WELCOME from the MMAR 2017 Organizing Committee

I would like to invite you to Międzyzdroje, Poland for the 22nd International Conference on Methods and Models in Automation and Robotics. Over 260 draft papers have been submitted, from which the International Program Committee, chaired by Professor Tadeusz Kaczorek, has selected 189 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, 28 August 2017. All four days of the conference begin with a plenary lecture delivered by a distinguished scientist, and further 6 papers are to be presented in the invited sessions organized by very active researchers from various countries. All other papers will be presented in four parallel regular sessions. Furthermore, several poster sessions will take place. Moreover, all the MMAR 2017 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 2017 Organizing Committee
Faculty of Electrical Engineering
West Pomeranian University of Technology, Szczecin

Organizer

Faculty of Electrical Engineering,
West Pomeranian University
of Technology,
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During the Conference

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WWW Site

The Final Program
of the MMAR 2017 Conference
can also be found on the Internet at:
`http://www.mmar.edu.pl`

Conference Proceedings

The Conference Proceedings will be submitted to 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 22nd in a series which started in 1994.

Venue and dates

The Conference will be held at the Amber Baltic Hotel in Miedzyzdroje, from Monday, 28 August till Thursday, 31 August 2017. The Conference registration desk in Amber Baltic Hotel will be opened on the Monday morning, 28 August and during each day of the Conference. The Conference will start on Monday, 28 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.

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We would like to thank the program committee members for contributing to the success of MMAR 2017 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 2017:

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Control Applications	Harald Aschemann Paweł Dworak
Intelligent Systems and Methods	Józef Korbicz Jacek Piskorowski
Robotics	Ahmed Chemori Krzysztof Kozłowski Jacek Piskorowski Cezary Zieliński
Modelling, Identification and Simulation	Wojciech Hunek Krzysztof Latawiec Andreas Rauh Jacek Piskorowski
Signal Processing and Networked Control Systems	Roman Kaszyński Krzysztof Okarma
Discrete Events and Hybrid Systems	Jacek Piskorowski
Distributed Parameter Systems Modelling, Control and Estimation	Harald Aschemann

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We would like to thank the following individuals for their efforts in the review process of MMAR 2017:

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Monday, Aug 28th, 2017

	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 18 **Control-Oriented Modelling and Observer-Based Control of Distributed Parameter Systems** speaker: Harald Aschemann			
16.10-16.30	*Coffee break* (in front of Kalman/Lehar)			
16.30-17.20	A2P-E, page 18 **Poster Session I** *Krzysztof Okarma*			
16.30-17.50	A3L-A, page 23 **Control and Systems Theory I** *Jerzy Klamka*	A3L-B, page 25 **Navigation Systems** *Stefan Palis*	A3L-C, page 27 **Adaptive Control** *Joachim Horn*	A3L-D, page 28 **Robotics I** *Krzysztof Tchon*
19.00	Welcome Party (Amber, Chopin room)			

Tuesday, Aug 29th, 2017

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Krzysztof Kozłowski* , page 32 **Quo Vadis Model Predictive Control? from Stabilizing to Distributed Economic MPC** speaker: Frank Allgower			
10.00-11.00	B2L-A, page 32 **Theory of Fractional Order Systems** *Tadeusz Kaczorek*	B2L-B, page 33 **Control Applications I** *Andres Peters*	B2L-C, page 35 **Distributed Parameter Systems - Modelling, Control and Estimation I (Invited Only)** *Harald Aschemann*	B2L-D, page 36 **Robotics II** *Navvab Kashiri*
10.00-12.00	B3P-E, page 38 **Poster Session II** *Przemyslaw Mazurek*			
11.00-11.20	*Coffee break* (in front of Kalman/Lehar)			

	Casino	**Kalman**	**Lehar**	**Strauss**
11.20-13.00	B4L-A, page 43 **Control and Systems Theory II** *Andrzej Bartoszewicz*	B4L-B, page 45 **Control Applications II** *Jacek Kabzinski*	B4L-C, page 47 **Identification** *Zygmunt Hasiewicz*	B4L-D, page 50 **Modelling and Simulation I** *Bill Goodwine*
13.00-15.00	*Lunch* (Amber hotel)			
15.00-16.20	B5L-A, page 52 **Robotic Manipulators** *Erhan Ilhan Konukseven*	B5L-B, page 54 **Sliding Mode Control** *Andreas Rauh*	B5L-C, page 56 **Optimization** *Krzysztof Galkowski*	B5L-D, page 58 **Scheduling** *Jozef Korbicz*
15.00-17.00	B6P-E, page 60 **Poster Session III** *Rafal Stanislawski*			
16.20-16.40	*Coffee break* (in front of Kalman/Lehar)			
16.40-18.00	B7L-A, page 65 **Control and Systems Theory III** *Wieslaw Krajewski*	B7L-B, page 67 **AI Methods I** *Marcin Witczak*	B7L-C, page 68 **Distributed Parameter Systems - Modelling, Control and Estimation II (Invited Only)** *Harald Aschemann*	B7L-D, page 70 **Speech Processing & Recognition** *Georgy Kostin*
19.00	Conference Banquet (Międzyzdroje International House of Culture)			

Wednesday, Aug 30th, 2017

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Jozef Korbicz* , page 74 **Control of Complex Robotic Systems: Challenges, Design and Experiments** speaker: Ahmed Chemori			
10.00-11.00	C2L-A, page 74 **Biomedical Signals** *Ryszard Beniak*	C2L-B, page 76 **Applications of Fractional Order Systems** *Piotr Ostalczyk*	C2L-C, page 77 **Robotics III** *Bernd Finkemeyer*	C2L-D, page 79 **Predictive Control** *Frank Allgower*
10.00-12.00	C3P-E, page 80 **Poster Session IV** *Witold Mickiewicz*			
11.00-11.20	*Coffee break* (in front of Kalman/Lehar)			
11.20-13.00	C4L-A, page 86 **Robust Control** *Wojciech Hunek*	C4L-B, page 88 **Control Applications III** *Przemyslaw Ignaciuk*	C4L-C, page 90 **Modelling and Simulation II** *Paolo Mercorelli*	C4L-D, page 93 **Image Processing** *Krzysztof Okarma*
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 31st, 2017

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Andrzej Bartoszewicz* , page 98 **Towards Safe Human-Robot Collaboration** speaker: Bernd Finkemeyer			
10.00-11.00	D2L-A, page 98 **Signal Processing** *Alexander Winkler*	D2L-B, page 100 **Robotics IV** *Krzysztof Kozłowski*	D2L-C, page 101 **Control and Systems Theory IV** *Krzysztof Latawiec*	D2L-D, page 102 **AI Methods II** *Janusz Szpytko*
10.00-12.00	D3P-E, page 103 **Poster Session V** *Pawel Dworak*			
11.00-11.20	*Coffee break* (in front of Kalman/Lehar)			
11.20-12.30	D4L-A, page 110 **Signal Processing & Networked Control Systems** *Rafal Stanislawski*	D4L-B, page 112 **Modelling and Simulation III** *Jaroslaw Figwer*	D4L-C, page 113 **Control Applications IV** *Vaclav Zada*	D4L-D, page **??**
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 28th, 2017

Plenary: H. Aschemann, A1L-A

Day: Monday, August 28, 2017
Time: 15:10 - 16:10
Room: Casino
Chair: Tadeusz Kaczorek

Paper: **6259** **A1L-A**

Control-Oriented Modelling and Observer-Based Control of Distributed Parameter Systems

Harald Aschemann[1]

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Poster Session I, A2P-E

Day: Monday, August 28, 2017
Time: 16:30 - 17:20
Room: Poster Area
Chair: Krzysztof Okarma

Paper: **6007** **A2P-E**

Domain Specific Language for Structural Modeling of Logically Controlled Discrete-Event Mechatronic Systems

Krzysztof Pietrusewicz[1], **Michael Scopchanov**[2]

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The transition from a model–driven to a requirements–driven approach in the software development for programmable logic controllers will allow the developers to focus on the proper definition of the problem which needs to be solved and let the computer find a suitable solution for it automatically. This article presents a domain specific language intended to support this transition. The main focus is on the creation of a structural model of the controlled mechatronic system and the subsequent transformation of this model into a partial model of the control software. The functional aspects however are left for future work. All proposed concepts are applied for the Pick&Place station by Festo and the obtained results are presented and discussed.

Paper: **6015** **A2P-E**

Dynamic Positioning with Voith Schneider Propeller: Experimental System Validation with a Model-Scale Offshore Supply Vessel

Philipp Koschorrek[1], Charlotte Siebert[2], Lasse Theilen[3], Ole Detlefsen[4], Michael Palm[5], Klaus-Peter Mach[6], Marc Steinwand[7], Torsten Jeinsch[8], Moustafa Abdel-Maksoud[9]

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Dynamic Positioning (DP) is an essential capability of marine vessels required for diverse scenarios. The retention of position by solely usage of thrusters requires an efficient and dynamic propulsion system. A Voith Schneider Propeller (VSP) features such qualities. In this paper a DP system is shown that utilizes the properties of a VSP in an enhanced way, especially in the thrust allocation. Parametrization of the DP system components was conducted by usage of hydrodynamic simulations. Experiments with a model-scale version of an offshore supply vessel were performed to validate the DP system, its components and the design and parametrization techniques. The trials show that thrusters with higher dynamic yield better DP quality. Furthermore, these were, to the knowledge of the authors, the first DP trials performed with a VSP-optimized allocation.

Paper: **6026** **A2P-E**

Direct Algorithm for Optimizing Robust MPC of Drinking Water Distribution Systems Hydraulics

Arkadiusz Ciminski[1], Kazimierz Duzinkiewicz[2]

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[2] *Gdańsk University of Technology* kazimierz.duzinkiewicz@pg.gda.pl

Model-based predictive control is an effective method for control the large scale systems. Method is based on on-lin solution of control task over the control horizon using current and past measurements as well as the system model. Because model and measurement uncertainty, predicted and plant outputs might be different and plant output may exceed plant output constraints. Generated control is not then robustly outputs feasible. In this paper robustly outputs feasible direct control algorithm, based on robust output prediction and control vector are presented. Proposed robustly outputs feasible MPC applied to drinking water distribution system (DWDS) of the Chojnice city is presented.

Paper: **6072** **A2P-E**

Practical Verification of Active Disturbance Rejection Controller for the Pneumatic Setup

Pawel Nowak[1], **Jacek Czeczot**[2]

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[2] *Silesian University of Technology* jacek.czeczot@polsl.pl

In this paper, the practical verification of Active Disturbance Rejection Controller (ADRC) implementation for pneumatic setup is investigated. Apart from experimental results, the inverse half-rule is suggested to support ADRC tuning for the second order processes by adjusting the value of the scaling factor. This rule is based only on the approximation of the process step response by First Order plus Dead Time (FOPDT) model. The results show the practical applicability of the suggested tuning method and the superiority of ADRC control performance over the conventional PI controller.

Paper: **6111** **A2P-E**

Open-Loop Control System of Liquid Level in Double Tank Cascade System

Krzysztof S. Kula[1]

[1] *Gdynia Maritime University* k.kula@we.am.gdynia.pl

This paper presents the control system of water level in double tank system with free flow, which uses in its structure a nonlinear model of the plant taking into account the dependence of the time constants on the value of the controlled variable. A model that reflects the properties of an object and is a part of the controller allows significant to shorten the settling time if the liquid is regulating in the upper regions of the tank

Paper: **6133** **A2P-E**

Isopropanol Concentration Control in the Ultrasonic Nebulization Process

Dariusz Choinski[1], **Piotr Skupin**[2], **Piotr Krauze**[3], **Witold Ilewicz**[4], **Zdzisław Bielecki**[5]

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The paper presents the application of the linearizing control technique for stabilization of the isopropanol concentration in the ultrasonic nebulization process. The isopropanol concentration has to be kept constant to make the nebulization process more efficient. This is achieved by manipulating the inlet flow rate of a fresh isopropanol-water mixture.

Because the content of the vessel is not well-mixed, it was shown that by measuring only the isopropanol concentration at the bottom of the vessel, the control system performance could be improved by the optimal selection of controller parameters. Moreover, the simulation results have shown that the closed-loop system was stable and exhibited similar behavior, even if the nebulization rate was not know precisely.

Paper: **6138** **A2P-E**

Crazyflie 2.0 Quadrotor as a Platform for Research and Education in Robotics and Control Engineering

Wojciech Giernacki[1], Mateusz Skwierczyński[2], Wojciech Witwicki[3], Paweł Wroński[4], Piotr Kozierski[5]

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In this paper a Crazyflie 2.0 nano quadrotor(quadcopter) as an open source experimental platform for research and education has been presented. This low cost, easily expandable and upgradeable unmanned aerial vehicle (UAV) is here characterized in terms of hardware and software. Three aspects are discussed. The first one is an acquisition of measurement data from test flights by the proposed, freely available "black-box" software. The second is the use of a new, advanced 4FLY Simulator in order to utilize the MATLAB®/Simulink environment to easily implement a mathematical model of Crazyflie 2.0 dynamics, as well as for a synthesis of various types of controllers with support of OpenGL cross-language in the visualization of simulations results. The 4FLY Simulator allows to test autonomous flights (and landings) with obstacles avoidance and to conduct learning and teaching the basics of Crazyflie 2.0 piloting. In the third aspect the authors outlined promising, preliminary results obtained in control of flying robot by pointing device (positioner) and with the support of a vision system, which basis only on a single Kinect sensor.

Paper: **6173** **A2P-E**

Improving the Quality of the Classic Servo Drive by Modifying the Motion Control Algorithm

Bogdan Broel-Plater[1], Krzysztof Jaroszewski[2]

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Frequently CNC machines use rotary servo drives and a kinematic chain in the form of pulling screw with a nut. The disadvantage of that structure is: non-linear and falling friction, the susceptibility of the pulling screw to the torsion deformation and the backlash. In [3-5] outlines ways to modify the servo drive structure to minimize frictional effects

and pulling screw elasticity in order to achieve better motion quality. The present paper presents modified structure of the digital servo drive control system to eliminate the oscillations of the servo drive position with backlash.

Paper: **6188** **A2P-E**

Cascade Control Algorithms of Position and Attitude for Multirotor UAV

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This paper presents the development process of different cascade controllers for multirotor UAVs. Two main usage areas of this method are described - the control of position and attitude. Based on the literature and experience from previous research, structures of mentioned algorithms are proposed. Adequate data-driven simulation models are formulated and used in the tuning process. Additionally, a customised test bench was constructed and utilised for experiments. Comparison between previous solutions and new control structures is performed in both simulation and field experiments. Better performance, robustness and flexibility of cascade control algorithms are proven on the basis of gathered results.

Paper: **6181** **A2P-E**

Study of the Efficiency of an Algorithm That Improves the Accuracy of Slow-Motion Control of a Servo Drive

Bogdan Broel-Plater[1], Krzysztof Jaroszewski[2]

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The paper describes methods of improving motion quality of servo drive in case of set a very small motion changes. Servo drive as well as control problems connected with static friction are described. Solutions of such problems are offered. First one is integration zeroing, second one based on a unique idea introduced by authors and finally feeding into the system an insensibility. All that methods were verified on the base of simulation as well as practical validation, what was described.

Paper: **6087** **A2P-E**

Influence of Free Convection on Heat Transfer in Control Problems for a Cylindrical Body

Dmitri Knyazkov[1], Georgy Kostin[2], Vasily Saurin[3]

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The paper considers influence of free convection on controlled heating or cooling of cylindrical bodies. Horizontal and vertical alignments of the body are studied. Free convection appears to be the main way of heat transfer for parameters of the considered experimental setup. An experiment of free cooling of a horizontal cylinder in ambient air has been performed. Its results are consistent with numerical estimations. Simulation of cylinder controlled heating shows that the non-uniformity of the heat transfer coefficient along the cylinder's surface can have considerable influence on the temperature at some critical points for materials with relatively small conductance.

Control and Systems Theory I, A3L-A

Day: Monday, August 28, 2017
Time: 16:30 - 17:50
Room: Casino
Chair: Jerzy Klamka

Paper: **6027** **A3L-A**

Reduction of Wave Linear Repetitive Processes to Singular Roesser Model Form

Krzysztof Galkowski[1], Mohamed Boudellioua[2], Eric Rogers[3]

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Using the elementary operations algorithm (EOA), it is shown that a system matrix describing a wave discrete linear repetitive process can be reduced to that for a 2D singular Roesser model. The transformation linking the original polynomial system matrix with its associated 2D singular Roesser form is inputoutput equivalence. The nature of the resulting system matrix in singular form and the transformation involved are established.

Paper: **6016** **A3L-A**

Extension of Cayley-Hamilton Theorem and a Procedure for Computation of the Drazin Inverse Matrices

Tadeusz Kaczorek[1]

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The classical Cayley-Hamilton theorem is extended to Drazin inverse matrices. A new procedure based on this extension for computation of the Drazin inverse matrices is proposed.

Paper: **6201** **A3L-A**

The Analysis of Permissible Quality Indices of the System with Affine Uncertainty of Characteristic Polynomial Coefficients

Sergey Gayvoronskiy[1], **Tatiana Ezangina**[2], **Ivan Khozhaev**[3]

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The goal of this article is to analyze the assurance of permissible quality indices in an interval system through the construction of the edge route and the use of D-partition method. There were obtained conditions for construction of D-partition domains on one and two edges of one face. On the basis of these conditions the technique for assurance of the permissible degree of robust stability and oscillation was developed. The article presents a numerical illustration.

Paper: **6206** **A3L-A**

Finding a Set of (A,B,C,D) Realizations for Single-Input Multiple-Output Dynamic System: First Approach Using Digraph-Based Method for Solutions with Intersection Vertex

Konrad Markowski[1], **Krzysztof Hryniów**[2]

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This paper presents the first proposition of a method allowing the determination of a set of (A,B,C,D) realisations of the one-dimensional single-input multi-output (SIMO) dynamic system from created digraph. The algorithm presented is the extension of previously published algorithm that finds a complete set of all possible realisations, instead of only a few realisations, as was in case of canonical form methods. The advantages of the proposed method are the possibilities of obtaining a set of state matrices directly from digraph form of the system and using fast parallel computing method. The algorithm is presented in pseudo-code and illustrated with example.

Navigation Systems, A3L-B

Day: Monday, August 28, 2017
Time: 16:30 - 17:50
Room: Kalman
Chair: Stefan Palis

Paper: **6063** **A3L-B**

Triangulation Positioning System Based on a Static IR Beacon-Receiver System

Maciej Ciezkowski[1]

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The primary goal of each of the navigation systems is to determine the object's position in a given reference frame. It can be achieved in many ways such as GPS, celestial navigation, inertial navigation etc. In local positioning systems a very important role is played by triangulation methods. This paper presents a new beacon-based triangulation system, in which both the transmitter and receiver do not contain any mechanical moving parts. Lack of mechanical moving parts makes the system less complex and more robust. The work contains a description of all the necessary steps to determine the object's position in a given reference frame.

Paper: **6198** **A3L-B**

Data Fusion of GPS Sensors Using Particle Kalman Filter for Ship Dynamic Positioning System

Krzysztof Jaroś[1], **Anna Witkowska**[2], **Roman Śmierzchalski**[3]

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Depending on the standards and class of dynamic positioning ships, some vessels have a different number of redundant sensors to determine current ship position. In the paper multisensor data fusion algorithm in the dynamic positioning systems were presented to take a proper signal from a few sensors (GPS receivers). During research Particle Kalman Filter with data fusion was used to estimate the position of the vessel. The presented algorithms generate a virtual measurement using three measurements from independent sensors. The performance of the Particle Kalman Filter algorithm was evaluated by simulation tests in two instances, when the signal disappears of one of the sensors during operation and regular work.

Paper: **6145** **A3L-B**

Evaluating the Ellipsoidal Collision Avoidance Region for the Future DAA Systems

Mateusz Spychała[1], **Rafał Osypiuk**[2]

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The steeply increasing numbers of manned and unmanned aerial operations requires safe methods of airspace sharing. This paper analyses ellipsoidal areas, which seem to be an interesting alternative to often proposed, spherical areas. They allow i.e. alarm generation areas to be smaller and the average time from an alarm to a collision to be extended. The proposed methods may be used in DAA (Detect and Avoid) systems which are a subject of standardisation work of various aviation institutions and organisations.

Paper: **6098** **A3L-B**

Design of Ship Course-Keeping System via Robust Adaptive Approach

Zenon Zwierzewicz[1]

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The paper considers the problem of ship autopilot design based on Bech's model of the vessel. Since the ship model is highly nonlinear and the state vector is not completely measurable, the control system synthesis is performed by means of output feedback linearization method combined with a state observer. Due to considerable parameter variations and other substantial uncertainties a robust-adaptive version of the method has been applied. The whole control system is able to ensure tracking performance on the Hinf optimal attenuation level. This is the so-called Hinf tracking problem in an adaptive system. Simulations of the ship course-changing process have confirmed a good performance of the proposed controller.

Adaptive Control, A3L-C

Day: Monday, August 28, 2017
Time: 16:30 - 17:50
Room: Lehar
Chair: Joachim Horn

Paper: **6088** **A3L-C**

Adaptive Optimal Control Algorithm for Vibrational Systems Under Nonlinear Friction

Maciej Wasilewski[1], Dominik Pisarski[2]

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In this paper a novel control algorithm for vibration attenuation is presented. Proposed scheme is developed to control linear systems with presence of external disturbance. The goal of the control is to steer the system to prescribed reference trajectory by minimizing associated quadratic performance index. The synthesis of the control law consists of two steps. At the first step, past measures of disturbance are used to develop local linear approximation of dynamics of disturbance signal. Weights of the associated auto-regressive model are calculated by the least-square algorithm. At the second step, calculated model is used to obtain linear time-invariant approximation of the control system. The receding horizon control law is then calculated by using finite horizon Linear Quadratic Regulator. The algorithm is verified numerically for torsional vibrating system under nonlinear, timevarying friction. The results of simulation are compared to a standard Linear Quadratic Gaussian control.

Paper: **6219** **A3L-C**

Adaptive and Robust Motion Control in Presence of LuGre-Type Friction

Marcin Jastrzębski[1], Jacek Kabziński[2], Przemysław Mosiołek[3]

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The proposed approach to the adaptive motion control in the presence of LuGre-type friction consists in the compensation of all components containing the internal model variable by a robust control term, based on a special "bounding function". To minimize the chattering effect, this function is approximated by a linear-in-parameters model. The model is tuned on-line by the adaptive control, together with the remaining unknown parameters.

Paper: **6247** **A3L-C**

Direct Fuzzy Adaptive Control and Nonparametric Identification of Robot Manipulator with Elastic Joints

Jurek Z. Sąsiadek[1], Steve Ulrich[2], Adam Krzyżak[3]

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In this paper an elastic joint two-link flexible link robot manipulator is considered. An advanced control system has been presented. The controller uses adaptive fuzzy logic approach. Nonlinear friction in the joints is modeled by the Hammerstein system. It is identified by the algorithm based on nonparametric nearest neighbor regression estimation. The asymptotically optimal choice of the parameters of the algorithm are investigated.

Robotics I, A3L-D

Day: Monday, August 28, 2017
Time: 16:30 - 17:50
Room: Strauss
Chair: Krzysztof Tchon

Paper: **6223** **A3L-D**

Mobile Agents and Their Use in a Group of Cooperating Autonomous Robots

Zbyněk Obdržálek[1]

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This paper describes the use of mobile agents in the group of cooperating UAV and UGV autonomous robots. Multi-agent system simulation uses an environment that integrates robot operating system (ROS), V-REP simulation environment and JADE multi-agent system. Mobile agents ensure the continuation and completion of the mission even in case of failure of a device from a group. Paper describes a particular scenario for application of mobile agents.

Paper: **6163** **A3L-D**

Implementation and Evaluation of a Bilateral Teleoperation with Use of Wave Variables in the ReMeDi System for Remote Medical Examination

Adam Kurnicki[1], Mateusz Cholewiński[2], Bartlomiej Stańczyk[3], Krzysztof Arent[4]

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The article presents a bilateral teleoperation architecture with wave variables that has been applied in a new robotic system for remote medical examination. First we discuss specificity of requirements of the ReMeDi medical system with respect to teleoperation architecture and the process of its selection. Then we discuss implementation issues concerning the architecture. Finally we present evaluation results.

Paper: **6257** **A3L-D**

Rapid Navigation Function Control for Omnidirectional Mobile Platform

Wojciech Kowalczyk[1], Mateusz Przybyła[2], Krzysztof Kozłowski[3]

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This paper presents an extension of navigation function used to control an omnidirectional robot. Navigation function is used to control position coordinates while the orientation variable is controlled with simple proportional controller. The extension relies on a specific normalization of navigation function gradient. Presented method results in much more rapid convergence in comparison to classic approach based on negative gradient of the navigation function. The most noticeable result of the extension is observed for high values of K parameter, which must be increased if the distances between obstacles are small. Experimental results are given to illustrate effectiveness of the proposed algorithm.

Nonlinear Inverse Modeling with Signal Prediction in Bilateral Teleoperation with Force-Feedback

Mateusz Saków[1], Arkadiusz Parus[2], Mirosław Pajor[3], Karol Miądlicki[4]

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In the paper a sensor-less control scheme for a bilateral teleoperation system with a force-feedback based on a prediction of an input and an output of a non-linear inverse model by prediction blocks was presented. The prediction method of an input and an output of an inverse model was designed to minimize the effect of the transport delay and the phase shift of sensors, actuators and mechanical objects. The solution is an alternative to complex non-linear models like artificial neural networks, which requires complex stability analysis and control systems with high computing power. The effectiveness of the method has been verified on the hydraulic manipulator test stand.

Tuesday
August 29th, 2017

Plenary: F. Allgower, B1L-A

Day: Tuesday, August 29, 2017
Time: 09:00 - 10:00
Room: Casino
Chair: Krzysztof Kozłowski

Paper: **6262** **B1L-A**

Quo Vadis Model Predictive Control? from Stabilizing to Distributed Economic MPC

Frank Allgower[1]

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Theory of Fractional Order Systems, B2L-A

Day: Tuesday, August 29, 2017
Time: 10:00 - 11:00
Room: Casino
Chair: Tadeusz Kaczorek

Paper: **6023** **B2L-A**

Existence and Continuous Dependence of Solutions on Controls for Linear Control Systems with Different Fractional Orders

Rafał Kamocki[1]

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The paper concerns linear continuous control systems with different fractional orders involving the Caputo derivatives. In the first part, an existence and uniqueness of a solution to such systems is studied. Next, based on the existence result, a theorem on the continuous dependence of solutions on controls is obtained.

Paper: **6192** **B2L-A**

Novelty Fractional-Order Backward Difference and its Applications in a Control System Analysis

Piotr Ostalczyk[1]

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In the paper a novelty fractional-order backward difference is proposed. On a basis of the classical first-order backward difference and its generalization into the fractional-order case we intorduce a constant parameter a which essentionally influences on the differentiation

action. This novelty fractional-order backward difference will be further named as a-difference. Its fundamental properties are established. A numerical exmple shows the a-differentiation effects.

Paper: **6229** **B2L-A**

A Comparative Analysis of Two Methods for Model Predictive Control of Fractional-Order Systems

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

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The paper presents a comparative analysis of extended horizon model predictive control deployed for two various state prediction algorithms designed for discrete-time fractional-order state space systems. The first one is a finite fractional difference state predictor derived on the basis of a finite-length approximation of the fractional-order state space system. The second one is a BTA-based integer-order state space approximation of the fractional-order system. Simulation results show that second approach is more promising.

Control Applications I, B2L-B

Day: Tuesday, August 29, 2017
Time: 10:00 - 11:00
Room: Kalman
Chair: Andres Peters

Paper: **6174** **B2L-B**

Damping of Resonance Peaks Using Adaptive Notch Filters in Gearless Servo Drives

Mario Aldag[1], Joachim Horn[2]

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For applications of an gearless servo system on a milling machine the parameters of the mechanical resonances differ from workpiece to workpiece and thus cannot be calculated a priori. In this paper an online mechanical resonance frequency identification algorithm and online notch filter depth tuning algorithm are presented. The performance of these algorithms is shown on a test axis and on a round table with a direct torque motor on

a production milling machine. Multiple resonances present on the milling machine can be damped subsequently and the controller gains can be increased to improve the overall tracking performance.

Paper: **6176** **B2L-B**

Estimation Problems of Pneumatic Transport System for Electromagnetic Grinding

Zbigniew Ogonowski[1], **Szymon Ogonowski**[2]

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The paper presents models and estimation algorithm of the air stream velocities in pneumatic material transport for supervisory and direct control layers of electromagnetic milling system. The algorithm uses redundant measurement system and identifies parameters of the first principle model to increase reliability of the measurements and to give rise of the fault detection system.

Paper: **6235** **B2L-B**

Development of Microprocessor, Time Optimized Stepper Motor Driving Algorithm

Łukasz Przeniosło[1], **Marcin Hołub**[2]

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In the paper a stepper motor closed loop driver algorithm is presented, which emphasizes the processor overhead minimization in which it is implemented, as well as rotor average torque and set position acquisition. The program was tested as a simulation in MATLAB environment and on a physical driver based on STM32 microcontroller connected with a motor and an encoder. Exemplary results are introduced in the work.

Distributed Parameter Systems - Modelling, Control and Estimation I (Invited Only), B2L-C

Day: Tuesday, August 29, 2017
Time: 10:00 - 11:00
Room: Lehar
Chair: Harald Aschemann

Paper: **6060** **B2L-C**

Tracking Control for a Long Pneumatic Transmission Line

Richard Kern[1], **Nicole Gehring**[2]

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This paper presents a tracking controller for a long pneumatic transmission line modeled by a bidirectionally coupled system of partial differential equations (PDEs) and ordinary differential equations (ODEs). The feedforward part of the controller is designed by applying a flatness-based approach for hyperbolic PDEs to a quasilinear model of the pneumatic system. The stabilizing feedback is derived by application of a recently developed backstepping approach for coupled PDE-ODE systems to a different, more simple, linear model of the line. In simulations, the tracking controller is used to asymptotically stabilize a complex quasilinear third-order distributed parameter model of the pneumatic transmission line along a desired trajectory. This complex model has previously been shown to accurately reproduce the behavior of the pneumatic test bench.

Paper: **6074** **B2L-C**

Optimal Multivariable Flux Control of Heat Transfer in a Metal Bar

Georgy Kostin[1], **Andreas Rauh**[2], **Harald Aschemann**[3], **Vasily Saurin**[4]

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An optimal control problem for heat conduction in a metal bar heated and cooled by two Peltier elements attached to its bottom surface is investigated. The bar has the shape of an elongated cuboid, the vertical sides of which are insulated, whereas the heat exchange with the environment takes place on the upper surface. The problem is to find the time history of the elements' heating powers transferring the system from its initial thermal state to a stationary terminal state and simultaneously minimizing a quadratic cost function.

Paper: **6080** **B2L-C**

Boundary Control of Heat Transfer Processes in a Cylindrical Body

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

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The problem of boundary control for heat transfer processes in a cylindrical body under the minimum condition of a quadratic functional is considered. With the help of the Fourier method an optimal feedback control law for the lowest two modes is designed. The influence of the control on higher modes is analyzed.

Robotics II, B2L-D

Day: Tuesday, August 29, 2017
Time: 10:00 - 11:00
Room: Strauss
Chair: Navvab Kashiri

Paper: **6047** **B2L-D**

Object Identification by Tactile Sensors with Improved Sensor Resolution

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In the case that tactile sensor matrices are placed at the fingers of a robotic gripper, it is possible to identify objects during grasping. In this article we present an approach for object identification using tactile information. For verification a test scenario is developed where the robot should sort workpieces which are based on Lego bricks. In comparison to images of camera systems commonly used in robotics, the resolution of force images provided by tactile sensors is much lower. For that reason it may be in some case useful to increase the resolution of tactile measurement to perform some tasks of object identification successfully. This article additionally includes an algorithm to improve the resolution of tactile sensors.

Paper: **6049** **B2L-D**

Mobile Robot with Non-Slip Castor Wheel

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

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In this paper we address a problem of a non-slip castor wheel's impact on the control system of a tri-wheel mobile robot, which moves on a flat surface. We derive relations between the castor wheel's torsion angle and drive velocities and show results of controller's simulation, with and without the impact of the castor wheel

Paper: **6070** **B2L-D**

A Simulation Evaluation of gCBHD Formula for Driftless Nonholonomic Systems

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In this paper an accuracy of local motion planning based on the generalized Campbell-Baker-Hausdorff-Dynkin formula was evaluated for a few nonholonomic robotic systems. For a given set of controls, an exact trajectory is computable via an integration of equations of motion. This reference trajectory is compared with with a trajectory based on shrinked versions of the gCBHD formula. An impact of controls (linear time and amplitude scaling, their rotations) on the accuracy of reaching the final goal (important in motion planning) and retrieving a shape of the trajectory (important while avoiding obstacles) will be discussed and illustrated with simulations.

Poster Session II, B3P-E

Day: Tuesday, August 29, 2017
Time: 10:00 - 12:00
Room: Poster Area
Chair: Przemyslaw Mazurek

Paper: **6105** **B3P-E**

Criterions of ν-Similarity for the Two-Dimensional Birth-Death Processes

Marzena Filipowicz-Chomko[1], Ewa Girejko[2], Anna Poskrobko[3]

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We examine ν-similarity of birth-and-death processes in two-dimensional case that turn out to improve capacity planning of modern telecommunication systems. A necessary condition for two processes being similar by obtaining relations between their birth and death rates is derived. We analyze situation for ν-similar birth-death processes, what is a generalization of the previous results for similar birth-and-death processes. In our case birth and death rates of two ν-similar processes are state-dependent ones. Special case as possible genetic application is provided.

Paper: **6108** **B3P-E**

Research on Possibilities of Transporter Movement Using Brain-Computer Interface Based on Steady-State Visually Evoked Potential (SSVEP)

Arkadiusz Kubacki[1], Arkadiusz Jakubowski[2], Dominik Rybarczyk[3]

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This paper presents the research on the possibility of transporter movement with the use of SSVEP based on a brain-computer interface (BCI). In the first paragraph, the authors present general information about human-computer communication. The next chapter concerns theoretical background about BCI based on EEG. The authors present a method how to place electrodes during an EEG and a general classification of BCI. The current state of knowledge about SSVEP (Steady-State Visually Evoked Potential) is presented. In the next paragraph concerns used equipment and software, also a block diagram of the program and a description of the test stand. In the last part, the authors described the results of their research on the movement of the transporter in two directions using SSVEP.

Paper: **6113** **B3P-E**

Running Pace Estimation Using Complementary Filter Based Fusion of GPS and Pedometer Data

Krzysztof Skrzypczyk[1]

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This paper presents an application of a complementary filtration for estimating running pace using GPS and pedometer data. In the approach presented the two information sources are fused with dynamically adjusted importance factors. In the case of poor GPS signal the pedometer data are included in the filter with higher weight, and otherwise. The method proposed was verified using multiple simulations.

Paper: **6159** **B3P-E**

Adaptive Correction of the Quantisation Error in the Frequency-to-Code Converter

Piotr Warda[1]

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This paper presents a method of the adaptive correction of the quantisation error in the frequency-to-code converter (f/N). For the application of this method a f/N converter using a "on-the-fly" counter has been selected. The principle of the method is discussed. The results of the experiment verifying the operation of the method were presented.

Paper: **6161** **B3P-E**

Quaternion-Based Determination of 3D Objects Orientation

Witold Żorski[1]

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The problem of 3D objects orientation recognition in a three-dimensional image space is considered in this paper. The used method is a quaternion-based approach applied to images acquired by CT-like devices. The concept of orientation recognition comes from the well-known Ballard method of arbitrary shapes detection in two-dimensional images, now commonly known as the generalized Hough transform. Aside from quaternions, used as the main mathematical tool, the orientation recognition is based on determination of an accumulator array for Euler angles. Values in the accumulator are received using so called counting method, adopted here for voxels. Objects orientation is determined by coordinates of an element in the accumulator array with a maximum number of votes received. The elaborated method may be useful in the area of robotic surgery, especially in cases of penetrating injuries caused by foreign bodies.

Paper: **6175** **B3P-E**

Two Level Algorithm with Tabu Search Optimization for Task Scheduling Problem in Computing Cluster Environment

Wojciech Bożejko[1], Piotr Nadybski[2], Mieczysław Wodecki[3]

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This article presents a proposal of solution for the problem of optimal task allocation and scheduling for computing cluster with multiple nodes.

Paper: **6203** **B3P-E**

Experimental Results of Stable Time-Varying Multi-Notch Filter

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

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This paper presents experimental results of a stable time-varying IIR narrow multi-band-stop filter. The design and stability check procedures have been shown. The experimental hardware used to conduct the measurement of the ECG was presented. The concept of the time-varying coefficients was used in order to reduce the transient time of the filtering structure. The advantages of the proposed methodology were confirmed with three test cases focused on denoising the input signal.

Paper: **6208** **B3P-E**

Design of Stable LTV Multi-Notch IIR Filter with Lookup Tables

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The paper presents a concept of designing a stable time-varying IIR narrow multi-band-stop filter. The proposed structure is based on an all-pass prototype. The stability analysis of the time-varying design is presented. In order to reduce the transient time, the varying rejection bandwidth in time is introduced. The paper also presents the idea of the LUT's (Lookup Table) to control the memory usage of the time-varying filtering structure. The results of the methodology are presented and compared with the stationary counterpart. The proposed stable time-varying filtering structure is applied to the noised test signal in the simulation environment.

Paper: **6228** **B3P-E**

Bayesian Estimator of a Faulty State: Logarithmic Odds Approach

Piotr Bania[1], **Jerzy Baranowski**[2]

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Fault detection and isolation is crucial for efficient operation and safety of any industrial process. Methods from all the areas of data analysis are being used for this task including Bayesian reasoning and Kalman filtering. In this paper authors use the discrete Field Kalman Filter for detecting and recognising faulty conditions of the system. Proposed approach, devised for stochastic linear systems allows analysis of faults that can be expressed both as parameter and disturbance variations. It is formulated for the situations when the fault catalogue is known, but because of that very efficient algorithm can be obtained. For implementation logarithmic odds are considered to improve numerical properties. Its operation is illustrated with numerical examples and both its merits and limitations are critically discussed.

Paper: **6232** **B3P-E**

Particle Swarm Based Airfoil Optimization for sUAV's Operating in a Low Range of Reynold's Number

Tom Kusznir[1], **Jarosław Smoczek**[2]

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The paper focuses on Particle Swarm Optimizationof an airfoil model for small unmanned aerial vehicles operating in low Reynolds number. The objective function to be maximized is the lift-to-drag ratio subject to different penalty constraints. The airfoil parameterization is done using Class/Shape function Transformation. Blade Element Momentum Theory is used to develop an optimum hovering propeller with the optimized airfoil and the Clark Y airfoil. The results of the numerical simulation are discussed in the paper.

Paper: **6240** **B3P-E**

Application of System on Chip (SoC) Devices for the Design of a Smoke Detector Working with Megapixel Image Streams

Wiesław Pamuła[1], Maciej Sajkowski[2], Tomasz Stenzel[3], Jarosław Michalak[4], Grzegorz Baron[5], Bartłomiej Szady[6]

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The paper discusses the application of System on Chip devices for processing Megapixel video streams. The domain of image processing using high resolution images is very demanding in the scope of calculating power and frequently exploits special processing hardware. The design of a smoke detection system is used for evaluating the advantages and drawbacks of using such SoC solutions. Identical image processing algorithms are implemented in the case of FPGA and DSP. Both solutions meet the real time image processing requirements. FPGA based solution is faster as it uses pipelining for improving the utilisation of memory resources.

Paper: **6251** **B3P-E**

Learning Process for Nonstationary Filtering Network Using Genetic Algorithms

Adrian Sztandera[1], Katarzyna Wiechetek[2]

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In the paper a concept of nonstationary network consisted of 1st order elements is presented. Research in order to approximate the assumed frequency response using the filtering network were conducted. Learning the network was achieved by minimizing the assumed error function using genetic algorithms. Introducing time function in place of time constant reduced the duration of the transition processes.

Control and Systems Theory II, B4L-A

Day: Tuesday, August 29, 2017
Time: 11:20 - 13:00
Room: Casino
Chair: Andrzej Bartoszewicz

Paper: **6212** **B4L-A**

New Interesting Facts About Minimum-Energy Perfect Control for LTI Nonsquare State-Space Systems

Wojciech Hunek[1]

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In this paper a breakthrough in the area of the minimum-energy perfect control for discrete-time state-space systems with different number of input and output variables is presented. Following the recently performed heuristic simulation studies corresponding to mentioned control strategy, the analytical confirmation is presented through this paper. Up to now, the statement that the so-called right (sigma)-inverse clearly outperforms the minimum-norm (T-)inverse in terms of minimum-energy of the MV/perfect control inputs design has been based on optimization tasks only. Therefore, the heuristic studies made in Matlab environment could not be treated as the representative ones in some sense, so far. Simple analytical illustrative example shows the big minimum-energy applicability of (sigma)-inverse over usage of classical minimum-norm one. Note that full proof is not given yet and still waiting for deep exploration.

Paper: **6002** **B4L-A**

A Method for the Order Reduction of Linear Switching Systems

Franco Blanchini[1], **Daniele Casagrande**[2], **Wieslaw Krajewski**[3], **Umberto Viaro**[4]

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The paper deals with the problem of reducing the order of an original high–order asymptotically stable linear switching system by independently approximating the (stable) LTI systems corresponding to every fixed value of the switching signal. Precisely, each reduced–order model is obtained by minimising the L_2 norm of a weighted equation error by means of an efficient algorithm that ensures model stability as well as the retention of a number of first– and second–order information indices, such as the Markov parameters and the impulse–response energies. Then, the stability of the switching system is

guaranteed, irrespective of the switching law, by realising the aforementioned reduced models in such a way that they share a common Lyapunov function. To this purpose, a simple state–coordinate transformation amenable to online implementation is applied to the state models initially derived. To improve the approximation, the state after every switching is reset, with due care for stability, according to a fast inclusion–projection procedure. Two examples taken from the literature show that the suggested reduction technique compares favourably with existing techniques.

Paper: **6009** **B4L-A**

Controllability of Delayed Systems

Jerzy Klamka[1]

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The main purpose of this paper is to study the relative controllability of linear infinite delay dynamical systems containing both multiple lumped time varying delays and distributed delays in the state variables and multiple lumped time varying delays in the in admissible controls.

Paper: **6022** **B4L-A**

String Stability of a Leader Following Formation Control with Dynamic Weights

Andrés Peters[1]

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In this work, we study the string stability properties of a leader following formation control architecture that uses non homogeneous weights for the leader and predecessor vehicle states. The architecture was presented recently and it was shown to achieve constant inter-vehicle spacings (with no transient) for almost every vehicle pair when there are no disturbances at the followers. We expand the analysis of this interconnection by obtaining a condition on the design parameters that ensures the string stability of the interconnection to disturbances at any follower. Numerical simulations illustrate our results.

Paper: **6140** **B4L-A**

Decentralized Fixed Mode Radius of LTI System with Multiple Input and Output Delays

Pradosh Ranjan Sahoo[1], **Sandip Ghosh**[2], **Pawel Dworak**[3]

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Decentralized Fixed Mode (DFM) radius is a robustness measure of decentralized control

system reflecting how far a system is from having DFM. In this paper, real DFM radius is defined for decentralized control systems with input and output delays, and a computing formula is derived for the same using restricted real perturbation measures. Results of this paper for computing DFM radius of time-delay system are studied with the help of numerical

Control Applications II, B4L-B

Day: Tuesday, August 29, 2017
Time: 11:20 - 13:00
Room: Kalman
Chair: Jacek Kabzinski

Paper: **6115** **B4L-B**

Dynamical Aspects of Multi-Input Single-Output Control for Heat Distribution Processes: Case Study

Michal Fratczak[1], Pawel Nowak[2], Piotr Laszczyk[3]

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In this paper, the possibility of Multi-Input Single-Output control of the heat distribution processes is investigated. Based on the validated model of the example experimental setup, the static and dynamical properties of the process are investigated and discussed in terms of control performance and efficiency. Two potential manipulating variables are considered and different control strategies are discussed, including control by only single manipulating variable and by the proper and simultaneous adjustment of both of them. The energy efficiency is also considered.

Paper: **6077** **B4L-B**

Oscillation Attenuation for Crane Payloads by Controlling the Rope Length Using Extended Linearization Techniques

Andreas Rauh[1], Robert Prabel[2], Harald Aschemann[3]

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Oscillation attenuation is an essential task for practically any crane application. Classically, such control strategies make use of the actuation of a crane trolley to counteract the motion of a swinging payload. As an alternative to controlling trolley motions, variations of the rope length can be considered. In contrast to scenarios where trolley motions are used to attenuate oscillations, the control of the rope length is a more challenging task due to non-negligible nonlinearities and due to the presence of points in the state-space

for which controllability is not guaranteed. In this paper, a novel extended linearization approach is presented for the oscillation attenuation in crane systems, where the feedback gains are determined by using a robust optimization procedure which employs a formulation of the control task in terms of linear matrix inequalities. Simulation results and an experimental validation highlight the practical applicability of the proposed control procedure.

Paper: **6132** **B4L-B**

Experimental Validation of a Sensitivity-Based Learning-Type Controller for a Linear Time-Varying Model of a Flexible High-Speed Rack Feeder

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In many control applications, it is desired to repeat the same control task numerous times with identical reference trajectories. As long as only model inaccuracies and disturbances, which are practically identical for each new execution, appear as external uncertainty, such tasks are well suited for the implementation of learning-type strategies. The fundamental idea of such controllers is not only to stabilize the dynamics during a single execution of the control task but also to improve the tracking behavior successively from execution to execution. This can be achieved by an adaptation of the control signal on the basis of the time history of the tracking error from a previous execution. Well-known learning-type approaches, summarized as ILC techniques (iterative learning control), make use of linear dynamic system models which are assumed to be time-invariant in many cases. If techniques for differential sensitivity analysis are employed for the purpose of control design, also nonlinear and time-varying system models can easily be handled in the frame of a learning-type control design.

Paper: **6136** **B4L-B**

A Discrete-Time Norm-Optimal Approach to Iterative Learning Control of a Bridge Crane

Harald Aschemann[1], Alexander Wache[2], Ole Kraegenbring[3]

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In this contribution, a norm-optimal iterative learning control (NOILC) for the two main axes of a bridge crane is presented. For each axis, the NOILC operates in parallel to a linear-quadratic (LQ) state feedback of the tracking error. Regarding the tracking of repetitive trajectories, the ILC-part contributes to a significant reduction of the tracking

error from iteration to iteration, up to an accuracy that is determined by the quality of the measurement signals. In this paper, the ILC law is based on the minimization of a cost functional and involves both feedforward and feedback control actions. The control structure has been implemented at a bridge crane test rig with three axes, where the lateral rope deflections are determined by means of a CMOS camera. Experimental results show that a fast error convergence and a small remaining tracking error can be achieved with the proposed control structure.

Paper: **6156** **B4L-B**

Friction Hysteresis Compensation Using Phase Correction of Periodic Trajectories

Benedikt Haus[1], **Paolo Mercorelli**[2], **Nils Werner**[3]

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This paper presents a heuristic, signal-based approach to compensate time delay-like effects caused by friction hysteresis in a novel kind of valve actuator. It works by exploiting a-priori knowledge about (and the periodicity of) the desired trajectory, under the premise that an existing feedforward control already tracks the desired trajectory, apart from the mentioned time delay effect. However, the emphasis of this contribution is put on experimental results obtained with a test stand in order to substantiate the effectiveness of the simplistic compensating technique that was already described in earlier works. The hysteresis loop is modelled and simulated to match the measurements, though no model is needed by the compensation algorithm.

Identification, B4L-C

Day: Tuesday, August 29, 2017
Time: 11:20 - 13:00
Room: Lehar
Chair: Zygmunt Hasiewicz

Paper: **6010** **B4L-C**

An Addendum to Continuous-Time Dynamic System Identification with Multisine Random Excitations - from Frequency Response to Transfer Function

Jarosław Figwer[1]

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In this paper an approximation algorithm allowing to calculate parameters of rational and fractional continuous-time transfer functions as well as transfer functions being their

connections with delay from the identified frequency response is proposed. Parameters of the mentioned transfer functions are obtained by an optimisation algorithm utilizing ideas of randomized search. The presented discussion is illustrated by simulation experiments devoted to calculating parameters of rational, rational with delay and fractional with delay transfer function approximations. The corresponding frequency responses are identified using an approach in which as an excitation realisations of continuous-time multisine random processes are used.

Paper: **6076** **B4L-C**

Robust Identification of Quadrocopter Model for Control Purposes

Krzysztof Arminski[1], Tomasz Zubowicz[2]

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The paper addresses a problem of quadrotor unmanned aerial vehicle (so-called X4-flyer or quadrocopter) utility model identification for control design purposes. To that goal the quadrotor model is assumed to be composed of two abstracted subsystems, namely a rigid body (plant) and four motors equipped with blades (actuators). The model of the former is acquired based on a well-established dynamic equations of motion while the latter is to be identified as a static relationship from laboratory experiments data. Moreover, the actuator model is to account for the on-flight battery power source voltage drop effects. The actuator parameter identification algorithm is kept in a set-membership framework. In addition a mechanism to reduce the conservativeness of the solution is proposed and applied. Numerical illustration of the results is provided.

Paper: **6082** **B4L-C**

Multistage Identification of an N-L-N Hammerstein-Wiener System

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In the paper we consider a problem of Hammerstein-Wiener (N-L-N) system identification in the presence of random input and random noise. The proposed strategy combines both parametric (e.g. least squares) and nonparametric (kernel) estimates. First, the impulse response of the linear block, and the composition of two nonlinear characteristics are identified independently. Next, the nonlinear function composition is splited into two parts to obtain the models of all individual blocks of the system. The consistency of the proposed estimates is analyzed and simple simulation example is presented.

Paper: **6075** **B4L-C**

Accelerating the Rate of Convergence for LMS-Like on-Line Identification and Adaptation Algorithms. Part 1: Basic Ideas

Jarosław Figwer[1], **Małgorzata Michalczyk**[2], **Teresa Główka**[3]

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In the paper a modification enabling acceleration of the rate of convergence for LMS-like on-line identification and adaptation algorithms is proposed. This is based on the artificial decaying of initial conditions in recursive identification as well as adaptation algorithms. The decaying is done using a set of the most recent measurements. Properties of the proposed modification are illustrated by simulation examples, in which accelerated and non-accelerated identification and adaptation algorithms are compared.

Paper: **6205** **B4L-C**

Smart Beam System: Identification and Minimal Realization Using Digraphs Theory

Konrad Markowski[1], **Cristina Muresan**[2]

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For modelling the dynamics and study of the active vibration suppression possibilities in aircraft wings, the smart beam is widely used. The advantages obtained through this approach are numerous. One of them are: aircraft stability and manoeuvrability, turbulence immunity, passenger safety and reduced fatigue damage. In this paper, the identification process has been presented, in the first step. As a result the transfer function of the continuous-time linear system was given. Then, for the obtained function the forms of minimal realisations were determined. The realisation was obtained using the method based on one-dimensional digraph theory.

Modelling and Simulation I, B4L-D

Day: Tuesday, August 29, 2017
Time: 11:20 - 13:00
Room: Strauss
Chair: Bill Goodwine

Paper: **6062** **B4L-D**

An Approach to Automated Tacit-Knowledge Acquisition and Transformation in Manufacturing Companies

Justyna Patalas-Maliszewska[1], Irene Krebs[2], Adam Dudek[3]

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This paper presents an approach to the real-time acquiring of tacit knowledge from employees, and to transform this knowledge using the example of service departments in manufacturing companies, based on the results of research at German and Polish Manufacturing Enterprises. The discussed approach was prepared using the speech-recognition method, Web Ontology Language, and also the Euclidean-distance method, in order to validate the following of standard procedures in service departments in a manufacturing company. The prepared system is believed to be very useful for the companies.

Paper: **6078** **B4L-D**

Position Estimation at Zero Speed for PMSM Using the Principal Component Analysis

Konrad Urbanski[1], Krzysztof Nowopolski[2]

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The article proposes a method for estimating the shaft position of a synchronous motor with permanent magnets for the zero and very low speed range. Presented method involves a comparison of obtained shape of current hodograph to the reference pattern using the principal component analysis. Although this method imply the recognition of a currents hodograph, in a case of using this method, it is no necessity to calculating the ellipse position. The method can achieve satisfactory accuracy in the case of small values of the inductance asymmetry ratio, also in the case of a presence of a measurement noise.

Paper: **6096** **B4L-D**

Dynamical Behavior of the Hybrid Exothermic Chemical Reactor with Imperfect Mixing

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The main goal is to design a hybrid exothermic chemical reactor that exhibits hysteresis or oscillatory behavior. Then, the hybrid system can be used as a benchmark plant for testing new control algorithms. In the hybrid reactor, the reactor vessel and jacket are real, but the reaction heat is simulated by means of the electric heater and a mathematical model of the process. Because in the real hybrid reactor the heating power is limited by its maximum value and the reactor content is not well-mixed, the paper discusses the influence of these factors on the dynamical behavior of the hybrid system. It is shown that the hysteresis or oscillatory behavior can be intensified, when the reactor content is poorly mixed. Furthermore, modification of the reaction parameters may also intensify the hysteresis behavior in the presence of heating power saturation.

Paper: **6101** **B4L-D**

Parametrization of Robotic Deburring Process with Motor Skills from Motion Primitives of Human Skill Model

Payam Parvizi[1], Musab Cagri Ugurlu[2], Kemal Acikgoz[3], Erhan Ilhan Konukseven[4]

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In this work, a new method to extract human skills from a model and use them for robot learning in a deburring process is presented. To accomplish this goal, a modified version of the classic Dynamic Movement Primitives (DMP) methodology is proposed, resulting in an specific DMP (sDMP). Particle Swarm Optimization is used to determine the parameters of the aDMP model.

Paper: **6137** **B4L-D**

Model of ADRC Speed Control System for Complex Mechanical Object with Backlash

Bartlomiej Wicher[1], **Krzysztof Nowopolski**[2]

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The article presents simulation research concerning speed control of two mass system with elastic joint and backlash utilizing the ADRC method. The model of the plant and the structure of the ADRC speed controller is presented. Finally the simulation results with comparison to 2DOF – PID speed controller, which acts as a reference, are carried out. Conclusions and future plans are stated.

Robotic Manipulators, B5L-A

Day: Tuesday, August 29, 2017
Time: 15:00 - 16:20
Room: Casino
Chair: Erhan Ilhan Konukseven

Paper: **6094** **B5L-A**

Emergency Control of a Space 3R Manipulator in Case of One Joint Failure

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The paper presents a concept of factitious force method used for controlling a 3R space manipulator. It was shown that the method works for a rigid manipulator where one of the joints is damaged and can not be controlled. It is important for space applications to have some means of control while the system is compromised. Three scenarios, for each joint, were presented. Each scenario compares error outputs when proposed controller has no information that the joint is broken and while this piece of information is incorporated into control algorithm in form of factitious force.

Paper: **6021** **B5L-A**

Application of Hamiltonian Mechanics to Control Design for Industrial Robotic Manipulators

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The paper deals with a tracking control for robotic manipulators, where the robot dynamics is described by means of Hamiltonian mechanics. This way leads to different physical descriptive quantities used in control design. In the paper, the model-oriented Lyapunov-based control is considered. It is introduced in the novel formulation using Hamiltonian mechanics and compared with the conventional formulation based on Lagrangian mechanics. The theoretical results, generally applicable to usual articulated industrial robotic manipulators, are demonstrated on one specific robot arm with three degrees of freedom.

Paper: **6055** **B5L-A**

Granular Jamming Manipulator Filled with New Organic Materials

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Variations of both strength and stiffness, lightweight, and high energy efficiency are the main considerable factors of Granular Jamming Flexible Manipulators (GJFM)s. These properties have distinguished the GJFMs from traditional manipulators. These factors can be provided by the most important element of their bulk which is granular media as filler. Hence, granular materials should have lightweight, and provide efficient strength and stiffness in each unique vacuum pressure. Moreover, the necessity of applying Organic Granular Materials (OGM)s was felt owing to their main properties including biodegradable ability, low cost, and availability. Therefore, in this research was striven to find a new filler which was a mix of black Pepper and Datura seeds by performing an experimental test. It was applied in a GJFM as filler, then the robot's performance was investigated experimentally as the reported results in this paper.

Paper: **6024** **B5L-A**

Regularization of the Differential Inverse Orientation Problem of Generic Serial Revolute Joint Manipulators

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Orienting manipulators in robotics are used to achieve the desired orientation of the end effector of the manipulator. These manipulators are composed of rotational joints, and thus inherently burdened with singularities. In singular configurations, the differential inverse orientation problem can not be applied since the Jacobian becomes singular. A regularization method is discussed that regularizes the Jacobian in singular configurations, by first transforming the angle-axis representation of angular velocities to infinitezimal rotation about an axis and infinitezimal translation perpendicular to that axis, then regularizing the infinitezimal translational motion in the new representation. It is shown that the Jacobian of generic manipulators composed of three rotational joints is always regularizable, so methods based on the Jacobian can be applied even in singular configurations. The method is generalized to redundant orienting manipulators as well, and its application is demonstrated on two examples: a 3R Euler wrist and a 4R Hamilton wrist.

Sliding Mode Control, B5L-B

Day: Tuesday, August 29, 2017
Time: 15:00 - 16:20
Room: Kalman
Chair: Andreas Rauh

Paper: **6129** **B5L-B**

Backstepping-Based Sliding Mode Control of an Electro-Pneumatic Clutch Actuator

Robert Prabel[1], **Harald Aschemann**[2]

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In this paper, a nonlinear control approach is presented for an electro-pneumatic clutch actuator for heavy trucks. A clutch is required at start-up or during gear shifts to disconnect the combustion engine from the gear box. This automated actuator provides the necessary actuation force according to the large torque transmitted through the power train. Based on a control-oriented system representation, a cascaded control structure is designed. The outer loop is related to the mechanical subsystem and guarantees an accurate tracking of desired trajectories for the clutch position using a backsteppingbased sliding mode control. Furthermore, hysteresis effects of the nonlinear clutch force are addressed properly by a Bouc-Wen hysteresis model. The inner loop controls the internal

pressure of the clutch actuator. A new nonlinear reduced-order observer is designed that estimates both the effective internal pressure and a mass flow offset. The benefits of the proposed control structure are demonstrated by experimental results from a dedicated test rig.

Paper: **6153** **B5L-B**

Reaching Law Based Discrete Time Switching Quasi-Sliding Mode Controller

Paweł Latosiński[1]

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In this paper, a new reaching law for discrete time systems is proposed and applied to obtain a sliding mode control strategy. The new strategy ensures a finite time convergence of the system representative point to the sliding surface and confines the state to a vicinity of this surface. The proposed strategy ensures switching in each time instant in the sliding phase, which means it is in line with the classic switching type definition of discrete time sliding motion. Simulations comparing the new result to a previously known strategy have been conducted and advantages of the new approach have been demonstrated.

Paper: **6147** **B5L-B**

Simulation of Hybrid Systems with Sliding Modes

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The paper concerns the problem of the numerical simulation of hybrid systems with sliding modes. We give an overview of the numerical simulation procedures which have been described in the literature and next we present our proposition of the simulation code. What differs our solution from others is the utilization of differential-algebraic equations (DAEs) during the simulation of a sliding motion phase. We discuss our solution in detail and present the numerical results for simulation of the exemplary nonlinear system.

Paper: **6154** **B5L-B**

Inventory Management Strategies with Higher Relative Degree Sliding Variables

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

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In this paper, sliding mode control of inventory management systems is considered. A new method of sliding hyperplane selection for these systems is proposed. The method utilizes

the state matrix in the so called Frobenius form in order to simplify the selection process of the sliding variable. In contrast to most conventional approaches, the sliding variables considered in this work can have any relative degree. It is demonstrated that the proposed method ensures the desirable properties of the considered inventory management system. Furthermore, the new method is shown to guarantee a finite time response of the system even though it does not require explicit eigenvalue placement.

Optimization, B5L-C

Day: Tuesday, August 29, 2017
Time: 15:00 - 16:20
Room: Lehar
Chair: Krzysztof Galkowski

Paper: **6059** **B5L-C**

Accelerating PSO Based Feedrate Optimization for NURBS Toolpaths Using Parallel Computation with OpenMP

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Over the last few years generation of a time-optimal feedrate profile for CNC machines has recieved significant attention. This is a difficult optimization problem usually requiring long computation time. In the proposed solution, optimization is performed by parallel Particle Swarm Optimization with Augmented Lagrangian constraint handling technique. In order to decrease computation time the authors previously developed algorithm was reimplemented using Open Multi-processing. OpenMP utilizes the ability of modern CPUS to run multiple threads and reduce the algorithm's runtime by using parallel processing. The performance gain (speed-up) of the algorithm parallelized on a multi-core system has been tested. The experimental results of a time-optimal feedrate profile generated using an example toolpath are presented to illustrate the capabilities of parallel computation to improve the algorithm's performance.

Paper: **6061** **B5L-C**

A Nonparametric Estimation Method for Stochastic Differential Equation with Sub-Fractional Brownian Motion

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A parametric identification problem for stochastic differential equation (SDE) with sub-fractional Brownian motion (sfBm) is considered in this paper. The task of parametric

estimation is formulated as the constrained optimization problem, which is solved by means of random search algorithm. This mathematical technique, used for the non-convex, non-differentiable, and possibly discontinuous objective function on continuous, discrete or mixed search domain, allows to estimate both drift and diffusion parameters of SDE with sfBm involved in the model multiplicatively or additively. Simulations confirm the effectiveness of developed methodology.

Paper: **6193** **B5L-C**

Concept of Iterative Optimization of Minimally Invasive Surgery

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The interconnection of therapy devices and the associated intelligent usage of available information is a key element for future improvements of medical therapies. The basic idea can be summarized by an increased usage of available data during an intervention. These information can be used to build an assistance system for the clinical staff, which supports with automatic device configuration, reference value settings, monitoring and safety features. A second innovation of the concept results from a postoperative correlation analysis between the course of the intervention and the clinical result. Knowledge can be derived from this statistical data and improve following interventions.

Paper: **6134** **B5L-C**

Extremal Problems for Distributed Parabolic Systems with Boundary Conditions Involving Time-Varying Lags

Adam Kowalewski[1]

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Extremal problems for parabolic systems with time-varying lags are presented. An optimal boundary control problem for distributed parabolic systems with boundary conditions involving time-varying lags 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.

Scheduling, B5L-D

Day: Tuesday, August 29, 2017
Time: 15:00 - 16:20
Room: Strauss
Chair: Jozef Korbicz

Paper: **6231** **B5L-D**

Energy-Aware Scheduling of Jobs Performed Sequentially

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We consider a problem of energy allocation to computational jobs performed on one machine, where jobs may be performed with different speeds. An energy amount is related to a particular speed of a job, and this relation is nonlinear. The objective is to find a minimum energy allocation which guarantees that the last job in the sequence is finished before a deadline. A model of job processing, a general approach, and a heuristic algorithm are proposed in the paper.

Paper: **6254** **B5L-D**

Big Valley in Scheduling Problems Landscape – Metaheuristics with Reduced Searching Area

Wojciech Bożejko[1], Czesław Smutnicki[2], Mariusz Uchroński[3], Mieczysław Wodecki[4]

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Created in the 1990s of the past century methods of constructing algorithms (metaheuristics), inspired by the no free lunch theorem, using specific properties of problems, do not meet present expectations of practitioners. Commonly used artificial intelligence algorithms in recent years have also proved to be ineffective in solving a large group of extremely difficult instances of various problems. In the work we present some empirical methods of exploration of solution space in optimization problems whose solutions are represented by permutations. While sampling the set of permissible solutions we designate the histogram of the frequency of occurrence of local minima and on this basis we verify the statistical hypothesis concerning the (normal) distribution of occurrence of these minima. Due to this process we can flexibly change the "radius" of the searched area. Computational experiments performed on examples of the job shop problem are promising and inspire to conduct further research in this direction.

Paper: **6255** **B5L-D**

Minimizing Cycle Time in Manufacturing Systems with Additional Technological Constraints

Czesław Smutnicki[1]

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This paper reports successive results of the research dealing with so called cyclic production system, which provides constantly on the output a fixed mixture of various goods produced in a short series. Starting from our previous results developed already for classical systems occurring in OR field, as well as formulated for basic manufacturing systems with cycle time criterion, we extend the approach on cases with some constraints generated by practice, namely: set-ups, changeover times, no-wait, limited waiting time, buffering, no store, transport, pallets, etc. Analyses are carried out for quite general structure of manufacturing system, namely the job-shop scheduling problem. We focus chiefly on the modelling aspect by using combinatorial representation of a solution with the support of unique class of graphs. We propose the method of finding the minimal cycle time for fixed (given) job processing order in each considered case on the base of graph and other special features of the problem.

Paper: **6120** **B5L-D**

Metaheuristics for Some Discrete-Continuous Project Scheduling Problems to Maximize the Net Present Value

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A discrete-continuous project scheduling problem with discounted cash flows is considered. Each activity of the project requires for its processing discrete resources and an amount of a continuous, renewable resource. Processing rate of an activity is an increasing function of the amount of the continuous resource allotted to this activity at a time. A positive cash flow is associated with the completion of each activity. The objective is the maximization of the net present value. A heuristic procedure for allocating the continuous resource is presented. Three local search metaheuristics: simulated annealing, tabu search, and genetic algorithm are proposed for the defined problem, and compared a basis of a computational experiment.

Poster Session III, B6P-E

Day: Tuesday, August 29, 2017
Time: 15:00 - 17:00
Room: Poster Area
Chair: Rafal Stanislawski

Paper: **6006** **B6P-E**

The Cauchy Problem for Linear Nonstationary Fractional Systems

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The paper is concerned with the existence and uniqueness of a solution to time variant linear fractional systems. We present representation of the solution in the form of series fractional integrals of the coefficients of the system. We prove uniform converges of this series. The considerations are illustrated by example.

Paper: **6017** **B6P-E**

Decentralized Stabilization of Descriptor Fractional Positive Continuous-Time Linear Systems with Delays

Łukasz Sajewski[1]

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Decentralized state-feedback method for stabilization of descriptor fractional positive continuous-time linear systems with delays in state-space vector is proposed. Necessary and sufficient conditions for the decentralized stabilization of the descriptor fractional positive continuous-time linear systems with delays in state-space vector are established. Method is based on decomposition of the descriptor system to standard and algebraic subsystems. Numerical example is given.

Paper: **6040** **B6P-E**

Multiple Model Adaptive Control Applied to Fractional Order Systems

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A new structure to design an adaptive controller for a fractional order system is presented in this paper. The system has two layers, in which the first one consists of multiple models, while the second one interconnects them to provide weighted state estimates. The key challenge is to analyze the stability of multilayer fractional order adaptive processes. The primary objective is to determine the feedback for the computation of the second layer

weights. The multiple models from the first layer are used to define the adaptive law. The proposed multilayer structure significantly improves the transient characteristics of the fractional order adaptation process, which results in a more effective control system.

Paper: **6050** **B6P-E**

Modelling of a Batch-Fired Straw Boiler for Control of the Combustion Chamber Temperature

Wojciech Kreft[1]

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The paper proposes a batch-fired straw boiler model, which is used to control the temperature of the combustion chamber. Based on the presented model, one proposed a closed-loop system to control the temperature of the combustion chamber. The closed-loop system consists of the classical PID controller and some linear part of the boiler model. For the rest (nonlinear) of the boiler model, there is calculated an inverse transfer function. In this way, there is calculated a control variable, which results a reference value of the combustion chamber temperature. The paper presents results of simulation of this closed-loop system in MATLAB/Simulink.

Paper: **6083** **B6P-E**

On the Application of Laplace Transform to Fractional Differential-Algebraic Systems with Delays

Zbigniew Zaczkiewicz[1]

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The paper present new results of application the Laplace transform to fractional differential-algebraic systems with delays (DAD). Exponential evaluation of solutions to DAD systems with one delay is shown.

Paper: **6090** **B6P-E**

Optimal Stopping Areas for Discrete Time Linear Quadratic Control Problem

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The problem of determining of optimal stopping areas for discrete time linear stochastic controlled system is investigated in this paper. Sometimes we have no information how long the system will be controlled. In this case we have a complex problem: the system should be controlled and stopped at the appropriate moment. To solve this problem the dynamic programming and optimal stopping rules for stochastic processes was employed. The paper presents the method of determining the optimal stopping areas - sets of states where the system should be stopped.

Paper: **6110** **B6P-E**

Decomposition and Application of Jordan Form to Controllability Test of Positive Fractional Discrete-Time Systems with Delay in State Vector

Rafał Kociszewski[1]

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In the paper the linear discrete-time fractional systems with one delay in state vector is considered. For this class of systems the problems of decomposition of uncontrollable system into controllable subsystem and controllability test using Jordan form are presented and discussed. The considerations are illustrated by numerical examples.

Paper: **6118** **B6P-E**

Exponential Stability of Systems Under Periodic Sampling of the Second Order

Justyna Janczak[1], **Ewa Pawluszewicz**[2]

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The problem of exponential stability of linear time-invariant systems under periodic sampling of the second order is considerate. The sufficient conditions basing on eigenvalues of the state matrix of the considered system are given. Obtained results are illustrated on the example.

Paper: **6155** **B6P-E**

Sliding Mode Control Based on the Reaching Law Approach - a Brief Survey

Paweł Latosiński[1]

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This paper presents a concise survey on reaching law based sliding mode control. The goal is to highlight the most important developments related to reaching laws for both continuous time systems and discrete time ones. First, origins of reaching law methodology for continuous time systems are brought up and essential properties of these control methods are discussed. Advances in continuous time reaching laws are subsequently surveyed and several examples of such strategies are given. Then, discrete time reaching laws are reviewed. Furthermore, the division between switching type and non-switching type discrete reaching laws is elaborated upon and examples from both categories are provided.

Paper: **6183** **B6P-E**

Comparison of FOC and DTC Methods for a Matrix Converter-Fed Permanent Magnet Synchronous Motor

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This paper presents a comparison between Field Oriented Control and Direct Torque Control methods of a Matrix Converter-fed (MC) Permanent Magnet Synchronous Motor (PMSM). MC is becoming widely used because of the unity power factor and the lack of energy storage element. FOC method calculates the duty of MC states with use of geometric relations between voltage and current vectors. DTC method, on the other hand, is based on controlling the length and angle of a stator flux linkage vector with MC states chosen from a Switching Table. Simulation research of control algorithms was performed in MATLAB/Simulink 2013b. Authors compared the quality of moment regulation in both methods, including the electromagnetic torque rise time and torque variance. Moreover, influence of a control algorithm on the power grid current was researched in frequency domain by FFT and THD. DTC method for MC proved to be faster in torque control. FOC method, however, has visibly lower torque ripples and lower THD. Both methods performed well in a torque regulation of a MC fed motor.

Paper: **6204** **B6P-E**

Application of Higher Relative Degree Sliding Variables for Congestion Control in Communication Networks

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In this paper we introduce a new design method of the sliding mode controller for connection oriented communication networks. To determine the controller we transform the state matrix describing the network dynamics into the Frobenius form and select the sliding variable with relative degree less than or equal to the order of the system. Data losses and transmission delays are taken into consideration. The design method proposed in this paper results in finite time queue length convergence to its demand value. This desirable property is obtained without the need of explicit selection of the closed-loop system state matrix eigenvalues. Then, a time-varying sliding hyperplane is introduced in order to constrain the data flow rate at the beginning of the control process.

Paper: **6214** **B6P-E**

Model Matching Level Control for a Coupled Tanks System Using Time-Scale Separation Technique

Valery Yurkevich[1], **Marian Blachuta**[2], **Rafal Grygiel**[3], **Robert Bieda**[4]

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The problem of a level control system design for a specific connection of two tanks is discussed. We compare two algorithms for the first tank: a nonlinear feedback linearization algorthm and one based on a time-scale separation. The second technique leads to a PI controller for the level control in the first tank and either a single loop PID or a cascade of P/PI controllers for the level control in the second tank. A design methodology based on the time-scale separation technique is proposed in which controller parameters are selected such that fast and slow modes are induced in the closed-loop system. Hence, the singular perturbations method is used to analyze the closed-loop system properties. A particular feature of the considered two tanks connection is that its high frequency gain tends to infinity when the system attains equilibrium. Therefore, the fast-motion transients are analyzed based on Popov absolute stability criterion in presence of a sector-like condition in control. Numerical simulations confirm robustness with regard to plant parameters and external disturbances.

Paper: **6237** **B6P-E**

Robust Stability Conditions of Fractional Order Discrete-Time Linear Systems

Andrzej Ruszewski[1]

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The paper considers the robust stability problem of uncertain discrete-time fractional order linear state-space systems. The state matrix is the interval matrix whose entries are convex combinations of the entries of two known constant matrices. The necessary and sufficient condition for robust stability is proposed. This condition is stated with respect to eigenvalue-loci placement in the complex plane. The sufficient condition for robust stability based on matrix measures is also given. In this case the rectangle covering all the eigenvalues of the interval state matrix is determined.

Paper: **6207** **B6P-E**

Relating Phase-Field and Perimeter Based Structural Optimization of Variational Inequalities

Andrzej Myśliński[1], **Konrad Koniarski**[2]

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The paper is concerned with the analytical aspects of structural optimization problems for bodies in unilateral contact governed by variational inequalities. The original optimization problem is regularized in terms of material density function as well as of phase field model rather than domain perimeter functional. As the interface width parameter tends to zero the convergence of the first order necessary optimality conditions for the phase field regularized optimization problem to the first order optimality conditions for the perimeter regularized optimization problem obtained in the framework of shape calculus is shown.

Control and Systems Theory III, B7L-A

Day: Tuesday, August 29, 2017
Time: 16:40 - 18:00
Room: Casino
Chair: Wieslaw Krajewski

Paper: **6184** **B7L-A**

Inverse-Based Methods to Minimum-Energy MV Control for Nonsquare State-Space Systems

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The paper presents an approach to the synthesis of MV control systems with respect to minimum-energy of the control inputs. Due to the reason, a recently introduced polynomial matrix sigma-inverse is applied to LTI nonsquare systems described by discrete-time state-space framework. It is shown that classical minimum-norm right inverse is not sufficient to obtain the minimum-energy of control runs. Thus, the sigma-inverse with parameter/polynomial, so-called degrees of freedom, gives better results than typical Moore-Penrose inverse in terms of said lower energy. The effectiveness of the presented method is confirmed by simulation examples in Matlab environment.

Paper: **6211** **B7L-A**

Extended LMI Characterization of Some Control Problems for Linear Repetitive Processes

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In this paper the projection lemma is used as a basis to develop extended linear matrix inequality characterizations of the stability and control problems for both differential and discrete linear repetitive processes. The new results cover the existing results but also provide novel conditions for output feedback control. The new approach enables differential and discrete to be analysed in unified manner. A numerical example is given to illustrate the new results.

Paper: **6043** **B7L-A**

Stability of Positive Nonlinear Systems

Tadeusz Kaczorek[1], **Kamil Borawski**[2]

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The stability of time-invariant positive nonlinear systems is addressed. Necessary conditions for the stability of positive time-invariant continuous-time and discrete-time nonlinear systems are established. It is shown that the positive nonlinear systems are asymptotically stable only if the corresponding positive linear systems are asymptotically stable. Considerations are illustrated by numerical examples and simulations are performed in Matlab-Simulink environment.

AI Methods I, B7L-B

Day: Tuesday, August 29, 2017
Time: 16:40 - 18:00
Room: Kalman
Chair: Marcin Witczak

Paper: **6256** **B7L-B**

Theoretical and Experimental Background for Artificial Neural Network Modeling of Alpha Type Stirling Engine

Adrian Chmielewski[1], Jakub Możaryn[2], Maciej Krzemiński[3]

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This article presents a theoretical background for an artificial neural network (ANN) model of the alpha type Stirling engine where thermodynamic dependencies, connected with equations of motion for the piston-crankshaft system with three degrees of freedom were taken into account. Because of the highly nonlinear description of Stirling engine dynamics, the ANN was employed, that modelled output power of Stirling engine as a function of the input power, molar mass, load current, pressure obtained by gas combustion and working parameters of the engine. The ANN model was tested on experimental data, gathered at the laboratory stand, in different working conditions. The proposed ANN model provides good results for both training and testing data-sets.

Paper: **6124** **B7L-B**

Recursive Neural Network as Speed Controller for Two-Sided Electrical Drive with Complex Mechanical Structure

Krzysztof Nowopolski[1], Bartlomiej Wicher[2], Dominik Łuczak[3], Przemysław Siwek[4]

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In the paper, an adaptive structure for two-sided electrical drive is presented. The control object has a MIMO structure, since two input signals (motor torques) are available for the controller. The assumed model of the plant is non-linear (presence of backlash) and reveals resonant nature (elasticity in the mechanical structure). The controller is a two-layer recursive neural network, which outputs are reference torques of motors of the electromechanical plant. The conducted research investigation included variety of structures of the neural controller, with different numbers of recursive feedbacks, different horizon of former measurements. Operation of this control structure with and without

external anti-resonant filtration was compared as well.

Paper: **6013** **B7L-B**

Fuzzy Arithmetical Controller Design for Active Road Vehicle Suspension in the Presence of Uncertainties

Andreas Hofmann[1], **Michael Hanss**[2]

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This paper presents a method for designing a robust controller for an active road vehicle suspension. Unlike conventional robust control techniques, a fuzzy arithmetical approach is used to configure a so-called skyhook damper. The presented method is based on the covariance analysis of a quarter car model which is subject to random roadway excitation. The resulting controller improves the driving comfort and safety, and it increases robustness against uncertainty due to modeling errors or variations in the operational conditions. The fuzzy arithmetical approach allows to incorporate additional information about the shape of the inherent uncertainty into the resulting controller design. Furthermore, a possibilistic sensitivity analysis is employed to assess the individual influence of the uncertain parameters on the controller quality, providing useful information for the design process.

Distributed Parameter Systems - Modelling, Control and Estimation II (Invited Only), B7L-C

Day: Tuesday, August 29, 2017
Time: 16:40 - 18:00
Room: Lehar
Chair: Harald Aschemann

Paper: **6135** **B7L-C**

An Iterative Solution Approach to Eigenvalue Problems for Linear Hamiltonian Systems and its Application to a Hybrid System Control Problem

Alexander Gavrikov[1]

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The eigenvalue problem for self-adjoint linear Hamiltonian systems with nonlinear dependence on the spectral parameter and parameter dependent boundary conditions is considered. A Newton-type iterative solution method is presented. With the help of this technique the boundary control problem for a non-uniform string is studied. The linear-

quadratic regulator problem is considered, and an optimal feedback control law for the first mode of the hybrid system is designed.

Paper: **6195** **B7L-C**

Online Parameter Identification for Continuous Fluidized Bed Spray Granulation with External Sieve-Mill Cycle

Stefan Palis[1], **Achim Kienle**[2]

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Parametrization of process models is an important task and often the first step in process control and monitoring. For continuous fluidized bed spray granulation, being often described by population balance models parameter estimation is particularly challenging due to the infinite-dimensional state space. In this contribution a Lyapunov-based approach is used to derive the appropriate online parameter estimation laws for a fluidized bed spray granulation with external sieve-mill cycle.

Paper: **6199** **B7L-C**

Control-Based Damping of Elastic Gantry Crane Vibrations

Ievgen Golovin[1], **Stefan Palis**[2]

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This article is concerned with a control-based reduction of gantry crane elastic swinging in the trolley travel direction. As acceleration forces of the trolley are often the reason of these vibrations, they can be used in an appropriate damping strategy. For an elastic crane a dynamic model is derived applying the finite element method (FEM). This approach results in a high order state-space model, which should be reduced for the controller design procedure. In order to design a controller, which can be applied for simultaneous damping of elastic vibrations of crane construction and payload sway with varying rope length a robust control approach has been applied.

Speech Processing & Recognition, B7L-D

Day: Tuesday, August 29, 2017
Time: 16:40 - 18:00
Room: Strauss
Chair: Georgy Kostin

Paper: **6089** **B7L-D**

Comparison of Different Filter Approaches for the Online Frequency Analysis of Speech Signals

Andreas Rauh[1], Susann Tiede[2], Cornelia Klenke[3]

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The fundamental building block of spoken languages is a list of phonemes from which syllables and, hence, also words are formed. A systematic distinction between these phonemes becomes possible by the characteristic frequency components that are included in each sound. On the one hand, voiced phonemes are characterized by several sharp frequency components. On the other hand, wide, typically blurred frequency spectra are common for unvoiced sounds. Software-based assistance systems for the automatic classification of phonemes, therefore, have to estimate the variation of frequencies and their associated bandwidths that are included in a speech signal. This paper gives a comparison of different stochastic filtering approaches for the online estimation of the formant frequencies of phonemes from both a methodological and an application-oriented point of view. This approach for online frequency estimation is an integral component for the development of the assistance system SUSE which aims at supporting the detection and classification of linguistic disorders in the everyday work of speech therapists.

Paper: **6164** **B7L-D**

Polish Whispery Speech Recognition – Minimum Sampling Frequency

Piotr Kozierski[1], Talar Sadalla[2], Szymon Drgas[3], Adam Dąbrowski[4], Wojciech Giernacki[5]

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The article presents studies on the automatic whispery speech recognition. In the performed research a new corpus with whispery speech has been used. It has been checked how is the speech recognition quality changing at variables sampling frequency and sig-

nal frame length. It has been found that the optimal sampling frequency of whispery speech is about 32-48 kHz, while the optimal signal frame length is about 32-43 ms. The comparison of spectrograms between the normal and whispery speech has been also presented.

Paper: **6246** **B7L-D**

The Impact of Vocabulary Size and Language Model Order on the Polish Whispery Speech Recognition

Piotr Kozierski[1], Talar Sadalla[2], Szymon Drgas[3], Adam Dąbrowski[4], Joanna Zietkiewicz[5]

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The article presents studies on the automatic whispery speech recognition. In the performed research a new corpus with whispery speech has been used. The aim of studies presented in this paper was to checking, how the vocabulary size and the language model order influence on the speech recognition quality. It has been concluded that even using recordings with only 5,000 different words it is possible to prepare large vocabulary continuous speech recognition (LVCSR) model. It has been also found that the third order of language model is the best choice. The difference between normal and whispery speech is negligible and is manifested only in higher word error rate index (about 1.5 times higher for whispery speech).

Wednesday
August 30th, 2017

Plenary: A. Chemori, C1L-A

Day: Wednesday, August 30, 2017
Time: 09:00 - 10:00
Room: Casino
Chair: Jozef Korbicz

Paper: **6260** **C1L-A**

Control of Complex Robotic Systems: Challenges, Design and Experiments

Ahmed Chemori[1]

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Biomedical Signals, C2L-A

Day: Wednesday, August 30, 2017
Time: 10:00 - 11:00
Room: Casino
Chair: Ryszard Beniak

Paper: **6227** **C2L-A**

Electrochemical Impedance Spectroscopy Applied for Assessment of Electrodes Used in EEG Examination

Przemysław Makiewicz[1], **Joanna Górecka**[2]

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The aim of this paper was to assess commercially available electrodes used in EEG examination. Electrochemical Impedance Spectroscopy was used to investigate properties of four types of electrodes in different temperatures. Special attention was paid to the usability of electrodes used for registration of slow EEG potentials. Obtained results allowed to compare examined electrodes and to form recommendation on choose of the type of electrode.

Paper: **6151** **C2L-A**

An Expert System for Pre-Diagnostics Screening Using Neurofeedback Signals

Magda Zołubak[1], Mariusz Pelc[2], Aleksandra Kawala-Janik[3], Rafał Stanisławski[4]

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Policy-based computing is one of the software and knowledge engineering methods (along with Artificial Neural Networks, Fuzzy Logic, etc.) that allows incorporating a specified expert knowledge into various kind of decision making processes. In this paper a preliminary study is undertaken in order to determine applicability of this technology supported by selected trend analysis methods for the problem of pre-diagnostics patients screening based on bio-feedback signal(s). For this purpose an architecture for an automated pre-diagnostics screening system is presented together with methodology that would allow early detection of functional brain impairments, for example issues related to learning processes. Selected preliminary test results are included in order to provide assessment of the proposed methodology and its functional place in the whole system.

Paper: **6142** **C2L-A**

Trial Measurement of Movement-Related Cortical Dynamics Using Electroencephalography and Diffuse Correlation Spectroscopy

Chase Haddix[1], Ahmed A Bahrani[2], Aleksandra Kawala-Janik[3], Walter Besio[4], Guoqiang Yu[5], Sridhar Sunderam[6]

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To better characterize movement-related neurophysiological change, the authors propose to measure not only neural activity through the electroencephalogram (EEG) but also cerebral blood flow (CBF) using a new technology, near-infrared diffuse correlation spectroscopy (DCS). A preliminary trial is described, in which EEG, DCS, and exerted force were simultaneously recorded during a cue-triggered hand grip task. Eight channels of EEG were acquired from frontal, central, and occipital regions, and DCS signals were collected from locations over frontal and motor cortex. Event-related desynchronization (ERD) was observed at the onset of hand movement and lasted until movement ceased. EEG from the motor area showed a significant ERD in the 8-13 Hz mu band ($p<0.001$).

Mean CBF increased during the task by 6.8

Applications of Fractional Order Systems, C2L-B

Day: Wednesday, August 30, 2017
Time: 10:00 - 11:00
Room: Kalman
Chair: Piotr Ostalczyk

Paper: **6196** **C2L-B**

Tracking Performance of Angular Velocity in a Servo System with Fractional-Order PI Controller and Anti-Windup Compensation

Talar Sadalla[1], Dariusz Horla[2], Wojciech Giernacki[3], Piotr Kozierski[4]

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The main aim of this paper is to present the analysis of tracking performance obtained by means of experiments from laboratory stand comprising a small DC-motor-driven servo drive, continuous-time fractional-order PI controller and simple anti-windup compensation systems. It is an extension to authors' previous work where the stability of a first-order plant model with time delay and fractional-order PI controller was analyzed basedn simulation results. The tuning method of the non-integer ordercontroller is based on Hermite-Biehler and Pontryagin Theorems, and the tracking performance is based on quality indices, the Integral of Absolute Error and Integral of a Squared Error.

Paper: **6222** **C2L-B**

Analogue Electronic Active Filter Implementation of an Approximate State Space Realisation of a Fractional-Order System

Andrzej Tutaj[1], Jerzy Baranowski[2]

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The paper presents a procedure of approximate implementation of a given fractional-order system as an electronic analogue active filter. Employment of LIRA method of impulse response approximation allows the filter to be only composed of standard RC components and operational amplifiers. A proposed state variable transformation helps to simplify filter structure and reduce component count while improving its noise properties and accuracy of integer-order prototype frequency response reproduction. The paper provides and compares results of realistic LTspice IV simulations for both implementations based on

the LIRA realisation and its transfromed variant respectively. They confirm effectiveness of the presented approach involving LIRA approximation and state transformation steps.

Paper: **6035** **C2L-B**

Robust Fractional Order Controller for a Linear Active Magnetic Bearing System

Tomasz Nartowicz[1], Ewa Pawluszewicz[2], Arkadiusz Mystkowski[3]

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In the paper the fractional order PID feedback control loop is designed in order to stabilize the unstable linear current-controller active magnetic bearing (AMB) system. The review for stability analysis of fractional continuous-time linear systems described by the transfer functions is given. The specified fractional order controllers, obtained for desired different phase margins, are verified by means of numerical simulations. The robust stability of fractional order PID feedback-loop is shown due to AMB parametric uncertainty.

Robotics III, C2L-C

Day: Wednesday, August 30, 2017
Time: 10:00 - 11:00
Room: Lehar
Chair: Bernd Finkemeyer

Paper: **6004** **C2L-C**

Stiffness Variations in Granular Jamming Robots, an Experimental Method

Seyed Mohammad Zeyb Sayyadan[1], M. Mehdi Moniri[2], Faezeh Gharib[3]

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In this paper was introduced a both simple and beneficial formulation of relation between elastic module and vacuum pressure. It aids to predict the amounts of stiffness based on variations of vacuum pressure. The proposed procedure was examined by performing an experimental test as well. On the other hand, a usable mix of black Pepper seeds and Datura grains was introduced as usable media. This blend had a lightweight construction with high ratio of strength under external forces, therefore, it can be applied when a both high-strength and lightweight jammable structure in soft robotics is required.

Paper: **6044** **C2L-C**

Localization and Efficient Grasping of Objects by a Manipulator Using RFID Technique

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

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The paper investigates applications of RFID technique (radio-frequency identification) in combination with industrial robots. For this purpose an Industry 4.0 scenario is developed which makes workpieces intelligent by supplying the objects with RFID transponders. The RFID tags are able to store information decentral which can be later used to optimize the task of the robot. In our example first the workpiece width is identified by the robot gripper and saved in the object. Afterwards this value can be read out and used for further fast and sensitive catching of the object. In this context it is investigated how parameters like grasping force and velocity of the fingers influence the force overshoot during catching an object. In the paper further proposals are given concerning to the kind of information which can be useful stored within the workpieces handle by robots. Furthermore, a simple approach is presented for localization of workpieces in the robot workspace by the robot which is equipped with a RFID antenna. All algorithms proposed in this paper are verified by practical experiments successfully.

Paper: **6052** **C2L-C**

Exploiting the Natural Dynamics of Compliant Joint Robots for Cyclic Motions

Navvab Kashiri[1], **Emmanouil Spyrakos-Papastavridis**[2], **Darwin Caldwell**[3], **Nikos Tsagarakis**[4]

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This work presents a novel scheme employing the natural dynamics of compliant joint robots in order to perform cyclic motions. The use of the system's natural dynamics can therefore result in the execution of robot movements that consume a slight amount of energy as compared to the energy they generate, provided that the motion trajectory is on the limit cycle manifold. The energy efficiency advantages during such cyclic motions, which have rarely been studied in the literature, are also discussed. The proposed scheme, which is based on modal decoupling of the system's natural dynamics, is finally evaluated in simulation in order to investigate the energy-efficiency of different modal motions, as well as the effect of various joint stiffness levels.

Predictive Control, C2L-D

Day: Wednesday, August 30, 2017
Time: 10:00 - 11:00
Room: Strauss
Chair: Frank Allgower

Paper: **6217** **C2L-D**

The Distributed Model Predictive Controller for the Nuclear Power Plant Turbo-Generator Set

Paweł Sokólski[1], Tomasz Adam Rutkowski[2], Kazimierz Duzinkiewicz[3]

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There are typically two main control loops with PI controllers operating at each turbo-generator set. In this paper a distributed model predictive controller DMPC, with local QDMC controllers for the turbine generator, is proposed - instead of a typical PI controllers. The local QDMC controllers utilize stepresponse models for the controlled system components. These model parameters are determined, based on the proposed blackbox models of the turbine and synchronous generator, which parameters are identified on-line with RLS algorithm. It has been found that the proposed DMPC controller realize the reference trajectories of the effective power and the angular velocity, and damp generator voltage oscillations with satisfactory quality in comparison to the typical control structure with PID controllers.

Paper: **6018** **C2L-D**

Predictive Control for Offset-Free Motion of Industrial Articulated Robots

Květoslav Belda[1], Václav Záda[2]

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This paper deals with the design of model predictive control for the precise motion of industrial articulated robots. The solution is based on specific incremental formulations of equations of predictions. The proposed formulations enable the design to compensate and suppress undesirable positional offsets. The corresponding incremental predictive algorithms incorporating discrete integrators are introduced. The theoretical results are demonstrated by the set of simulation examples with the six-axis multipurpose ABB robot IRB 140 that belongs to the large class of industrial articulated robots.

Paper: **6048** **C2L-D**

Online Tuned Model Predictive Control for Robotic Systems with Bounded Noise

Květoslav Belda[1], **Lenka Pavelková**[2]

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This paper deals with predictive control design for motion control of robotic systems. The design considers time-varying state-space model. Used states are estimated from measured robot outputs. These outputs represent controlled quantities including a bounded noise. The paper introduces a novel solution to the state and noise parameter estimations based on linear programming incorporated in the control design. Estimated states are utilised for updating state-dependent elements in the robot model and for control design itself. Estimated noise parameters are employed in advanced tuning of control parameters, namely penalisation matrices. The proposed theoretical outcomes are demonstrated on one multi-input multi-output robot-manipulator.

Poster Session IV, C3P-E

Day: Wednesday, August 30, 2017
Time: 10:00 - 12:00
Room: Poster Area
Chair: Witold Mickiewicz

Paper: **6005** **C3P-E**

Inquiry on Braking and Accelerating Maneuvers Optimization for Wheeled Robots

Boguslaw Schreyer[1]

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In some types of wheeled robots it is important to secure starting acceleration and deceleration maxima while at the same time maintaining transversal stability. In this paper torque distribution between the front and rear wheels as well as the timing of torque application have been calculated. Both secure an optimum traction coefficient. This paper also identifies required input signals to a control unit, which controls the torque values and timing. Using a three dimensional, two mass model of a robot developed by the author a computer simulation was performed confirming the calculations presented in this paper. These calculations were also implemented and confirmed during military robot testing

Paper: **6045** **C3P-E**

The Diagnostic Gastroenterology Needs in Relation to Exisiting Tools, Research and Design Work on a New Tool in Endoscopy Field

Lukasz Fracczak[1], Agnieszka Kobierska[2], Katarzyna Koter[3], Paweł Żak[4], Elżbieta Czkwianiac[5], Michał Kolejwa[6], Andrzej Nowak[7], Anna Socha – Banasiak[8], Joanna Ślęzak[9]

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Diagnostics of the digestive system carried out properly is becoming more and more important where patients' health status and lives are concerned. Current diagnostic methods include but are not limited to the following: radiodiagnostics, endoscopy, enteroscopy and capsule endoscopy. This article contains a brief presentation of these methods and it describes their main advantages and disadvantages. One of the main conclusions summarizing the description of diagnostic methods is to indicate any "blank spots" in the diagnosis and treatment of the digestive system. This article also presents studies of new devices that will eventually fill in the blank spots in the diagnosis of the digestive system. In the conclusions this article characterizes the most important parameter requirements that a device should possess to meet the expectations of physicians and allow for comprehensive diagnostic assessment of the intestines and taking of samples for further tests.

Paper: **6158** **C3P-E**

Static and Dynamic Properties Investigation of New Generation of Transversal Artificial Muscle

Katarzyna Koter[1], Lukasz Fracczak[2], Anna Wojtczak[3], Barbara Bryl-Nagorska[4], Artur Mizejewski[5], Adam Sawicki[6]

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Pneumatic Artificial Muscles are under investigation for many years. One of their advantages, low emittance of heat of working medium, makes them useful in medical robotics. Transversal Pneumatic Artificial Muscles were developed at Lodz University of Technology to solve a problem of combination of advantages of this drive and preferable for

medical use size. Thanks to the innovative structure, designed muscles characterize much smaller dimensions and high strength relative to the total volume change. The article presents the results of static and dynamic tests of Transversal Pneumatic Muscles.

Paper: **6187** **C3P-E**

Ground Plane Estimation from Sparse LiDAR Data for Loader Crane Sensor Fusion System

Karol Miądlicki[1], Mirosław Pajor[2], Mateusz Saków[3]

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Research on the development of control systems for loader cranes, despite their importance in the industry, is conducted by only a few scientific centers. West Pomeranian University of Technology, Szczecin in collaboration with loader cranes manufacturer - Cargotec company, started research on the multisensory monitoring system for cranes. proposed system also allows you to track the position of the operator. This paper presents the subsystem for ground plane estimation and ground points filtration. The developed algorithm uses data from the Velodyne LIDAR VLP-16 scanner. The subsystem is designed for real time operation. It is based on the RANSAC algorithm and vector dot product. The effectiveness of the algorithm was compared with other algorithms described in this publication. Tests were carried out on a loader crane test bench at various positions of the LIDAR sensor. Experiments confirms that ground plane estimation results of the proposed algorithm are better than other presented methods.

Paper: **6189** **C3P-E**

Minimum Effort Position Control of Legged Robots Equipped with Serial Manipulators in Stance Phase

Mohammad Reza Lavaei[1], Mohammad Mahjoob[2], Amir Behjat[3]

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A legged robot equipped with a serial manipulator can perform different tasks such as position control of the end-effector using active joints of both manipulator and the legs. We consider the robot in its stance phase and synthesize a controller which in addition to tracking the desired position/orientation of the end-effector keeps all the legs in contact with the ground and prevent them from slipping. The kinematic/dynamic model of the general legged robots with a serial manipulator is derived. The contact forces are then obtained in terms of the state and actuation vectors. The optimal controller based on inverse dynamics of the robot (subjected to requirements of contact forces) minimizes the actuation effort. The proposed method is then implemented on a simplified model of a quadruped robot to control the position of the end-effector.

Paper: **6242** **C3P-E**

Adaptive Head Movements Tracking Algorithms for AR Interface Controlled Telepresence Robot

Aleksei Shchekoldin[1], Alexander Shevyakov[2], Nikolay Dema[3], Sergey Kolyubin[4]

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The paper is devoted to the design of the telepresence robot controlled via the head-mounted display equipped with an inertial measurement unit (IMU). To be able to control the robot and the camera gimbal motion independently with only 3 DOF reference, we developed algorithms based on nonlinear filtering and fuzzy-logic techniques to process IMU measurements and capture head motion patterns. We implement this solution for shared autonomy remotely controlled robots with an augmented reality (AR) interface, which are in a rising demand for technical drills, monitoring and maintenance applications as well as for in door guided tours.

Paper: **6248** **C3P-E**

Autonomous Drone Control System for Object Tracking: Flexible System Design with Implementation Example

Paweł Smyczyński[1], Łukasz Starzec[2], Grzegorz Granosik[3]

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Paper contains presentation of the flexible control system for an autonomous drone. Presented system is utilizable on various hardware platforms and capable of realizing different missions with minimal adjustments.

Paper: **6250** **C3P-E**

Design, Modeling and Fabrication of a 3-DOF Wrist Rehabilitation Robot

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Human wrist is an intricate and effective body joint which plays a vital role in performing essential activities of daily living (ADL). Wrist impairment is a common cause of full/partial functional loss in the elderly. It also occurs after stroke, sport injuries or spinal cord injuries. To increase the muscle tone, rehab exercises are suggested after surgery or

impairment. Extensive researches have been carried out on rehabilitation devices to facilitate the treatment course. In this paper, a wrist rehabilitation robot is presented. The mechanical structure is developed based on the design requirements. The dynamic model of the robot is derived following anthropometric data. The final prototype (made at reasonable cost) offers three wrist degrees of freedom (DOF) and major wrist ranges of motion (ROM) needed in usual rehab treatment.

Paper: **6053** **C3P-E**

Software-Based Method of Increasing the Effective Resolution of a Measurement Chain for a Transducer with a Pulse Frequency Output

Eligiusz Pawłowski[1]

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The article covers the problems of digital signal processing in a measurement chain that uses a measuring transducer with a pulse frequency output. Such a measurement chain arrangement presents numerous advantages, particularly due to the high accuracy of frequency conversion to digital form, and the high immunity of a frequency signal to interference. However, the assessment of the metrological characteristics of such a measurement chain, especially in dynamic states, presents a challenge. This problem stems from the fact that digital frequency measurement is always a mean value measurement, which introduces a greater dynamic error for longer averaging times. At the same time, a quantization error occurs, which also depends on the averaging time and measurement method. The work presents the possibility of increasing the effective resolution of a measurement chain with a frequency signal by using software methods of reciprocal counting. An algorithm developed for this purpose and the results of conducted simulation studies are presented.

Paper: **6185** **C3P-E**

Analysis of a Mechanical Resonance in the Flapping Wing Actuation

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The goal of this paper is to analyse the mechanical resonance that appears during the oscillatory motion in the flapping wing robots. The prototype of the actuation mechanism has been proposed that involves a DC motor directly driving a set of bioinspired wings. The resulting motion has been analysed using a high speed camera.

Paper: **6216** **C3P-E**

Constrained Generalized Predictive Control with Particle Swarm Optimizer for an Overhead Crane

Jarosław Smoczek[1], **Janusz Szpytko**[2]

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The paper focuses on multivariable generalized predictive control (GPC) of an underactuated overhead crane with constraints on manipulated variable and sway angle of a payload. The adaptive control scheme is developed based on the discrete-time linear parameter varying model of a crane dynamic identified using the recursive least square (RLS) algorithm with parameter projection. Particle swarm optimization (PSO) is applied to solve the optimization control problem subject to hard constraint on control signal and the soft constraint payload deflection in the transient state. The feasibility and applicability of the proposed control approach is confirmed using a laboratory scaled overhead crane for different constraint and operating conditions.

Paper: **6230** **C3P-E**

Behaviour of the Fractional Cucker-Smale Type Model for a Couple of Agents

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

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The behaviour of fractional-order systems with two agents is considered. In the paper, interactions between agents are defined like in Cucker-Smale models, where equations related to the position are the ordinary differentia equations and velocities of agents are described by fractional differential equations. It allows us to take into account the memory that is included by taking the fractional-order, what seems to significantly improve the classical model. The conditions for achieving the consensus for the considered models are formulated based on the stability analysis of the appropriate linear systems. Finally, the behaviours of systems are illustrated by examples.

Paper: **6236** **C3P-E**

On-Line Spectrophotometric Measurements of Isopropanol Concentration in Process of Nebulization

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In the paper there are presented tests of the method for on-line measurement of isopropanol concentration in the ultrasonic nebulization process using BW-Tek compact UV/Vis spectrophotometer. Experimental setup with nebulization vessel was constructed with probe for on-line measurement. Tests were performed using standard mixture of isopropanol and water with volume concentration of isopropanol in range 19% to 83%. Results of online spectrophotometric method were verified using stationary spectrophotometer and additionally a gas chromatography method was tested as a potentially reference measurement method in the future. Linear calibration for obtained data was performed and measurement uncertainties for tested method were evaluated as confidence intervals.

Robust Control, C4L-A

Day: Wednesday, August 30, 2017
Time: 11:20 - 13:00
Room: Casino
Chair: Wojciech Hunek

Paper: **6003** **C4L-A**

An Indirect Backstepping Robust Control for Flyback Type DC to DC Converter

Havva Ozkaya[1], Erkan Zergeroglu[2], Murat Seker[3]

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In this work, an indirect backstepping approach is introduced for the robust regulation of the output voltage of DC/DC flyback converters. Specifically, a high gain type robust controller with comparatively smoother controller action is presented which regulates the corresponding current required to set the output voltage to its desired value. Simulation results are presented to illustrate the efficiency and feasibility of the proposed method.

Paper: **6031** **C4L-A**

Semi-Symbolic Operational Computation for Robust Control System Design

Leandro Gil[1], **Martin Radetzki**[2]

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We propose an affine arithmetic based operational computation method which is faster than step integration methods and allows the direct evaluation of system robustness to parameter variations. In order to improve the simulation performance during design optimization, we derive a novel operational method to compute the multiplication of signal expansions. Thus, common nonlinear cost functions can be directly computed, using only signal coefficients. We validate the capability of our design methodology for the improvement of system performance and robustness by optimizing a DC motor control. The obtained results show a compelling effectiveness of affine arithmetic computations for robust control system design optimizations.

Paper: **6150** **C4L-A**

Robust Backstepping Stabilization of Nonlinear Systems with Time-Varying Parameters

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

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Backstepping-based, robust stabilization procedure for nonlinear systems with time-varying parameters is presented. The general approach for nonlinear parameter dependence is developed, next the special case of a linear-in-parameters system is considered. Available simplifications of the design and benefits due to this system structure are discussed and illustrated by examples.

Paper: **6197** **C4L-A**

Interval Methods for the Implementation and Verification of Robust Gain Scheduling Controllers

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

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This paper presents a novel approach for an interval-based gain scheduling control design aiming at a guaranteed stabilization of the system dynamics over a predefined time horizon. Due to the goal of asymptotic stability, the design aims at the temporal reduction of the widths of intervals representing worst-case bounds of the system states at a specific

point of time. The main idea of the control approach is the computation of feedback gains for an initial state interval with a subsequent verification step. Controller gains can be calculated off-line so that predefined performance criteria on the closed-loop structure are satisfied.

Control Applications III, C4L-B

Day: Wednesday, August 30, 2017
Time: 11:20 - 13:00
Room: Kalman
Chair: Przemyslaw Ignaciuk

Paper: **6066** **C4L-B**

The Active Vibration Control of the Plate Structure by Using LQG Controller and Piezo-Stripes

Andrzej Koszewnik[1]

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The active vibration control of SFSF (Simply Supported-Free-Simply Supported-Free) smart plate by using linear quadratic Gaussian (LQG) controller is described in the paper. In order to design proper optimal control law two pairs of PZT actuators and sensors oriented in two perpendicular directions X and Y are glued to the plate. The aforementioned locations and orientations of PZT elements allow to decouple the TITO system onto two SISO subsystem for separately control odd and even modes. The process of design LQG controller is performed in two stages. In the first stage with using Matlab software the parameters of controllers are determined based on the simulations results in time and frequency domains. On the other hand, in the second step the designed controllers are verified on the lab stand by implemented control laws to real time processor (Dspace).

Paper: **6213** **C4L-B**

High Performance PID Control of a Cascade Tanks System as an Example for Control Teaching

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

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A detailed analysis of PID level control in the second tank of the cascade of two tanks is performed with respect to both, load disturbance attenuation and set-point change. Approximate formulas for extrema of time responses and for certain performance indices are derived, giving guidelines for controller settings. A simple method of choosing controller

parameters is proposed that bases on time scale separation. For a reasonable transfer from one operating point to another, under control signal limitations, command signal generators with a feed-forward from the reference are proposed and the effect of anti-windup controller augmentation is examined. Moreover, partial invariance of the control systems properties with respect to the changes of working point is highlighted.

Paper: **6011** **C4L-B**

Velocity Estimation for Slow Motion Devices Equipped with Encoder

Krzysztof Kołek[1], **Maciej Rosół**[2]

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This paper addresses the problem of velocity estimation for slow motion elements equipped with encoders. The slow movement causes rare pulses generated from the encoder, rarer than the sampling frequency. In such conditions, the velocity calculation by numeric derivative or Luenbergera observer fails. For that, it is proposed a new velocity estimation algorithm that uses information specific for encoder operating mode. Simulation and real-time experiments have shown a significant reduction in velocity error estimation of the proposed algorithm in comparison to conventional algorithms.

Paper: **6117** **C4L-B**

Application of a Modified Error Governor to Electronic Throttle Control

Alexander Schöley[1], **Wolfgang Drewelow**[2], **Torsten Jeinsch**[3], **Nick Weinhold**[4]

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The control of an electronic throttle in an automotive vehicle is considered in this paper. Due to a saturation non-linearity in the control loop, a nominal controller produces undesired windup effects. Because of mechanical restrictions, especially windup-induced overshoots of the throttle plate angle should be prevented. Well-known anti-windup methods, like back-calculation, can only be effectively used with PID controllers. Since the nominal controller is not of PID-type, an Error Governor (EG) is used to prevent windup. Additionally the original EG is modified to meet special characteristics of the throttle control. One modification is to handle a non-linear feedforward part, that is used to compensate for friction of the throttle plate. And a second adjustment concerns time-variant saturation limits that occur due to voltage fluctuations of the car's battery. The suggested method is tested on a throttle test bench.

Paper: **6114** **C4L-B**

Improvement of Accuracy of the Membrane Shape Mapping of the Artificial Ventricle by Eliminating Optical Distortion

Wojciech Sulej[1], **Krzysztof Murawski**[2], **Tadeusz Pustelny**[3]

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The paper presents new technique for correcting the desired shape of the flaccid membrane used in the artificial heart chamber. The original shape of membrane was obtained using specially developed type of method - Depth from Defocus. Accurately determining the shape of the diaphragm is very important. The shape of the membrane affects the final accuracy of determining the stroke volume of extracorporeal pneumatic heart assist pump. Three rigid membranes were used in the study. Each of them was developed on the basis of the original shape of the flaccid membrane and was examined.

Modelling and Simulation II, C4L-C

Day: Wednesday, August 30, 2017
Time: 11:20 - 13:00
Room: Lehar
Chair: Paolo Mercorelli

Paper: **6012** **C4L-C**

Exponentially Weighted Aggregation of Models for Wiener-Hammerstein System Modelling

Paweł Wachel[1], **Zygmunt Hasiewicz**[2]

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In the paper the problem of Wiener-Hammerstein system (LNL) modelling by exponentially weighted aggregation of models is discussed. The class of systems under consideration admits almost any LNL objects even with infinite memory and virtually arbitrary nonlinear characteristic. Given the set of various possible models of the true system (being e.g. the result of prior identification attempts), the proposed approach yields mixed model that efficiently mimics input-output relationship of the genuine LNL system. Detailed analysis of the approach demonstrates good theoretical properties of the resulting (aggregated) model, whereas numerical simulations illustrate practical aspects of the considered method.

Paper: **6194** **C4L-C**

Implementation of Hierarchical Control of Drinking Water Supply System: Didactic Project – Computer Controled System

Jaroslaw Tarnawski[1], Tomasz Adam Rutkowski[2], Arkadiusz Ciminski[3]

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The paper presents the outline of the didactical project of a complex computer controlled system. The synthesis, implementation and analysis of a multilayer hierarchical control system for drinking water supply system (DWSS) are main topics of that project. The scope of the project covers many aspects of automation: mathematical modeling, dynamic object identification, real-time simulation, acquisition and scaling of signals, estimation, PID control, definition of optimization criteria, predictive control technology, control synthesis, SCADA and HMI application development, OPC communication, hardware-in-the-loop technology, and many others tools and methods needed to obtain a functional control system structure. The undoubted advantage of presented project is the integration into one coherent, functional system many separately recognized methods and tools.

Paper: **6178** **C4L-C**

Application of the Waveform Relaxation Technique to the Co-Simulation of Power Converter Controller and Electrical Circuit Models

Michal Maciejewski[1], Idoia Cortes Garcia[2], Sebastian Schöps[3], Bernhard Auchmann[4], Lorenzo Bortot[5], Marco Prioli[6], Arjan Verweij[7]

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In this paper we present the co-simulation of a PID class power converter controller and an electrical circuit by means of the waveform relaxation technique. In order to maintain the time-stepping characteristic of both models, we treat them separately by means of input/output relations and propose an application of a waveform relaxation algorithm. Furthermore, the maximum and minimum number of iterations of the proposed algorithm are mathematically analyzed. The concept of controller/circuit coupling is illustrated by an example of the co-simulation of a PI power converter controller and a model of the main dipole circuit of the Large Hadron Collider.

Paper: **6258** **C4L-C**

Modelling Dynamics of Strongly Coupled Air Paths in Pneumatic Transport System for Milling Product

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In the milling circuit with an electromagnetic mill, a pneumatic system is used to transport the material and to maintain several parameters of the process. The pneumatic system contains three air inlets with controllable flaps and each inlet stream serves a different purpose, however, they are strongly physically coupled through the rest of the installation. Thus, position of each control flap strongly and nonlinearly affects the operating point of each inlet stream. Dynamics of air velocity within the main inlet pipe with respect to the setpoint of the main flap's position has been identified for multiple operating points of the installation, and the estimated models were checked and assessed. The resultant models may then be used to tune controller parameters for subsequent operating points. Identification and verification of the derived models was performed on data measured at an experimental milling installation.

Paper: **6245** **C4L-C**

Preliminary Studies on Modelling the Drying Process in Product Classification and Separation Path in an Electromagnetic Mill Installation

Jan Wegehaupt[1], Dariusz Buchczik[2], Oliwia Krauze[3]

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The process of loose materials grinding is directly dependent on the type of feed and its physical parameters resulting from presence of water in the material. The grinding process in the electromagnetic mill installation is carried out on dry material, using pneumatic transport and classification system with recycle. Preliminary analyses have shown the possibility to significantly improve the product quality and efficiency of the milling process by appropriate control of the moisture content of the milled material. The main objective of the research is to develop a model describing the changes of moisture content of bulk material in the installation of the electromagnetic mill. This paper presents the results of preliminary studies on the accurate models describing the drying process in the path of material classification and its separation from the transport air.

Image Processing, C4L-D

Day: Wednesday, August 30, 2017
Time: 11:20 - 13:00
Room: Strauss
Chair: Krzysztof Okarma

Paper: **6020** **C4L-D**

On the Efficiency of a Fast Technique of Impulsive Noise Removal in Color Digital Images

Łukasz Malinski[1], Bogdan Smolka[2], Danuta Jama[3]

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In the paper the detection efficiency of a fast algorithm of impulsive noise reduction in color images is investigated. The analyzed algorithm is based on the sum of dissimilarity measures between the processed pixel and its neighbors and various metrics, which express the difference between pixels, are evaluated. The detection part of the algorithm is mainly analyzed using binary classification, in contrast to other works, which focus on overall impulsive noise detection and suppression efficiency. The most efficient measures of a distance between pixels are examined and tuning parameters of the analyzed algorithm, adjusted to the impulsive noise intensity, are recommended, so that they can be used in various real-time image enhancement applications.

Paper: **6160** **C4L-D**

Novel Method for Joining Missing Line Fragments for Medical Image Analysis

Patryk Najgebauer[1], Leszek Rutkowski[2], Rafał Scherer[3]

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We present a method of predictive reconstructing connections between parts of object outlines in images. The method was developed mainly to analyze microscopic medical images but is applicable to other types of images. Examined objects in such images are highly transparent, moreover close objects can overlap each other. Thus, segmentation and separation of such objects can be difficult. Another frequently occurring problem is partial blur due to high image magnification. The method is based on edge detection to extract object contours and represent them in a vector form and uses the Gestalt Laws describing human perception.

Paper: **6162** **C4L-D**

A 2D, Stochastic Model of a Phase-Detection Autofocus

Adrian Gałęziowski[1]

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A 2D stochastic model of a phase-detection autofocus is proposed. A comprehensive analysis of its formal properties is conducted and its validity for a wide class of stochastic processes is proved. Moreover, formal properties of the phase-detection autofocus are analysed, together with assumptions necessary for its unimodality. Lastly, practical experiments, incorporating thermographic camera, which confirm theoretical findings, are described.

Paper: **6130** **C4L-D**

Estimation of DC Motor Parameters Using a Simple CMOS Camera

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

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We consider a mobile robot and its dynamic model. DC motor parameters are identified using suitable measurements. A method of estimating the DC motor parameters of the mobile robot using a simple CMOS camera is proposed. A marker indicates the position of the robot. Step excitation is applied, and estimation of robot's movement parameters is performed by image processing. The response of the identified model is adjusted to the measured step response. The available maximum camera framerate appeared to be too low. This obstacle is overcome by using the tuning utility of CMOS cameras.

Paper: **6218** **C4L-D**

A Smooth Local Polynomial Model of Vignetting

Andrzej Kordecki[1], **Artur Bal**[2], **Henryk Palus**[3]

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The vignetting is one of image distortions, which refers to the fall-off of pixel intensity due to optical properties of the camera and lens system. The effect of vignetting on image is unwanted in image processing and analysis. The vignetting correction need to obtain the real vignetting of the camera-lens system, which can be determined using the vignetting model. The local vignetting polynomial model allows to fit the vignetting data with more flexibility, but at the cost of increased of vignetting function distortions. This paper introduces a new smooth local polynomial vignetting model, which is a modification of

local vignetting polynomial model. The conducted experiments on broad range of lens settings shows that filtering allows to improve the vignetting function smoothness.

Thursday
August 31st, 2017

Plenary: B. Finkemeyer, D1L-A

Day: Thursday, August 31, 2017
Time: 09:00 - 10:00
Room: Casino
Chair: Andrzej Bartoszewicz

Paper: **6261** **D1L-A**

Towards Safe Human-Robot Collaboration

Bernd Finkemeyer[1]

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Signal Processing, D2L-A

Day: Thursday, August 31, 2017
Time: 10:00 - 11:00
Room: Casino
Chair: Alexander Winkler

Paper: **6019** **D2L-A**

Multi-Frequency Conditioning System of the Inductive Loop Sensor - Simulation Investigations

Zbigniew Marszalek[1], **Ryszard Sroka**[2], **Tadeusz Zeglen**[3]

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The concept of the multi-frequency conditioning system of the individual inductive loop sensor signal, with the separation of impedance components was presented in the hereby paper. Simulation investigations concerning dynamic states in the system excited by a step change of the sensor impedance parameters, were performed. The system behaviour in the presence of disturbances - induced in the sensor circuit - was also studied. The analysis of electromagnetic interferences generated by engines of vehicles was preliminarily performed. The simulation investigations confirm that the operation of the conditioning system - simultaneously - at two frequencies allows to obtain magnetic pairs of resistance and reactance profiles. This ensures that at least one pair of undisturbed signals will be obtained. This can ensure improvements of the operation reliability of the axles loop detection systems as well as the systems of measuring vehicle parameters in traffic.

Paper: **6200** **D2L-A**

Mechatronic Sound Intensity 2D Probe

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

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The paper addresses a problem of sound intensity measurement in acoustic field using mechatronic one-microphone probe. The new probe is not able to substitute the traditional p-p sound intensity probe in any case, but in many cases poses a cost-effective solution with acceptable metrological quality. The way of working of proposed probe bases on pressure-pressure probe principle, where parallel data acquisition by precisely matched microphones are substituted by a series of acquisitions by the same microphone channel with precise replacement of the sensor. If the sound intensity vector measurement is made in one, two or three dimensions, one or two stepper motors are used to position the microphone in the space around the measurement point. In the paper the idea of construction and preliminary test results of the new probe used as a direct sound and first reflection directivity sensor are presented. The experiments show, that presented kind of probe can be a cost-effective tool for electroacoustic systems designers and room acoustics consultants. Obtaining better metrological properties needs some improvements in microphone directional phase characteristic.

Paper: **6226** **D2L-A**

Estimation of Micro-Doppler Signals Using Viterbi Track-Before-Detect Algorithm

Przemyslaw Mazurek[1]

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The application of Viterbi based system for the processing of low SNR micro-Doppler signal is considered. Main signal is suppressed in spectrogram using averaging. Rayleigh noise is assumed in tests. Monte Carlo tests are provided for analysis of algorithm for selected cases. The results show possibilities of micro-Doppler signal tracking using Track-Before-Detect algorithm. This is useful approach especially for small deviations and amplitudes.

Robotics IV, D2L-B

Day: Thursday, August 31, 2017
Time: 10:00 - 11:00
Room: Kalman
Chair: Krzysztof Kozłowski

Paper: **6152** **D2L-B**

Using a Nonlinear Mechanical Control Coupling Metric for Biped Robot Control and Design

Tan Chen[1], Xiangyu Ni[2], James Schmiedeler[3], Bill Goodwine[4]

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This paper uses results from geometric mechanics and control to determine the degree of coupling between actuated and unactuated degrees of freedom in a two-link biped robot. By comparing the degree of coupling when ankle actuation is used and when hip actuation is used, it is clear that ankle actuation affords stronger dynamic coupling and hence, may provide a superior means for control design for robust gait and posture control. This is true both in the case where the robot is configured as a bipedal walker and the case where it is configured to model posture control. In the case of posture control, these results are consistent with some literature on the means by which humans maintain posture.

Paper: **6099** **D2L-B**

General Lagrangian Jacobian Motion Planning Algorithm for Affine Robotic Systems with Application to a Space Manipulator

Krzysztof Tchoń[1], Joanna Ratajczak[2]

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In this paper we extend the concept of the General Lagrangian Jacobian Inverse from driftless to control affine robotic systems, and establish a corresponding Jacobian motion planning algorithm in the parametric form. A specific choice of the Lagrangian is recommended. The motion planning algorithm is applied to the motion planning problem of a free-floating space manipulator with non-zero momentum. A conjecture is formulated that for this specific choice of the Lagrangian the motion planning algorithm outperforms the other Jacobian algorithms in terms of the length of the resulting robot trajectory.

Paper: **6084** **D2L-B**

Singularity Avoidance in a Robotized Ultrasound Scan

Aicha Fonte[1], Pierre Vieyres[2], Gerard Poisson[3], Cyril Novales[4]

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In a robotized ultrasound scanning system and more generally in any system which interacts with a human, the used control laws have to satisfy a safety of operating and functioning. Moreover these control laws have to guarantee a high precision in the medical gesture tracking, and especially within the framework of the ultrasound scanning, they assure the ultrasound plane preservation. The mechanical architecture of the designed robot takes into account the medical specifications of the remote ultrasound scan application. This robot is compact and lightweight but presents singular configurations on its workspace. These configurations perturb the follow-up of the medical remote gesture and lead to a loss of precision which induce errors in the path following as well as in the ultrasonic plan. To solve this problem we set up specific control that takes into account these singular configurations and allows to reproduce the movements generated by the medical expert with a great accuracy.

Control and Systems Theory IV, D2L-C

Day: Thursday, August 31, 2017
Time: 10:00 - 11:00
Room: Lehar
Chair: Krzysztof Latawiec

Paper: **6028** **D2L-C**

Characteristic Equations for Descriptor Linear Electrical Circuits

Kamil Borawski[1]

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The characteristic equations of descriptor linear electrical systems are investigated. The comparison of the characteristic equations obtained from three different methods is performed. The methods are based on: the analysis of the pair (E,A) (to be called here the "standard method"), the Weierstrass-Kronecker decomposition and the shuffle algorithm. It is shown that: 1) the characteristic equations obtained from the standard method and Weierstrass-Kronecker decomposition method are the same; 2) the characteristic equation obtained from the shuffle algorithm method has h additional zero roots, where h is the number of shuffles. The considerations are illustrated by numerical examples.

Paper: **6056** **D2L-C**

Non-Invasive Control of the Hegselmann-Krause Type Model

Ewa Girejko[1], Agnieszka Malinowska[2]

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In this paper, the Hegselmann-Krause type model with leadership is considered. We look for optimal control strategies for the system to attain a consensus in such a way that the control mechanism is included in the leader dynamics. Necessary optimality conditions are obtained by the use of the weak maximum principle for control problems on time scales. The validity of the proposed control strategy is illustrated by examples.

AI Methods II, D2L-D

Day: Thursday, August 31, 2017
Time: 10:00 - 11:00
Room: Strauss
Chair: Janusz Szpytko

Paper: **6014** **D2L-D**

Combined Estimation of Actuator and Sensor Faults for Non-Linear Dynamic Systems

Marcin Pazera[1], Marcin Witczak[2], Józef Korbicz[3]

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The paper deals with the problem of simultaneous estimation of the state as well as actuator and sensor faults for non-linear dynamic systems. The actuator and sensor faults can appear simultaneously, at the same time. The proposed strategy is based on quadratic boundedness approach allowing the convergence analysis of the proposed estimator. The final part of the paper shows an illustrative example based on a real multi-tank system, which clearly exhibits the performance of the proposed approach.

Paper: **6093** **D2L-D**

Simultaneous Estimation of Multiple Actuator and Sensor Faults for Takagi-Sugeno Fuzzy Systems

Marcin Pazera[1], Marcin Witczak[2], Mariusz Buciakowski[3], Marcin Mrugalski[4]

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The paper is devoted to the problem of a Takagi-Sugeno(TS)-based robust simultaneous actuator and sensor faults estimator design for the purpose of the Fault Diagnosis (FD) of non-linear systems. The proposed methodology of designing a TS-based $\mathcal{H}_\infty$ fault estimator is developed in this paper. The main novelty of the approach is associated with possibly of simultaneous sensor and actuator faults estimation. The developed approach guaranties a predefined disturbance attenuation level and convergence of the designed estimator. The illustrative part of the paper shows an example of the application of the developed approach in the task of the fault diagnosis of the multi-tank system.

Paper: **6131** **D2L-D**

Reduction Strategies for the Cardinality Constrained Knapsack Problem

Krzysztof Pieńkosz[1]

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In the paper the Cardinality Constrained Knapsack Problem is considered. It is a variant of the Continuous Knapsack Problem in which no more than a specified number of variables are allowed to have positive values. This problem arises when a limited resource is allocated among competing activities, and an upper bound is imposed on the number of activities that can be selected in a solution. The Cardinality Constrained Knapsack Problem is NP-hard. We analyze the structural properties of its optimal solutions and propose procedure allowing to reduce the size of the original problem.

Poster Session V, D3P-E

Day: Thursday, August 31, 2017
Time: 10:00 - 12:00
Room: Poster Area
Chair: Pawel Dworak

Paper: **6030** **D3P-E**

Speed as an Element of Optimal Vessel Traffic Scheduling

Waldemar Uchacz[1]

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The article presents two different models used for vessel traffic scheduling for fairway transits, as a factor increasing traffic safety: a model with fixed speeds of vessels on the fairway, and a model in which ship speed can be controlled within specific limits (vmin, vmax). Both models were compared to each other making use of the the actual traffic problem in the Szczecin - Świnoujście fairway. It has been found that both methods for the examined dimension of the problem are effective.

Paper: **6033** **D3P-E**

Analysis of 3D Model of Reluctance Stepper Motor with a Novel Construction

Jakub Kołota[1], **Slawomir Stępień**[2]

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A method of modeling and numerical simulation of the reluctance stepper motor using time stepping finite element method (FEM) is presented. In proposed model, the nonlinear electromagnetic field equations and the circuit equations are strongly coupled and solved together with motion equation at each time step. The subject of this paper is a novel form of construction of reluctance steppe motor bases purely on variable-reluctance principle. In this paper a modeling method and a numerical simulation of the two-phased variable reluctance stepper motor is presented. This approach demonstrates that the dynamics of classic reluctance stepper motor construction can be improved by 3D nonlinear distributed parameters models. The optimization of the motor geometry has been solved numerically and the proposed model may contribute to the improvement of the drives dynamics in the future prototypes.

Paper: **6036** **D3P-E**

Parametric Identification of Mathematical Model of Inverter Drive Hydraulic Pump with Induction Motor

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

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Problem of mathematical modelling and parameter identification of inverter drive hydraulic pump with induction motor was analysed. The numerical Box's method of static optimisation was applied in parametric identification of the drive system parameters. In identification studies excitation signal of synchronous frequency, slip frequency and amplitude of the stator voltage were used. The influence of the excitation signal on the values of identified parameters was shown in laboratory tests. It was concluded that the results of the identification were determined by the plan of the experiment and the applied drive signal. The changes of identified parameters were caused not only by changes in the real value of the drive parameters, but also by the identification errors. The experimental verification was carried out for the inverter-fed AC motor drive.

Paper: **6064** **D3P-E**

Modelling of a Contact Pressure Distribution Caused by Assembly Errors in a Spur Gear Transmission

Piotr Jabłoński[1], Rafał Talar[2], Katarzyna Peta[3], Karol Grochalski[4], Marcin Suszyński[5]

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Following paper presents development and results of FE (finite element) model for estimation of gear teeth load irregularities caused by assembly errors. Possible sources of geared train transmission components misalignment were presented. Method for pinon shaft misalignment were proposed. Simulation preparation including boundary conditions, geometry discretization and load modelling were described. Obtained results were presented and discussed.

Paper: **6067** **D3P-E**

Replacement Strategies of Genetic Algorithm in Parametric Identification of Induction Motor

Katarzyna Rutczyńska-Wdowiak[1]

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The paper presents the parametric identification of induction motor mathematical model with the use of genetic algorithm. The influence of population replacement strategy on the identification results is analyzed. The identified parameters of the model were determined as a result of minimization of performance index defined as the mean-square error of stator current and angular velocity. The experimental investigations were performed for induction motor powered from voltage inverter. The work deals with the problem of identification, genetic operators and replacement strategies. The algorithm was analyzed with regard to convergence and accuracy of identification process and the time of numerical calculations.

Paper: **6069** **D3P-E**

Hybrid Batch Reactor Modeling and Experimental Evaluation of Heat Transfer Process

Malgorzata Niedzwiedz[1], Piotr Laszczyk[2], Piotr Skupin[3], Mieczyslaw Metzger[4]

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In this paper a hybrid chemical reactor, known also as the partially simulated reactor, is presented. Such reactor consists of a jacketed vessel and LabVIEW based real-time simulator of a chemical reaction. This reactor can be used for testing advanced control strategies. Experimenting with the hybrid reactor exclude risk of a thermal runaway because the simulated chemical reaction can be stopped at any time. To make the hybrid reactor a highly nonlinear benchmark plant, the reaction parameters must be properly selected, taking into account all the constraints of the designed system. For this reason, preliminary tests using a numerical simulator were performed to avoid time consuming experiments with the hybrid reactor. In our research, we consider three different models of the batch hybrid reactor. Results show that an overall heat transfer coefficient cannot be assumed constant to obtain a good agreement between the simulation and the measurement data. Moreover, the overall heat transfer coefficient varies with flow through the jacket and a dispersion of its values is different for each model.

Paper: **6107** **D3P-E**

On Some Properties of ν-Similar One-Dimensional Birth-Death Processes

Marzena Filipowicz-Chomko[1], Ewa Girejko[2], Anna Poskrobko[3]

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The aim of this note is to exploit v-similarity of birth-and-death processes in one– dimensional case. In particular, a sufficient condition for two processes being similar is derived. We also give formulas for birth-and-death rates of similar processes. Example to illustrate the results is provided.

Paper: **6122** **D3P-E**

Developing a New Low and High Frequency Model to Three Phase Transformer by FRA Measurement

Moustafa Sahnoune Chaouche[1], Samir Moulahoum[2], Hamza Houassine[3]

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The behaviors analysis of the transformer is usually done using the FRA response, which is obtained by the application of a very low AC voltage in over a wide frequency range. However, this paper presents a high frequency modeling approach of a three-phase transformer, in addition, the developed model consists of a cascade of parallel RLC cells, whose parameters are identified using the FRA data measurements obtained on each transformer phase. Thus, the proposed model can simulate the frequency behavior of the transformer windings without resorting to the geometries of the coils which makes it easily usable in the failure diagnosis field. Experimental results on a 1kVA laboratory transformer validate the proposed model.

Paper: **6139** **D3P-E**

Rotational Speed Control of Multirotor UAV's Propulsion Unit Based on Fractional-Order PI Controller

Wojciech Giernacki[1], Talar Sadalla[2], Jarosław Gośliński[3], Piotr Kozierski[4], João Paulo Coelho[5], Saša Sladić[6]

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In this paper the synthesis of a rotational speed closed-loop control system based on a fractional-order proportional-integral (FOPI) controller is presented. In particular, it is proposed the use of the SCoMR-FOPI procedure as the controller tuning method for an unmanned aerial vehicle's propulsion unit. In this framework, both the Hermite-Biehler and Pontryagin theorems are used to predefine a stability region for the controller. Several simulations were conducted in order to try to answer the questions – is the FOPI controller good enough to be an alternative to more complex FOPID controllers? In what circumstances can it be advantageous over the ubiquitous PID? How robust this fractional-order controller is regarding the parametric uncertainty of considered propulsion unit model?

Paper: **6157** **D3P-E**

Toward Cache Based Decision Making Embedded Control Systems

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

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Typically, the deployment platform that is responsible for processing the information about a controlled system and provide control decisions are various kinds of embedded systems. These systems are known of increasing processing power yet the resource constraints are still a problem, especially when it comes to processing huge amounts of environmental information in real time. Implementing self-learning capability apart from an up-datable knowledge base will also a decision(s) cache that would allow to provide some ŕemembereddecisions rather than evaluate them from the very beginning. The aim of this paper is to analyse impact of a database system on the performance of the embedded control system through running sets of benchmarks involving various database systems.

Paper: **6165** **D3P-E**

Real-Time Monitoring System for Potentially Dangerous Activities Detection

Aleksandra Postawka[1]

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Cognitive impairments are an unavoidable community problem. People suffering from such diseases need all day long attention with varying care difficulty depending on the type of disorder. What makes care harder in the case of autism is the frequent occurrence of self aggressive behaviors. The monitoring system is supposed to detect such situations and differentiate them from similar normal activities. In this paper the Averaged Hidden Markov Models are used for potentially dangerous activities detection in the real time monitoring system. The acceleration measure has been used in order to discriminate dangerous and normal situations. Additionally algorithms for real time activity recognition have been presented. The experiments have been conducted for a set of data containing hitting and touching sequences obtained from the depth sensor.

Paper: **6170** **D3P-E**

Model of an Electric Vehicle Powered by a PV Cell – a Case Study

Adrian Chmielewski[1], Przemysław Szulim[2], Mariusz Gregorczyk[3], Robert Gumiński[4], Tomasz Mydłowski[5], Jędrzej Mączak[6]

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The paper presents a model of an electric vehicle with a thin flexible photovoltaic cell installed on the roof. The vehicle's model consists of the following sub-models: a set of batteries (LiFePO4), an electric machine, converters, resistance to motion and the gearbox model. Based on the analysis of an equivalent schematic for a photovoltaic cell, equations have been derived which account for the losses that occur in a real-life object. A simulation model has been developed in the Matlab&Simulink program while using the results of the analysis conducted for the physical models of the above-mentioned components of the electric vehicle – photovoltaic cell system. The driving cycle has been adopted on the basis of the road conditions while accounting for the changes in irradiance during the drive from Jelenia Góra to Olsztyn.

Paper: **6171** **D3P-E**

Model of a Stirling Engine with a Rhombic Drive: Case Study

Adrian Chmielewski[1], Robert Gumiński[2], Jędrzej Mączak[3], Tomasz Mydłowski[4]

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This work presents a dynamic model of the Stirling engine with a rhombic working mechanism which was combined with the thermodynamic model taking into consideration isothermal heat exchange in the compression and expansion spaces. On the basis of the conducted thermodynamic analysis for the working space in the Stirling engine and for the physical model of the rhombic drive system, a simulation model was developed using the Matlab&Simulink software. The model was prepared to analyse the influence of the selected thermodynamic and mechanical parameters including among other things: influence of the thermodynamic parameters, among others: temperature of the upper heat source on theoretical work increase and theoretical power. As a result of the performed simulations, the flow of the working gas mass at the control boundaries, as well as the heat flux waveforms were also shown, among other things.

Paper: **6215** **D3P-E**

Case Study of Switched Reluctance Motor for Use in the Electric Torque Tool

Jerzy Baranowski[1], **Tomasz Drabek**[2], **Tomasz Lerch**[3], **Paweł Piątek**[4]

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The paper presents a prototype of a high-speed Switched Reluctance Motor designed for power tools and results of simulations of the control system of this motor. The basic aims of the simulation was to determine the efficient control of the motor phases and to determine the electromagnetic torque ripple. Simulations have shown the necessity of modifying the drive control algorithm to reduce the amount of alternating components of the electromagnetic torque of the motor.

Signal Processing & Networked Control Systems, D4L-A

Day: Thursday, August 31, 2017
Time: 11:20 - 13:00
Room: Casino
Chair: Rafal Stanislawski

Paper: **6081** **D4L-A**

Base-Stock Distributed Inventory Management in Continuous-Review Logistic Systems – Control System Perspective

Przemyslaw Ignaciuk[1]

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In the paper, the dynamics of goods distribution systems managed according to the continuous-review base-stock inventory policy are investigated. As opposed to the previous studies, which limit the scope to the fundamental serial and tree-like settings, a multi-echelon mesh topology of interconnected actors (suppliers, distribution center, retailers) is considered. The exogenous, uncertain demand may be imposed on any node in the controlled system, not just conveniently selected end points. The stock replenishment orders are realized with nonnegligible delay. A state-space model to study the properties of base-stock policy is proposed. The choice of control system parameters for obtaining a high service level with reduced holding costs is discussed. The analytical findings are supported by numerical tests.

Paper: **6168** **D4L-A**

Determining Orientation of the Aerodynamically Adhesive Wall Climbing Robot

Vladislav Chashchukhin[1], Dmitri Knyazkov[2], Maxim Knyazkov[3], Armen Nunuparov[4]

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The paper considers determining the orientation of a vertically moving robot with an aerodynamic fixation. A design of the created robot is described. The problem of finding orientation of the robot from a data collected from an accelerometer sensor is considered. An accuracy and noise in the data are studied. The moving average filter for on-board real-time data processing is proposed and is implemented in the robot controller. The filter significantly decreases the noise level and makes the orientation data suitable for the robot operation.

Paper: **6243** **D4L-A**

Indirect Measurements of Milling Product Quality in the Classification System of Electromagnetic Mill

Dariusz Buchczik[1], Jan Wegehaupt[2], Oliwia Krauze[3]

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The article presents results of research on evaluation of the quality of material obtained in the milling and classification installation with the electromagnetic mill. The methods discussed in the paper are moisture content measurements of the milled material using impedance and IR absorption methods as well as vibration-based measurements of granularity and flow rate of the material. Indirect methods of moisture measurements provide satisfactory results, whereas vibration-based method fails in this case. The grains of copper ore examined in the experiments are too small and lightweight and the recorded acceleration signal is too noisy to be used.

Modelling and Simulation III, D4L-B

Day: Thursday, August 31, 2017
Time: 11:20 - 13:00
Room: Kalman
Chair: Jaroslaw Figwer

Paper: **6253** **D4L-B**

Multivariate Generalized Gaussian Function Mixture for Volume Modeling of Parathyroid Glands

Maria H. Listewnik[1], Hanna Piwowarska–Bilska[1], Krzysztof Safranow[1], Jacek Iwanowski[1], Maria Laszczyńska[1], Maria Chosia[1], Marek Ostrowski[1], Bozena Birkenfeld[1], Przemyslaw Mazurek[9]

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The main contribution of this paper is the proposal of volume modeling of parathyroid gland. Multivariate generalized Gaussian distribution (Multivariate GGD) mixture is assumed. Random walk optimization algorithm is applied for the estimation of parameters. There are 800 synthetic test cases applied for the evaluation of algorithm properties. Example result for real SPECT data are also shown. The essential is the computation time, so GPGPU implementation is proposed for reduction of processing time. Obtained parameters of mixture are required for further analysis of relation to patient data.

Paper: **6106** **D4L-B**

Takagi-Sugeno Fuzzy Model of Dissolved Oxygen Concentration Dynamics in a Bioreactor at WWTP

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The importance of dissolved oxygen (DO) concentration control in aeration tanks of a bioreactor at flow-through wastewater treatment plant (WWTP) can easily be justified by technological requirements as well as simple economics. Firstly, appropriate levels of DO concentration are essential for the vitality of microorganisms that comprise the bioreactor. Secondly, the costs of DO concentration control related to the blower station operation constitute up to 75

Control Applications IV, D4L-C

Day: Thursday, August 31, 2017
Time: 11:20 - 13:00
Room: Lehar
Chair: Vaclav Zada

Paper: **6058** **D4L-C**

Desiginig of Active Vibration Control System for Smart Structure 2-D with Non-Collocated Piezo-Elements

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To design vibration control system for flexible structures their mathematical model should be reduced. In the paper we consider the influence of the model reduction on the dynamics of the real closed-loop system. A SFSF smart plate as a TITO system is an object of consideration since we are able to formulate the exact analytical model of such structure. As a result of reduction the model with low frequency resonances is usually separated from the high frequency dynamics because high frequency part of the model is naturally strong damped. In order to estimate dynamical system for control purposes in the paper we applied a few orthogonal methods such as: modal and Schur decompositions. As it is shown all methods well calculate resonances frequencies but generate different anti-resonances frequencies. From control strategy in point of view of the flexible structures these anti-resonances have significantly influence on the stability and dynamics of the closed-loop systems.

Paper: **6104** **D4L-C**

Reconfiguration of Fixed-Wing UAV Control System in Autonomous Flight

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A reconfiguration method using model-based control allocation scheme is proposed in this paper. A reconfigurable closed-loop control system is established for control of a UAV fixed wing aircraft in autonomous flight in case of single and multiple control surfaces failures. The control allocation is determined by using of a nonlinear dynamic model of a UAV aircraft. The model is also used to demonstrate the proposed method. Simulation results show that the damaged aircraft control via proposed reconfiguration method can be carried out and satisfactory controllability performance may be achieved.

Paper: **6127** **D4L-C**

Deep Neural Networks Approach to Skin Lesions Classification – a Comparative Analysis

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The paper presents the results of research on the use of Deep Neural Networks (DNN) for automatic classification of the skin lesions. The authors have focused on the most effective kind of DNNs for image processing, namely Convolutional Neural Networks (CNN). In particular, three kinds of CNN were analyzed: VGG19, Residual Networks (ResNet) and the hybrid of VGG19 CNN with the Support Vector Machine (SVM). The research was carried out with the use of database of over 10 000 images representing skin lesions: benign and malignant. Because of an uneven number of images representing different classes of lesions, the up-sampling of underrepresented class was applied. The comparison of the CNN structures with respect to the accuracy, sensitivity and specificity was performed using k-fold validation method.

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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.