dulęba

Paper: **4030** **C4L-C**

Effective Use of Lightweight Robots in Human-Robot Workstations with Monitoring via RGBD -Camera

Kathrin Bothe[1], Alexander Winkler[2], Leif Goldhahn[3]

[1] *Hochschule Mittweida* bothe@hs-mittweida.de
[2] *Hochschule Mittweida* Alexander.winkler@hs-mittweida.de
[3] *Hochschule Mittweida* goldhahn@hs-mittweida.de

This article describes the integration and implementation of technologies intended to increase the flexibility and security of human-robot cooperation. Furthermore, a possible model for managing this transition is described in detail, involving the use of an RGBD camera. With this camera, it should be possible to detect state and position changes in the people at a human-robot workstation and consequently adapt the movements of the

robot. Overall, the essential aim of this paper is to suggest ways of increasing economic efficiency within assembly processes, while also increasing security.

Paper: **4170** **C4L-C**

Remote Control of Robotic Manipulator Under Delays in Communication Channel

Kamil Klimkowicz[1], Maciej Patan[2]

[1] *University of Zielona Góra* k.klimkowicz@issi.uz.zgora.pl
[2] *University of Zielona Góra* m.patan@issi.uz.zgora.pl

This work is intended as an attempt to design an effective remote control scheme for robotic manipulators under the presence of delays in the communication channel. Two control strategies in the trajectory tracking problem for robotic manipulator are investigated. First, the classical resolved rate motion control technique is adopted and enhanced with experimental delay prediction. As an alternative approach to circumvent the inherent uncertainty of the controlled system is to adopt the iterative learning scheme with error estimation based on the observations from previous trials of robot movements. Both methods are successfully implemented on within the cascade control scheme within the framework of client-server TCP/IP communication architecture. Then, their performance is compared experimentally on the real platform of KUKA Agilus KR6 industrial manipulator with KR C4 compact controller.

Paper: **4044** **C4L-C**

Efficient Evaluation and Optimization of Automated Gripper Finger Design for Industrial Robotic Applications

Aditya Kapilavai[1], Adam Wolniakowski[2], Troels Bo Jørgensen[3], Anders Prier Lindvig[4], Thiusius Rajeeth Savarimuthu[5], Norbert Krüger[6]

[1] *University of Southern Denmark* sak@mmmi.sdu.dk
[2] *Bialystok University of Technology* a.wolniakowski@pb.edu.pl
[3] *University of Southern Denmark* troels.joergensen@hotmail.com
[4] *University of Southern Denmark* anpl@mmmi.sdu.dk
[5] *University of Southern Denmark* trs@mmmi.sdu.dk
[6] *University of Southern Denmark* norbert@mmmi.sdu.dk

We use the previously proposed gripper finger design and optimization methods for generating a finger cut-out for an asymmetrical object used in industrial assembly tasks. We suggest two new alignment quality scores and compare their efficiency with preexisting methods. In addition, compare the performance of two optimization methods (one local and one global) and find the meta-parameters for the local method.

Paper: **4094** **C4L-C**

Preliminary Studies on Trajectories Generation for Walking Robot Based on Human Data

Paweł Parulski[1], Krzysztof Kozłowski[2]

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

The aim of this article is to present the preliminary results of work aimed at developing a system for analyzing and designing a gait of a walking bipedal robot, based on biological data. Biological data acquisition was made with a use of the Optitrack vision system and the Matlab environment. Generated trajectories form the reference data for creating sets of output functions, and consequently for the controller design, whose task will be to mimic a human gait.

Modelling & Simulation III, C4L-D

Day: Wednesday, August 29, 2018
Time: 11:20 - 13:00
Room: Strauss
Chair: Johannes Reuter

Paper: **4006** **C4L-D**

Comprehensive Modeling of Quadrotors for Maneuvering Flight Control Design

Kemao Peng[1], Mohamed Redhwan Bin Abdul Hamid[2], Junji Zhu[3], Feng Lin[4], Ben M Chen[5]

[1]*National University of Singapore* kmpeng@nus.edu.sg
[2]*National University of Singapore* tslmor@nus.edu.sg
[3]*National University of Singapore* tslzhuj@nus.edu.sg
[4]*National University of Singapore* linfeng@nus.edu.sg
[5]*National University of Singapore* bmchen@nus.edu.sg

A comprehensive model of a quadrotor is built for the maneuvering flight control design in which the nonlinearities of the quadrotor become dominant. The modeling is based on the components of the quadrotors such as the propellers by ignoring the weak coupling among the four propellers. The property of the propellers is tested in the wind tunnel in presence of the relative air flow and in each scheduled condition. The comprehensive model of the quadrotor is derived with the Newton's laws by integrating the property of the propellers. The built model is verified with the wind tunnel test data and The verification results show that the output of the propeller model is matched well with the test data. The built model is useful to the maneuvering flight control design of the quadrotors in high speed and large acceleration as the kinematical and aerodynamic nonlinearities are formulated in the model.

Paper: **4052** **C4L-D**

A Generalized Crank-Nicolson Method for the Solution of the Subdiffusion Equation

Marek Błasik[1]

[1] *Czestochowa University of Technology* marek.blasik@im.pcz.pl

In this paper we present a numerical solution of a one dimensional subdiffusion equation with a fractional time derivative in the Caputo sense. The proposed algorithm is an extension of the Crank-Nicolson method for a classical parabolic partial differential equation. In the final part, we also present examples illustrating the comparison of the analytical solution with the results received by the proposed numerical method.

Paper: **4061** **C4L-D**

Numerical Aspects of Extreme Learning Machine Implementation to Regression Problems

Jacek Kabziński[1]

[1] *Lodz University of Technology* jacek.kabzinski@p.lodz.pl

An Extreme Learning Machine (ELM) – a neural network with fixed hidden layer and adjustable output weights is able to solve complicated regression (approximation) problems, but the standard selection of input weights and biases may lead to ill-conditioning of the output weights calculation and result in high values of the output weights. Two modifications of standard ELM are discussed: deterministic generation of hidden nodes parameters and modifications of activation functions to improve numerical properties of the algorithm.

Paper: **4069** **C4L-D**

Estimation of a Stochastic Burgers' Equation Using an Ensemble Kalman Filter

Mariusz Domżalski[1], **Zdzisław Kowalczuk**[2]

[1] *Gdańsk University of Technology* mardo@eti.pg.edu.pl
[2] *Gdańsk University of Technology* kova@eti.pg.edu.pl

We consider a difficult problem of state estimation of nonlinear stochastic partial differential equations based on uncertain measurements. The presented solution uses the method of lines, which allows us to discretize a stochastic partial differential equation in a spatial dimension and represent it as a system of coupled continuous-time ordinary stochastic differential equations. For such a system it is possible to use the standard estimation methods based on Kalman filtration. In this paper we propose using an ensemble Kalman filter, which due to its characteristics can be successfully applied to problems with hundreds of state variables.

Efficiency Improvements to Uniformization for Markovian Birth-and-Death Models

Maciej Burak[1]

[1] *West Pomeranian University of Technology Szczecin* Maciej.Burak@zut.edu.pl

Finding transient solutions in queuing systems is crucial in many applications, including of service system modeling. As many of such systems are Markovian, their natural description is that of a continuous-time Markov chain (CTMC), and uniformization is widely considered an efficient method for transient analysis of CTMCs. In this paper we present significant efficiency improvements to the standard uniformization algorithm when used for transient analysis of time-inhomogenous Markovian birth-and-death queuing models. We exploit some of the distinct properties of birth-and-death models – in particular the structure of the generator matrix and the convergence properties of the model. Moreover, we utilize an example based on an realistic birth-and-death model of a call center in order to demonstrate that our proposal is especially advantageous for transient modeling of real service systems.

Thursday
August 30th, 2018

Measurement, D1L-A

Day: Thursday, August 30, 2018
Time: 9:00 - 10:20
Room: Casino
Chair: Wojciech Hunek

Paper: **4203** **D1L-A**

Mechatronic 3D Sound Intensity Probe and its Application to DOA

Witold Mickiewicz[1], **Michał Raczyński**[2]

[1] *West Pomeranian University of Technology Szczecin witold.mickiewicz@zut.edu.pl*
[2] *West Pomeranian University of Technology Szczecin michal.raczynski@zut.edu.pl*

This article aims to present the construction of one-microphone mechatronic sound intensity3D probe and verify how it is usable to direction of arrival (DOA) estimation of sound waves in auditory frequency range. Experiments with the prototype one-channel measurement system were conducted and the results were compared with geometrical model and commercial format-A microphone. The results show, that use of the medium quality microphone supported by mechatronic positioning system allows to build a sound intensity probe with acceptable quality to easy recognize the DOA of direct and reflected sounds.

Paper: **4187** **D1L-A**

New Approach to Accuracy Measurement of the Membrane Shape Mapping of the Heart Assist Pump

Wojciech Sulej[1], **Krzysztof Murawski**[2]

[1] *Military University of Technology wojciech.sulej@wat.edu.pl*
[2] *Military University of Technology krzysztof.murawski@wat.edu.pl*

This paper sets out a new approach to measuring the accuracy of the membrane shape mapping of the pulse-type heart assist pump. In the studies, the authors' method for determining the membrane shape in the actual dimensions was used. Accurately determination of the shape of the membrane is very important because this shape affects the final accuracy of determining the stroke volume of an artificial ventricle. Three rigid membrane models were used in the study. Each of them was developed on the basis of the original shape of the flaccid membrane. All models were tested and results obtained were presented.

Paper: **4049** **D1L-A**

Biomechanical System for Measuring the Breaking Force of the Inguinal Hernia Mesh After Lichtenstein Tension-Free Repair

Sebastian Grzeszewski[1], Marek Kamiński[2], Tomasz Okulik[3], Krzysztof Pietrusewicz[4], Michał Szydłowski[5], Paweł Waszczuk[6]

[1] *Pomeranian Medical University in Szczecin* sebastian.grzeszewski@pum.edu.pl
[2] *Pomeranian Medical University in Szczecin* marek.kaminski@pum.edu.pl
[3] *West Pomeranian University of Technology Szczecin* tomasz.okulik@zut.edu.pl
[4] *West Pomeranian University of Technology Szczecin* krzysztof.pietrusewicz@zut.edu.pl
[5] *West Pomeranian University of Technology Szczecin* michal.szydlowski@zut.edu.pl
[6] *West Pomeranian University of Technology Szczecin* pawel.waszczuk@zut.edu.pl

This article depicts developed biomechanical system designed for measuring the breaking force of the inguinal hernia mesh according to its fixation method – stitching and gluing. Authors describe in details structure of the laboratory stand which objective was to simulate Lichtenstein tension-free repair conditions as well as facilitate presentation of the methodology of conducted experiments. Statistical analyze of obtained data was performed to confirm usefulness of both fixation techniques. The goal of the presented in this work biomechanical system was to verify the reliability of inguinal hernia mesh fixation methods and to reach conclusions that could be later put into clinical practice.

Paper: **4139** **D1L-A**

Measurement Uncertainty Evaluation of Results Provided by Transducers Working in Control Loops

Józef Wiora[1], Alicja Wiora[2]

[1] *Silesian University of Technology* jozef@wiora.pl
[2] *Silesian University of Technology* alicja.wiora@polsl.pl

Evaluation of measurement uncertainties covers uncertainty propagation from sources to a measured quantity. Phenomena taking place inside measuring transducers are typically considered applying Type B evaluation. It is evidenced in this work, that transducers included in a closed-loop control system should be treated in a different way because their uncertainty sources propagate through the dynamic system and change their limits of variabilities. Depending on frequencies, the limits may be either similar or lower or even higher. An especially dangerous case takes place when the variability at the output of the plant is greater than at the output of the transducer. In this work, such cases are presented and discussed.

Mobile Robotics II, D1L-B

Day: Thursday, August 30, 2018
Time: 9:00 - 10:20
Room: Kalman
Chair: Adam Krzyżak

Paper: **4137** **D1L-B**

Robust NMPC Schemes for the Control of Mobile Robots in the Presence of Dynamic Obstacles

Sankaranarayanan Subramanian[1], Shaghayegh Nazari[2], Muhammad Arslan Alvi[3], Sebastian Engell[4]

[1] *Technical University of Dortmund* Sankaranarayanan.Subramanian@tu-dortmund.de
[2] *Technical University of Dortmund* Shaghayegh.Nazari@tu-dortmund.de
[3] *Technical University of Dortmund* Muhammad-Arslan-Sajid.Alvi@tu-dortmund.de
[4] *Technical University of Dortmund* Sebastian.Engell@tu-dortmund.de

In recent years, there has been a large increase in the number of applications for mobile robots ranging from vacuum cleaners to Mars rovers. Depending on the applications, various challenges still need to be addressed related to the control of mobile robots and are being actively researched. We address here the problem of collision avoidance in the presence of dynamic obstacles using the Nonlinear Model Predictive Control (NMPC) framework. We use a scenario-tree formulation for the prediction of different trajectories of the dynamic obstacle and propose two strategies to avoid collisions. We propose a simple strategy to obtain the controlled inputs by solving a nominal NMPC problem by adding different scenarios of predicted obstacle trajectories as constraints. As a second strategy, a less conservative approach under the multi-stage NMPC framework by modeling the recourse in the predictions of the controlled robot is proposed. Both strategies can be applied in real-time and avoid collisions with dynamic obstacles. The non-conservative strategy shows superior performance at the expense of an increased computational effort.

Paper: **4144** **D1L-B**

Convolutional Neural Network Based Sensors for Mobile Robot Relocalization

Harsh Sinha[1], Jay Patrikar[2], Eeshan Dhekane[3], Gaurav Pandey[4], Mangal Kothari[5]

[1] *Indian Institute of Technology Kanpur* harshsin@iitk.ac.in
[2] *Indian Institute of Technology Kanpur* jaypat@iitk.ac.in
[3] *Indian Institute of Technology Kanpur* eeshangd@iitk.ac.in
[4] *Ford Motor Company* gpandey2@ford.com
[5] *Indian Institute of Technology Kanpur* mangal@iitk.ac.in

Recently many deep Convolutional Neural Networks (CNN) based architectures have been used for predicting camera pose, though most of these have been deep and require quite a

lot of computing capabilities for accurate prediction. For these reasons their incorporation in mobile robotics, where there is a limit on the amount of power and computation capabilities, has been slow. With these in mind, we propose a CNN based architecture which combines low-cost sensors of a mobile robot with information from images of a single monocular camera using an Extended Kalman Filter to perform accurate robot relocalization.

Paper: **4046** **D1L-B**

The Effect of an Off-Centered Orientable Wheel on Motion Characteristics of a Mobile Robot

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 discusses a comprehensive model of a mobile robot with a no-slip off-centered orientable wheel. Subsequently, by application of dynamic control, a comparison is made between two robot models: one accounting for the effect of the off-centered orientable wheel and another one excluding this effect. The aspects considered in the study include not only the error resulting from the drive along a given trajectory but also the consumption of energy of the compared models.

Paper: **4202** **D1L-B**

Coordination of Concurrent Mobile Robot Motion Processes with Composite Automaton Supervisor

Elzbieta Roszkowska[1], Piotr Dulewicz[2], Łukasz Janiec[3]

[1] *Wrocław University of Science and Technology* elzbieta.roszkowska@pwr.edu.pl
[2] *Wrocław University of Science and Technology* piotr.dulewicz@pwr.edu.pl
[3] *Wrocław University of Science and Technology* lukasz.janiec@pwr.edu.pl

Coordination of multiple mobile robots operating in the same area requires a discrete-event supervisor, whose role is to ensure their correct concurrent motion. Performance analysis of such a system requires a hybrid model that combines the DES model of the supervisor with the continuous time models of the robot motion processes. The contribution of this paper is twofold. We propose the logic that formally ensures collision and deadlock free robot coordination and implement it in the form of a composite automaton supervisor. This allows us to to combine the supervisor with time models of robot motion processes in Matlab/Simulink/Stateflow environment. The obtained simulation model of a system of multiple mobile robots ensures their formally correct co-operation and can be directly used for prediction or experimental optimization of the system performance.

Control & Systems Theory III, D1L-C

Day: Thursday, August 30, 2018
Time: 9:00 - 10:20
Room: Lehar
Chair: Krzysztof Latawiec

Paper: **4097** **D1L-C**

Extremal Problems for Parabolic Systems with Multiple Time-Varying Lags

Adam Kowalewski[1]

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

Extremal problems for parabolic systems with multiple time-varying lags are presented. An optimal boundary control problem for parabolic systems in which multiple time-varying lags appear in the state equations and in the boundary conditions simultaneously is solved. The time horizon is fixed. Making use of Dubovicki-Milutin scheme, necessary and sufficient conditions of optimality for the Neumann problem with the quadratic performance functionals and constrained control are derived.

Paper: **4168** **D1L-C**

State-Space Transformations of Uncertain Systems with Purely Real and Conjugate-Complex Eigenvalues Into a Cooperative Form

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

Cooperativity of uncertain dynamic systems can be exploited to simplify several tasks such as the computation of guaranteed state enclosures, the design of interval observers, forecasting worst-case bounds for selected system outputs in predictive control, and the identification of unknown parameters. Although many system models are naturally cooperative, there is also a great number of systems which do not show this property if the state equations are derived using first-principle techniques. Hence, it is often desired to transform such system models into an equivalent cooperative form. Unfortunately, these transformations are often not straightforward, especially, if linear systems and nonlinear ones with state-dependent system matrices are subject to bounded parameter uncertainty. This paper presents two approaches for the transformation of state equations into a cooperative form that do not fulfill sufficient criteria for cooperativity in their basic formulation. These are a time-invariant transformation for systems with purely real eigenvalues and a time-varying transformation in the case of conjugate-complex eigenvalues.

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

Numerical Test for Stability Evaluation of Discrete-Time Systems

Lukasz Grzymkowski[1], **Tomasz Stefański**[2]

[1] *Gdańsk University of Technology* lukegrzym@gmail.com
[2] *Gdańsk University of Technology* tomstefa@pg.edu.pl

In this paper, a new numerical test for stability evaluation of discrete-time systems is presented. It is based on modern root-finding techniques at the complex plane employing the Delaunay triangulation and the Cauchy's Argument Principle. The method evaluates if a system is stable and returns possible values and multiplicities of unstable zeros of the characteristic equation. For state-space discrete-time models, the developed test evaluates complex function related to the characteristic equation on the complex plane, so it does not require computation of state-matrix eigenvalues. The developed method is general because it allows to analyze systems whose the characteristic equation is not only a polynomial. Therefore, the verification of the proposed method is presented in benchmarks for both integer- and fractional-order systems.

Paper: **4117** **D1L-C**

When Is Naive Low-Pass Filtering of Noisy Measurements Counter-Productive for the Dynamics of Controlled Systems?

Andreas Rauh[1], **Swantje Romig**[2], **Harald Aschemann**[3]

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

In many practical applications, noisy measurements are low-pass filtered by (quasi-)continuous-time filters with linear, fixed-order lag behavior that are manually tuned according to the designer's gut feeling. However, if the time constants of these low-pass filters are neglected during control synthesis, oscillations may arise even in cases in which the non-filtered closed-loop dynamics are described by linear system models with purely real eigenvalues. In this paper, Lyapunov methods are applied to system models given in terms of stochastic differential equations to account for measurement and process noise and to predict the influence of noise on the filter and closed-loop system dynamics. In addition, an optimization approach for the parameterization of state observers is derived which is based on these Lyapunov techniques. It is implemented by a suitable problem formulation in terms of linear matrix inequalities. Illustrative simulation case studies, including a comparison with the well-known stationary Kalman Filter, conclude this paper.

Fault Detection, D1L-D

Day: Thursday, August 30, 2018
Time: 9:00 - 10:20
Room: Strauss
Chair: Marian Błachuta

Paper: **4100** **D1L-D**

Multiple-Model Based Fault-Diagnosis: an Approach to Heterogeneous State Spaces

Edmond Skeli[1], Dirk Weidemann[2]

[1] *University of Applied Sciences Bielefeld* edmond.skeli@fh-bielefeld.de
[2] *University of Applied Sciences Bielefeld* dirk.weidemann@fh-bielefeld.de

In the context of diagnosing technical systems, in addition to pure fault detection, it is also important to determine the fault location and the fault size (also known as fault identification). In many cases, model-based diagnostic methods are used for fault-localization and -identification, which are based on the simultaneous use of several mathematical models, so fault-localization and -identification can be performed in the sense of a multiple model estimation. Known approaches to multiple model estimation, such as generalized pseudo-Bayesian approaches or the Interacting Multiple Model approach, use a stochastic filter for each of the models considered, with the results of the individual stochastic filters being suitably aggregated. However, it has to be taken into account that the individual mathematical models have different dimensions and/or physically heterogeneous state spaces. Consequently, the aggregation, i.e. the weighted combination of the estimates can not be done without appropriate modification. Using a hydraulic cylinder, possible modification approaches for the interaction of filters applied to heterogeneous state spaces are explained.

Paper: **4141** **D1L-D**

Binary Classifier for Fault Detection Based on KDE and PCA

Tian Cong[1], Jerzy Baranowski[2]

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

The algorithm, Binary Classifier for Fault Detection (BaFFle), is devised to employ Principal Component Analysis (PCA) to reduce the variable number, and conduct classification using obtained operation model over each extracted component; subsequently BaFFle transforms a multivariate detection task into several univariate problem. In BaFFle, measured data subject to Gaussian model is assumed. In order to remove the inaccuracy of model assumption, this paper explores to solve the uncertainty of distribution model in origin BaFFle algorithm with Kernel Density Estimation (KDE). A main advance in

KDE is rewarded from the non-parametric work frame to estimate the density distribution, leading to a data decided estimation; meanwhile, a model selection issue is addressed. Experiments approved the efficiency and validation of KDE in BaFFle algorithm, thereby from the practice perspective, BaFFle would be more generally applied to various operation systems. Also, KDE-based BaFFle has the potential to improve the fault detection accuracy of the original BaFFle.

Paper: **4027** **D1L-D**

SVM Based Bearing Fault Diagnosis in Induction Motors Using Frequency Spectrum Features of Stator Current

Ignas Andrijauskas[1], Rimas Adaskevicius[2]

[1] *Kaunas University of Technology* ignas.andrijauskas@ktu.edu
[2] *Kaunas University of Technology* rimas.adaskevicius@ktu.edu

This study relies on stator current based diagnosis of induction motor bearing faults. Compared to the measurement of vibration, the stator's current-based method is less invasive and physically do not require to reach the motor housing. In this study, the most informative features are selected from stator current spectrum amplitudes. Feature weight vector is created by the application of Neighbourhood Component Feature Selection method. Support Vector Machine is used as supervised machine learning method for classification. In order to investigate feature selection and classifier performance an experiment with three artificially caused bearing faults were performed.

Poster Session V, D2P-E

Day: Thursday, August 30, 2018
Time: 9:30 - 11:30
Room: Poster Area
Chair: Krzysztof Okarma

Paper: **4004** **D2P-E**

Optimal Control of Sediment in Irrigation Canals

Miguel Ernesto Vázquez-Méndez[1], Lino José Alvarez-Vázquez[2], Aurea Martínez[3], Carmen Rodríguez[4], Miguel Angel Vilar[5]

[1] *Universidade de Santiago de Compostela* miguelernesto.vazquez@usc.es
[2] *Universidade de Vigo* lino@dma.uvigo.es
[3] *Universidade de Vigo* aurea@dma.uvigo.es
[4] *Universidade de Santiago de Compostela* carmen.rodriguez@usc.es
[5] *Universidade de Santiago de Compostela* miguel.vilar@usc.es

In this work a 2D mathematical model for simulating the sedimentation of suspended particles in canals is proposed. This model is obtained by coupling the shallow water equations for hydrodynamics with the Exner equations for sediment transport. Looking

to avoid the suspended particles settling and their unwanted effects, the model is used to formulate the problem of the management of an irrigation canal, as an optimal control problem (OCP) of partial differential equations. The OCP is solved by interfacing MIKE21 package for modelling stage, with the authors' own MATLAB code for optimizing purpose. Finally, some numerical results are presented for a realistic case.

Paper: **4083** **D2P-E**

Air Consumption Analysis in Compressed Air Powered Vehicles

Sebastian Uszyński[1], Leszek Ambroziak[2], Mirosław Kondratiuk[3], Zbigniew Kulesza[4]

[1] *Bialystok University of Technology* seb.uszynski@gmail.com
[2] *Bialystok University of Technology* l.ambroziak@pb.edu.pl
[3] *Bialystok University of Technology* m.kondratiuk@pb.edu.pl
[4] *Bialystok University of Technology* z.kulesza@pb.edu.pl

The paper presents the modelling and analysis of the air consumption in a pneumatic system of the compressed air powered vehicle. A mathematical model of the pneumatic system has been developed. The pneumatic system was analyzed during simulation studies and compared with experimental data logged on the prepared test rig. Performed analysis and presented results help to determine the efficiency of the pneumatic system in the compressed air car.

Paper: **4123** **D2P-E**

Dual Motor Single Shaft Powertrain Concept

Arkadiusz Hajduga[1]

[1] *Warsaw University of Technology* arkadiusz.hajduga@simr.pw.edu.pl

Most of modern electric vehicles are not equipped with additional transmission thanks to the very good electric motor (EM) torque speed characteristic. The changeable mechanical ratio of Automated Manual Transmission allows to adjust in the best way the operational parameters of electric machine to the load on the vehicle wheels, what , in consequence, may results in total drive efficiency increasing. In paper the structure consisted of two electric motors and one multispeed transmission was proposed. Proposed way of electric motor arrangement brings together the benefits of multispeed transmission application and the possibility of vehicle propelling during gear shifting.

Paper: **4132** **D2P-E**

Modeling and Simulation of the Averaged Dynamics of PWM Converters Operating in CCM and DCM

Damian Suski[1], **Dominik Górski**[2]

[1] *Warsaw University of Technology* suski@mchtr.pw.edu.pl
[2] *Warsaw University of Technology* dominik.gorski@ee.pw.edu.pl

The work concerns the problem of modeling and simulation of the averaged dynamics of PWM converters, which may operate alternately in continuous current mode (CCM) and discontinuous current mode (DCM). To capture different descriptions of converter dynamics in different current modes, the hybrid system concept is utilized. The derivation of the hybrid system,which models the average dynamics of the exemplary converter, is presented in details. The performance of the proposed hybrid systems is confirmed by numerical simulation tests.

Paper: **4142** **D2P-E**

Toward a Framework for Evaluation of Cache-Based Decision Making Process

Dominika Świerczyńska[1], **Tomasz Stach**[2], **Mariusz Pelc**[3]

[1] *Opole University of Technology* swierczynska.dominika@gmail.com
[2] *Opole University of Technology* stach.tomasz@gmail.com
[3] *Opole University of Technology / University of Greenwich* m.pelc@gmail.com

While willing to implement any self-learning mechanisms, the decision making process must be partially supported by recalling some previous decisions rather than triggering the reasoning process every time a decision is needed. For relatively simple systems storing previous decisions does not need any sophisticated mechanism but for some complex systems, when there are multiple decisions and many environmental information to be analysed while making those decisions, the whole context information (information about the environment state and accompanying decision) may need to be supported on one hand, by a database system (providing efficient search mechanisms) and on the other hand, by a cache-like system that would even improve decision making process by providing quick access mechanism in the most typical situations. The aim of this paper is to propose a framework for benchmarking real cache management algorithms within embedded systems.

Paper: **4161** **D2P-E**

Redesign of the Research Platform for Monitoring, Control and Security of Critical Infrastructure Systems

Tomasz Zubowicz[1], Krzysztof Arminski[2], Dawid Obremski[3], Jakub Pieńczewski[4]

[1] *Gdańsk University of Technology* tomasz.zubowicz@gmail.com
[2] *Gdańsk University of Technology* krzysztof.arminski@gmail.com
[3] *Gdańsk University of Technology* dawid.obremski@gmail.com
[4] *Gdańsk University of Technology* bukajabuk@interia.pl

Critical Infrastructure Systems (CIS) play a key role in modern societies. Their sustainable operation depends heavily on the performance of dedicated structures and algorithms targeting monitoring, control and security aspects. In previous work, a Research Platform (RP) for the design and simulation of such systems was presented. This works updates the information on the RP through the description of major hardware and software updates made. An example illustrating how this is to serve to include undergraduate students into research work is included.

Paper: **4193** **D2P-E**

Identifying Features Determining Mouse Behavior in Forced Swim Test

Tomasz Grzejszczak[1], Adrian Olczyk[2], Adam Gałuszka[3]

[1] *Silesian University of Technology* tomasz.grzejszczak@polsl.pl
[2] *Silesian University of Technology* adrian.olczyk@polsl.pl
[3] *Silesian University of Technology* adam.galuszka@polsl.pl

This paper presents the part of automation process of Forced Swim Test (FST). In the test a mouse behavior should be determined. In the automated process the mouse behavior is usually estimated with use of computer vision. Image processing algorithms are used to determine features that can determine mouse behavior. In this paper a common features are identified from a literature search. Those methods are presented and validated whether they can be used to create a classifier. The mouse position, speed and the sum of different pixels are compared to test outcome.

Paper: **4163** **D2P-E**

Minimizing the Impact of Non-Linear Stribeck Friction on Positioning of a Servo Drive

Bogdan Broel-Plater[1], Krzysztof Jaroszewski[2], Pawel Dworak[3]

[1] *West Pomeranian University of Technology Szczecin* bbp@zut.edu.pl
[2] *West Pomeranian University of Technology Szczecin* krzysztof.jaroszewski@zut.edu.pl
[3] *West Pomeranian University of Technology Szczecin* pawel.dworak@zut.edu.pl

In the paper we consider problems with precise control of position of the servo drive

while moving with very small velocities. Movements with small velocities or changing movement direction which a typical for e.g. milling machines are seriously influenced and the performance deteriorated by the motor friction. To solve this problem we propose to utilize a model following control (MFC) structure which together with the tuning algorithm of its controllers. The proposed control scheme seems to be easily implemented in the modern servo drive controller which may be of great practical importance.

Paper: **4188** **D2P-E**

Analysing Quality of Textual Requirements Using Natural Language Processing: a Literature Review

Jerzy Kocerka[1], Michał Krześlak[2], Adam Gałuszka[3]

[1] *Silesian University of Technology* Jerzy.Kocerka@polsl.pl
[2] *Automatix sp. z o.o.* m.krzeslak@automatix.com.pl
[3] *Silesian University of Technology* Adam.Galuszka@polsl.pl

Requirements engineering plays an important role in quality assurance, which is especially important for complex, embedded, safety-related systems. Such systems are often subject to additional regulations regarding functional safety such as ISO 26262 norm for road vehicles or EN 50128 for railway industry. Verifying quality of the requirements is a first step both for validation and verification of the system under test. This paper presents a review of the existing methods of automatic detection of the ambiguity and automatic assessment of the requirements quality together with the possible, future fields of research.

AI Methods II, D3L-A

Day: Thursday, August 30, 2018
Time: 10:40 - 12:00
Room: Casino
Chair: Andrzej Świerniak

Paper: **4114** **D3L-A**

Realization of Anchors Selflocalization During Preparation Stage of the Radiolocalization System

Sławomir Romaniuk[1], Zdzisław Gosiewski[2]

[1] *Bialystok University of Technology* s.romaniuk@pb.edu.pl
[2] *Bialystok University of Technology* z.gosiewski@pb.edu.pl

An approach for realization of the anchors self-localization algorithm in real time radiolocalization system is presented in the following paper. Distance measurements taken by the radio modules are used to estimate their positions. The proposed selflocalization algorithm utilizes anchors stationary model and is combined with Extended Kalman filter. Methodology including the mathematical model is presented, implemented and evaluated during the simulation and experimental test.

Paper: **4129** **D3L-A**

Observer Strategies for Virtual Sensing of Embroidered Metal-Polymer Heater Structure

Manuel Schimmack[1], Florian Pöschke[2], Horst Schulte[3], Paolo Mercorelli[4]

[1] *Leuphana University of Lueneburg* schimmack@uni-leuphana.de
[2] *University of Applied Sciences Berlin* florian.poeschke@htw-berlin.de
[3] *University of Applied Sciences Berlin* horst.schulte@htw-berlin.de
[4] *Leuphana University of Lueneburg* mercorelli@uni-leuphana.de

In this paper an Extended Kalman Filter (EKF) and a Takagi-Sugeno observer (TSO) are presented under the impact of parameter errors as an observer for temperature monitoring, like a virtual sensor, of a embroidered metal-polymer hybrid heater structure. An implementation of the temperature estimator for health monitoring is important to guarantee a gentle, fault-free operation of the heater. It can be used to control the resulting temperature without a direct measurement or to guarantee the users' safety by reacting to overheating. Simulations justify the different observation strategies.

Paper: **4140** **D3L-A**

Inference Methods for Detecting the Root Cause of Alarm Floods in Causal Models

Paul Wunderlich[1], Oliver Niggemann[2]

[1] *inIT - Institute Industrial IT / OWL University of Applied Sciences* paul.wunderlich@hs-owl.de
[2] *inIT - Institute Industrial IT / OWL University of Applied Sciences* oliver.niggemann@hs-owl.de

A novel approach to reducing alarm floods is concerned with learning the causal relationships between the alarms. The learned interrelations of the alarms are represented by a causal model. Based on these causal model, a root cause analysis is carried out to find out the cause of an alarm flood. This makes it possible to dramatically reduce the number of alarms and messages by displaying only the potential root causes. Therefore, we validate the approach of identifying the root cause of an alarm flood by a given causal model.

Paper: **4152** **D3L-A**

Optimal Selection of Input Features and an Acompanying Neural Network Structure for the Classification Purposes - Skin Lesions Case Study

Agnieszka Mikołajczyk[1], Michał Grochowski[2], Arkadiusz Kwasigroch[3]

[1] *Gdańsk University of Technology* agnieszka.mikolajczyk@pg.edu.pl
[2] *Gdańsk University of Technology* michal.grochowski@pg.edu.pl
[3] *Gdańsk University of Technology* arkadiusz.kwasigrochi@pg.edu.pl

The development in dermatoscopy and increasing the computing power of computers, caused that researchers are able to consider significantly more features of the analyzed

lesion in order to diagnose the cancer, than has been done so far. Therefore, there is a problem which of them to choose in order to get the best diagnosis results. In this paper we survey the kind of features taken into account by the researchers and then, selected the most efficient set of them. Proposed method jointly selects the optimal set of features representing the analyzed lesion together with accompanying form of the neural classifier.

Robotics II, D3L-B

Day: Thursday, August 30, 2018
Time: 10:40 - 12:00
Room: Kalman
Chair: Krzysztof Kozłowski

Paper: **4064** **D3L-B**

Theoretical and Algorithmic Aspects of Generating Pre-Control Form of the gCBHD Formula

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

The generalized Campbell-Baker-Hausdorff-Dynkin formula is a powerful tool in nonholonomic motion planning. It allows to construct a map from controls to displacements in a configuration space, primarily hidden behind differential equations. In this paper its pre-control form will be the main subject. The pre-control form means that a mapping is from general controls to local configuration shifts. In this paper it will be proven that coefficients of the pre-control form satisfy a nice property. An algorithm will also be presented to compute coefficients of pre-control form much faster than algorithms known in robotic literature. Appropriate simulation comparisons will be provided.

Paper: **4151** **D3L-B**

Kinematic Track Modelling for Fast Multiple Body Dynamics Simulation of Tracked Vehicle Robot

Satoshi Morita[1], Toshifumi Hiramatsu[2], Marta Niccolini[3], Alfredo Argiolas[4], Matteo Ragaglia[5]

[1] *Yanmar R&D Europe* satoshi_morita@yanmar.com
[2] *Yanmar R&D Europe* toshifumi_hiramatsu@yanmar.com
[3] *Yanmar R&D Europe* marta_niccolini@yanmar.com
[4] *Yanmar R&D Europe* alfredo_argiolas@yanmar.com
[5] *Yanmar R&D Europe* matteo_ragaglia@yanmar.com

This paper presents modelling technique for fast computation of multiple body dynamics of a tracked vehicle robot. Tracks are modelled as a series of small rigid plates constrained to move on a fixed path defined by the outline of the whole track. The tracks are modelled

without deformation, but the external force from the ground is considered and computed based on the contact force between the track plates and the ground. The constraint allows to significantly reduce simulation time. The validation of the model has been carried out against both a full dynamics model and experimentally measured data.

Paper: **4056** **D3L-B**

Accelerating Newton Algorithms of Inverse Kinematics for Robot Manipulators

Ignacy Duleba[1], Iwona Karcz-Duleba[2]

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

In this paper a few methods of accelerating computations of an inverse kinematic task for robot manipulators are discussed. Some of the methods rely on an approximation of inverse matrices, that are computed in each iteration of the Newton algorithm of inverse kinematics, with much computationally cheaper matrix polynomials. The computational efficiency of the methods is illustrated on planar pendula with a varied degree of redundancy.

Paper: **4199** **D3L-B**

Construction, Modelling and Identification of an Experimental and Educational 2DOF Manipulator for Investigation of Model Based Control Algorithms

Krzysztof Arent[1], Michał Prędkiewicz[2], Daniel Panachida[3], Wojciech Domski[4], Adam Klama[5]

[1] *Wrocław University of Science and Technology* krzysztof.arent@pwr.edu.pl
[2] *Wrocław University of Science and Technology* 202221@student.pwr.edu.pl
[3] *Wrocław University of Science and Technology* daniel.panachida@gmail.com
[4] *Wrocław University of Science and Technology* wojciech.domski@pwr.edu.pl
[5] *Wrocław University of Science and Technology* klama.adam@gmail.com

The article presents a modernized 2R planar manipulator at Wrocław University of Science and Technology designed for testing and development of control algorithms. The main attention is focused on the model development and verification with taking into account the specificity of the construction. In particular, the key stages of model development are presented and discussed. In turn, the model quality is elicited from the model verification which includes the results of experiments with the open and closed loop system.

Scheduling, D3L-C

Day: Thursday, August 30, 2018
Time: 10:40 - 12:00
Room: Lehar
Chair: Adam Kowalewski

Paper: **4054** **D3L-C**

An Enumerative Algorithm for a Two-Machine Preemptive Job Scheduling with a Learning Effect

Marcin Żurowski[1], Stanisław Gawiejnowicz[2]

[1] *Adam Mickiewicz University in Poznań* marcin.zurowski@amu.edu.pl
[2] *Adam Mickiewicz University in Poznań* stgawiej@amu.edu.pl

We consider a two-machine scheduling problem with a learning effect and the objective to minimize the schedule length. Jobs are preemptable but only preemption of a single job is allowed. We present basic properties of this problem and an enumerative algorithm for its exact solution.

Paper: **4210** **D3L-C**

Improving the Efficiency of Scheduling Jobs Driven by a Common Limited Energy Source

Rafał Różycki[1], Jan Węglarz[2]

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

We consider a problem of scheduling independent preemptable jobs on parallel identical machines to minimize a makespan. The processing rate of a job depends on a temporal allocation of limited power. Moreover, we assume that energy consumption is also constrained. Thus power/energy is treated as a doubly-constrained resource. In consequence the problem is to find a sequence of jobs on machines and simultaneously to determine an allocation of power to jobs that lead to a feasible schedule of minimal length. A complex non-linear mathematical programming problem has to be solved in a general case. In this paper we propose a solution procedure that utilizes an observation that usually only one limit for doubly-constrained resource is active in an optimal schedule.

Paper: **4040** **D3L-C**

Cyclic Scheduling in Interlaced and Non-Interlaced Mode

Czeslaw Smutnicki[1]

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

This paper deals with the discrete cyclic manufacturing system which provides on the output a fixed mixture of various products in a repetitive series of short or medium size length. The system works accordingly to so called job-shop strategy, which means that each product has its own independent technological route, various for different products. Based on our own achievements obtained for classical job shop batch scheduling problem, we discuss a few approaches relevant to introduce a cyclic manufacturing strategy. We consider two classes of the cyclic schedules: non-interlaced and interlaced. Proposed approach differs significantly from those known so far in the literature and is much more advantageous, due to lesser computational complexity and faster convergence to the optimal solution. We discuss some new properties useful for finding the minimal cycle time for fixed (given) job processing order on the base of graph paths as well as special features of the problem.

Paper: **4047** **D3L-C**

Power-Aware Scheduling of Preemptable Independent Jobs on a Single Processor to Meet a Schedule Deadline

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 problem of power allocation to computational jobs performed on a single processor, where jobs may be performed with different speeds. Power/energy is a continuous, doubly-constrained resource whose amount is nonlinearly related to a particular speed of a job. Jobs are preemptable, independent, and all are available at the start of the process. A so-called server problem is considered in which the power usage is to be minimized under the condition that an assumed schedule deadline is met for the completion of the given set of jobs. We analyze two cases of the problem: when the energy amount available is not limited, as well as when it is limited for the entire schedule.

Modelling & Simulation IV, D3L-D

Day: Thursday, August 30, 2018
Time: 10:40 - 12:00
Room: Strauss
Chair: Rafał Stanisławski

Paper: **4091** **D3L-D**

The Use of an Autoencoder in the Problem of Shepherding

Zdzisław Kowalczuk[1], Wojciech Jędruch[2], Karol Szymański[3]

[1] *Gdańsk University of Technology* kova@pg.edu.pl
[2] *Polish Naval Academy* w.jedruch@amw.gdynia.pl
[3] *Gdańsk University of Technology* karszyma@pg.edu.pl

This paper refers to the problem of shepherding clusters of passive agents consisting of a large number of objects by a team of active agents. The problem of shepherding and the difculties that arise with the increasing number of data describing the location of agents have been described. Several methods for reducing the dimensionality of data are presented. Selected autoencoding method using a Restricted Boltzmann Machine is then discussed. Autoencoding is deployed to reduce the dimensionality of graphic representation of clusters. Reduced data is used to train the neural network which determine movements of the active agents. Genetic algorithms are used in optimization of the parameters of this network.

Paper: **4136** **D3L-D**

On Control-Oriented Modeling in Heat Transfer Based on a Projection Technique and the Method of Integrodifferential Relations

Vasily Saurin[1], Andreas Rauh[2], Harald Aschemann[3]

[1] *Institute for Problems in Mechanics of the Russian Academy of Sciences* saurin@ipmnet.ru
[2] *University of Rostock* andreas.rauh@uni-rostock.de
[3] *University of Rostock* harald.aschemann@uni-rostock.de

In this paper, projection techniques of an initial-boundary value problem formulated originally in PDEs to a system of ODEs of small dimension are presented. Properties of various quadratic relations derived from energy terms that arise in different problems of mathematical physics are studied and discussed. As an example, integrodifferential formulations of a 2-D heat transfer problem are considered. A feedforward control problem for heat transfer processes in a metal plate is reduced to a system of ordinary differential equations based on the finite element method and semi-discrete approximations with polynomial basis functions and an analysis of the problem is performed. Finally, results of numerical simulations are presented and discussed.

Paper: **4172** **D3L-D**

Unintended Synchronisation Between Rotational Speed and PWM Frequency in a PM BLDC Drive Unit

Andrzej Tutaj[1], **Tomasz Drabek**[2], **Tomasz Dziwinski**[3], **Jerzy Baranowski**[4], **Paweł Piatek**[5]

[1] *AGH University of Science and Technology* tutaj@agh.edu.pl
[2] *AGH University of Science and Technology* drabek@agh.edu.pl
[3] *AGH University of Science and Technology* tdz@agh.edu.pl
[4] *AGH University of Science and Technology* jb@agh.edu.pl
[5] *AGH University of Science and Technology* ppi@agh.edu.pl

— In an electric drive with a three-phase PM BLDC motor, tasks of PWM modulation and six-step or twelve-step commutation of phases are usually combined and carried out by an MCU or CPU controlled MOSFET or IGBT transistor bridge. That approach cuts down electronic element count, decreases size and price of the inverter and reduces power losses. However, at the same time it can also give rise to an undesired phenomenon of a spontaneous synchronisation (locking) between the motor rotational speed and the PWM frequency. An inverter–motor drive system may behave like an unintended phase-locked loop (PLL), endeavouring to keep a constant ratio between the six-step commutation frequency and the PWM modulation frequency. Resulting nonlinearity, discontinuity, hysteresis and nonuniqueness of the drive unit mechanical characteristic makes it difficult to develop a controller algorithm. The paper shows this unexpected and unwanted effect and investigates its causes.

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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.