WELCOME from the MMAR 2016 Organizing Committee

I would like to invite you to Międzyzdroje, Poland for the 21st 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 210 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, 29 August 2016. 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 2016 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 2016 Organizing Committee
Faculty of Electrical Engineering
West Pomeranian University of Technology, Szczecin

Organizer

Faculty of Electrical Engineering,
West Pomeranian University
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During the Conference

Amber Baltic Hotel
Promenada Gwiazd 1
PL-72-500 Międzyzdroje, Poland
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WWW Site

The Final Program
of the MMAR 2016 Conference
can also be found on the Internet at:
`http://www.mmar.edu.pl`

Conference Proceedings

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

The Conference Proceedings are also attached to this booklet.

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 21st in a series which started in 1994.

Venue and dates

The Conference will be held at the Amber Baltic Hotel in Miedzyzdroje, from Monday, 29 August till Thursday, 1 September 2016. The Conference registration desk in Amber Baltic Hotel will be opened on the Monday morning, 29 August and during each day of the Conference. The Conference will start on Monday, 29 August at 3:00 p.m.

Presentation facilities

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

The official language of the Conference is English.

International Program Committee

We would like to thank the program committee members for contributing to the success of MMAR 2016 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 2016:

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Signal Processing and Networked Control Systems	Roman Kaszyński
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Control and Optimization of Infinite Dimensional Systems	Adam Kowalewski

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We would like to thank the following individuals for their efforts in the review process of MMAR 2016:

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Monday, Aug 29th, 2016

	Casino	Kalman	Lehar	Strauss
15.00-15.10	Conference Opening (Casino)			
15.10-16.10	Plenary Lecture (Casino), Chair: *Andrzej Bartoszewicz* , page 16 **Self-Optimizing Active Control of Narrowband Acoustic Noise** **Maciej Niedzwiecki**			
16.10-16.30	*Coffee break*			
16.30-17.50	A2L-A, page 16 **Robotics I** *Krzysztof Kozłowski*	A2L-B, page 18 **Signal Processing I** *Witold Mickiewicz*	A2L-C, page 20 **Control and Systems Theory I** *Jerzy Klamka*	A2L-D, page 22 **Iterative Learning Control** *Marcin Witczak*
16.30-17.50	A3P-E, page 24 **Poster I Session** *Krzysztof Okarma*			
19.00	Welcome Party (Chopin)			

Tuesday, Aug 30th, 2016

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Tadeusz Kaczorek* , page 32 **New Results on Switched Systems with Positivity Constraints** **Maria Elena Valcher**			
10.00-11.00	B2L-A, page 32 **Fractional Order Systems I** *Piotr Ostalczyk*	B2L-B, page 34 **Robotics II** *Ryszard Beniak*	B2L-C, page 35 **Identification** *Andreas Rauh*	B2L-D, page 37 **Control and Optimization of Infinite Dimensional Systems I (Invited)** *Adam Kowalewski*
10.00-12.00	B3P-E, page 38 **Poster II Session** *Przemyslaw Mazurek*			
11.00-11.20	*Coffee break*			
11.20-13.00	B4L-A, page 43 **Stability Analysis** *Wieslaw Krajewski*	B4L-B, page 45 **Robotics III** *Alexander Winkler*	B4L-C, page 48 **Modelling and Simulation I** *Ewa Niewiadomska-Szynkiewicz*	B4L-D, page 50 **Signal Processing II** *Krzysztof Okarma*
13.00-15.00	*Lunch*			
15.00-16.20	B5L-A, page 52 **Sliding Mode Control** *Wojciech Hunek*	B5L-B, page 54 **Control Applications I** *Jaroslaw Figwer*	B5L-C, page 56 **Robotics IV** *Cosmin Copot*	B5L-D, page 58 **Control and Optimization of Infinite Dimensional Systems II (Invited)** *Adam Kowalewski*
15.00-17.00	B3P-E, page 38 **Poster II Session** *Przemyslaw Mazurek*			
16.20-16.40	*Coffee break*			
16.40-18.00	C1L-A, page 67 **Predictive Control I** *Ryszard Palka*	C1L-B, page 69 **Ship Modelling and Control** *Janusz Szpytko*	C1L-C, page 71 **Robotics V** *Janusz Jakubiak*	C1L-D, page 73 **Distributed Parameter Systems** *Johannes Reuter*
19.00	Conference Banquet (Międzyzdroje International House of Culture)			

Wednesday, Aug 31st, 2016

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Krzysztof Kozłowski* , page 78 **Collaborative Robotics: from Workspace Sharing to Physical Interaction** **Vincent Padois**			
10.00-11.00	C3L-A, page 78 **Control and Systems Theory II** *Krzysztof Galkowski*	C3L-B, page 80 **UAVs** *Bogdan Kreczmer*	C3L-C, page 81 **Signal Processing III** *Przemyslaw Ignaciuk*	C3L-D, page 83 **Biological Modelling and Simulation** *Jozef Korbicz*
10.00-12.00	C4P-E, page 84 **Poster IV Session** *Rafal Stanislawski*			
11.00-11.20	*Coffee break*			
11.20-13.00	C5L-A, page 90 **Fractional Order Systems II** *Krzysztof Latawiec*	C5L-B, page 92 **Fault Detection** *Andreas Rauh*	C5L-C, page 95 **Modelling and Simulation II** *Joachim Horn*	C5L-D, page 97 **Robotics VI** *Ian Walker*
13.00-15.00	*Lunch*			
15.00-16.00	C6L-A, page 100 **Nonlinear Control** *Andrzej Bartoszewicz*	C6L-B, page 101 **Optimization I** *Ewa Pawluszewicz*	C6L-C, page 103 **Predictive Control II** *Harald Aschemann*	C6L-D, page 104 **Modelling and Simulation III** *Roman Smierzchalski*
16.45	Touristic Programme Bus to the Fort Gerhard, Świnoujście (leaving from the Amber Hotel)			

Thursday, Sep 1st, 2016

	Casino	Kalman	Lehar	Strauss
9.00-10.00	Plenary Lecture (Casino), Chair: *Jozef Korbicz* , page 108 **Intelligent Fault Monitoring of Critical Infrastructure Systems** **Marios M. Polycarpou**			
10.00-11.00	D2L-A, page 108 **Adaptive Control I** *Maciej Lawrynczuk*	D2L-B, page 109 **Control and Systems Theory III** *Tadeusz Kaczorek*	D2L-C, page 111 **Control Applications II** *Marian Blachuta*	D2L-D, page 112 **Robotics VII** *Przemyslaw Mazurek*
10.00-12.00	D3P-E, page 114 **Poster V Session** *Pawel Dworak*			
11.00-11.20	*Coffee break*			
11.20-13.00	D4L-A, page 120 **Adaptive Control II** *Krzysztof Latawiec*	D4L-B, page 123 **Optimization II** *Andrzej Myslinski*	D4L-C, page 125 **Modelling and Simulation IV** *Wojciech Hunek*	D4L-D, page 128 **Signal Processing IV** *Rafal Stanislawski*
13.00-15.00	*Lunch*			
13.15-13.30	Young Author Award Ceremony (Chopin)			
13.30	Farewell Lunch			

Monday
August 29th, 2016

Plenary Lecture I Session, A1L-A

Day: Monday, August 29, 2016
Time: 15:10 - 16:10
Room: Casino
Chair: Andrzej Bartoszewicz

Paper: **6279** **A1L-A**

Self-Optimizing Active Control of Narrowband Acoustic Noise

Maciej Niedzwiecki [1]

[1] *Gdansk University of Technology, Poland* maciekn@eti.pg.gda.pl

Robotics I Session, A2L-A

Day: Monday, August 29, 2016
Time: 16:30 - 17:50
Room: Casino
Chair: Krzysztof Kozłowski

Paper: **6129** **A2L-A**

Solvability of Reactions and Inverse Dynamics Problem for Complex Kinematic Chains

Marcin Pękal [1], **Janusz Frączek** [2], **Paweł Tomulik** [3]

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Driving forces and joint reactions for a known, prescribed motion of a robot have to be determined. For robots with complex kinematical structure and/or redundantly actuated the inverse dynamic problem may have non-unique solution. Certain driving forces or selected reactions in some joints may still be unique. The paper presents a general method of detection of unique drives and joint reactions. The kinetostatic analysis with free-body diagram is used. Three variants of the method are proposed: rank comparison method, and QR and SVD based methods. Two simple robotic systems are considered as examples: planar gripper and spatial redundant manipulator.

Paper: **6134** **A2L-A**

ArchGenTool: a System-Independent Collaborative Tool for Robotic Architecture Design

Emanuele Ruffaldi [1], Giannis Kostavelis [2], Dimitris Giakoumis [3], Dimitrios Tzovaras [4]

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[2] *Information Technologies Institute / CERTH, Greece* gkostave@iti.gr
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[4] *Information Technologies Institute / CERTH, Greece* dimitrios.tzovaras@iti.gr

Complex robotic architectures require a collaborative effort in design and adherence to the design in the implementation phse. ArchGentTool is a collaborative architecture generation tool which supports the design of the robotic architecture in a multi-level fashion. It comprises high-level conceptual analysis of the system to be designed, as well as low-level implementation breakdown of its functional components, acting complementary to the ROS framework. The tool facilitates reusability and expandability of the architecture to any robotic system, as it can be adapted to different specifications. A case study with the RAMCIP service robot is presented.

Paper: **6149** **A2L-A**

Output Robust Control with Anti-Windup Compensation for Robotic Boat

Oleg Borisov [1], Vladislav Gromov [2], Anton Pyrkin [3], Alexey Bobtsov [4], Igor Petranevsky [5], Alexey Klyunin [6]

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In this paper a problem of saturated control for a robotic boat with unknown parameters and unmeasurable velocity and acceleration is addressed. The controller design is based on the output robust control approach "consecutive compensator". It was augmented with an integral loop, which allows to eliminate a static error and implement the anti-windup scheme to reduce overshoot of the output variable. As result, the regulator generating the bounded control signal and avoiding windup for the boat was obtained. The efficiency of the proposed algorithm was illustrated by the experimental approval using the robotic boat setup. The comparison between three types of controllers (regular consecutive compensator, integral modification and one equipped with anti-windup) is presented.

Paper: **6033** **A2L-A**

Explicit and Implicit Force Control of an Industrial Manipulator - an Experimental Summary

Alexander Winkler [1], **Jozef Suchý** [2]

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[2] *Matej Bel University, Technische Universität Chemnitz, Slovakia* jozef.suchy@etit.tu-chemnitz.de

This paper investigates simple explicit and implicit force control approaches for industrial robots. They are applied to impact and contact control. Furthermore, some of these algorithms are used for force controlled contour following, extended by additional features to improve the control behavior. A lot of approaches published in the past are not easy to implement in commercial robot controllers, because the access to robot joint torques is assumed or the exact dynamic model of the manipulator is used. For that reason we investigated only position based algorithms which can be implemented on a position controlled robot. All algorithms proposed in this paper are successfully verified by practical experiments.

Signal Processing I Session, A2L-B

Day: Monday, August 29, 2016
Time: 16:30 - 17:50
Room: Kalman
Chair: Witold Mickiewicz

Paper: **6017** **A2L-B**

Signal Fusion of Changes in the Inductive Loop Impedance Components for Vehicle Axle Detection

Zbigniew Marszalek [1], **Ryszard Sroka** [2]

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[2] *AGH University of Science and Technology, Poland* ryszard.sroka@agh.edu.pl

The possibility of using the inductive loop sensor as an efficient axle detector of vehicles is presented in the hereby paper. The fundamental condition for using such sensors is the proper selection of its geometrical dimensions. The original conditioning system was applied for cooperating with the sensor. At this system's output two signals (magnetic profiles) proportional the changes in its impedance components are obtained. Identification results of the function parameters allowing the optimal fusion of the conditioner output signals for various vehicle classes, as well as the axle detection algorithm, were also presented. The applying inductive sensors good point is the possibility of detecting lifted axles in vehicles, which is impossible when currently widespread load sensors are applied.

Paper: **6025** **A2L-B**

SoftPOSIT Enhancements for Monocular Camera Spacecraft Pose Estimation

Jian-Feng Shi [1], **Steve Ulrich** [2]

[1] *Carleton University, Canada* *jianfeng.shi@carleton.ca*
[2] *Carleton University, Canada* *steve.ulrich@carleton.ca*

This paper propose several enhancements to the softPOSIT algorithm with applications to spacecraft pose estimation using a monocular camera. First, the proposed enhancements include a technique for reducing false matches as result of local minimum trapping. Second, this paper provides two strategies for iteration control parameter initialization by using trace of the correspondence distance, and by using image centroid matching. The method of image centroid matching allows the world model center of geometry to align with the image centroid. The alignment result in reasonable correspondence weighting values used for match optimization. The various algorithm enhancements were tested on 26,180 simulations with varying geometries and initial pose conditions. Results show a significant increase in accuracy when compared with the original method.

Paper: **6214** **A2L-B**

Implementation of Non-Zero Initial Conditions for Multi-Notch FIR Filter Using Raspberry Pi

Sławomir Kocoń [1], **Jacek Piskorowski** [2]

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In this paper a concept of finite impulse response narrow multi-band-stop filter with non-zero initial conditions based on linear Kalman prototype filter is proposed. The FIR multi-notch filter is used for removing power-line interferences from biomedical sources such as ECG. In order to reduce the duration of the transient state of the proposed FIR multinotch filter, optimal initial conditions for the filter have been determined. The algorithm for finding the length of the initial conditions vector is presented. The proposed filter is tested using sinusoidal and ECG signals. Computer simulations, hardware implementation, and performance indices demonstrate that the proposed FIR multi-notch filter with non-zero initial conditions based on the Kalman prototype filter possesses better properties than the traditional FIR multi-notch filter.

Paper: **6069** **A2L-B**

Real Time Localization System with Extended Kalman Filter for Indoor Applications

Slawomir Romaniuk [1], Leszek Ambroziak [2], Zdzisław Gosiewski [3], Pekka Isto [4]

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This paper presents the radio based localization system for indoor applications. For position determination radio COTS transceiver chip was used. Localization accuracy was improved by developing Extended Kalman Filter with modified PV model. Mathematical model of the nonlinear filter was presented and implemented. The described model as well as designed localization system was tested in a realistic environment. Presented results show accuracy of the localization system and enable the assessment possibility of using proposed localization system in further navigational investigations.

Control and Systems Theory I Session, A2L-C

Day: Monday, August 29, 2016
Time: 16:30 - 17:50
Room: Lehar
Chair: Jerzy Klamka

Paper: **6049** **A2L-C**

Linearization by Generalized Input-Output Injections on Homogeneous Time Scales

Monika Ciulkin [1], Ewa Pawłuszewicz [2], Vadim Kaparin [3], Ülle Kotta [4]

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The problem of linearization by generalized input-output injections is addressed for nonlinear multi-input single-output systems, described by higher order input-output delta differential equations, defined on homogeneous time scales. Necessary and sufficient conditions are formulated in terms of differential forms, associated with the input-output equation of the system. The paper provides a step-by-step algorithm for verification of the necessary and sufficient conditions and computation of generalized input-output injections.

Paper: **6097** **A2L-C**

Dynamic Stabilization of the Pendulum in a Moving Potential Well

Maciej Ciężkowski [1]

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The paper presents a new approach to the dynamic stabilization of the pendulum in an arbitrary angle. In this approach the desired angle of the pendulum's position is changed in time. This is achieved by controlling the angle of oscillations of the pendulum's suspension point which leads to controlling the pendulum in a moving potential well. The exemplary form of the input control was proposed and then the ability to control the pendulum was confirmed by numerical analysis. Additionally, the transition of the pendulum through the whole range of its angle position has been shown.

Paper: **6084** **A2L-C**

Computation of Final Dimension Initial Conditions and Inputs for Given Outputs of Differential-Algebraic Systems with Delay

Zbigniew Zaczkiewicz [1]

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The problem of computation of the initial date of finite dimension and inputs for given outputs of linear differential-algebraic systems with delay (DAD) is formulated and solved. Necessary and sufficient conditions for existence of solution to the problem are established. It is shown that there exist the unique solutions to the problem if DAD system is relatively observable.

Paper: **6197** **A2L-C**

Contribution of a New Matrix H-Inverse to Stabilizing the Perfect Control for LTI MIMO State-Space Systems

Wojciech Hunek [1]

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In this paper an useful application of a new right H-inverse to stabilization of perfect control for LTI MIMO discrete-time systems in state-space is shown. Following the recently introduced H-inverse, its intriguing property giving the stable perfect control is indicated here. Now, the SVD-based H-inverse with parameter and polynomial degrees of freedom clearly outperforms the classical minimum-norm right T-inverse in terms of its contribution to stable perfect control design. Simulation studies performed in Matlab environment confirm the big potential of the proposed method over existing ones.

Iterative Learning Control Session, A2L-D

Day: Monday, August 29, 2016
Time: 16:30 - 17:50
Room: Strauss
Chair: Marcin Witczak

Paper: **6135** **A2L-D**

Optimal Sensor Selection for Model Identification in Iterative Learning Control of Spatio-Temporal Systems

Damian Kowalów [1], Maciej Patan [2]

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An approach to sensor location problem for parameter estimation of a distributed system controlled under repetitive regime is presented. In order to reduce the uncertainty of the model used for the control design, thus increasing the system performance, the iterative learning control scheme is extended with parameter estimation of mathematical model with the use of the sequential experimental design. The related sensor location problem corresponds to situation where from among all potential sites where the sensors can be placed we have to select a subset which provide the most informative measurements in order to update the system parameter estimates. Thus, in each process trial, both the control performance and process model can be substantially improved. As an illustration of the proposed approach the application to nontrivial chemical process of fuel combustion is given

Paper: **6155** **A2L-D**

Design of Iterative Learning Control Schemes for Systems with Sector-Bounded Nonlinearities

Wojciech Paszke [1], Marcin Boski [2], Eric Rogers [3], Krzysztof Gałkowski [4]

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This paper develops a convex optimization approach to the problem of designing iterative learning control laws design for discrete-time systems with a static nonlinearity. The nonlinear part is assumed to be sector bounded, where such nonlinearities often arise in applications. For systems with such nonlinearities the repetitive process setting is exploited to develop a linear matrix inequality based conditions for computing the feedback and feedforward (learning) controllers. These controllers guarantee acceptable dynamics along the trials and ensure monotonic convergence of the trial-to-trial error dynamics, respectively. A simulation example is given to illustrate the new design scheme.

Paper: **6036** **A2L-D**

Optimal Iterative Learning Control of a PEM Fuel Cell System During Purge Processes

Christian Hähnel [1], Andreas Cloppenborg [2], Joachim Horn [3]

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This paper deals with an Optimal Iterative Learning Control approach for the anode pressure during the periodic purge processes of a fuel cell system. Due to accumulation of diffused nitrogen and water condensate inside the anode volume the chemical reaction is restrained. This adverse effect is avoided through the purge process, by which a short time opening of the exhaust valve forces the nitrogen and water out of the system. Unfortunately, the opening leads to a pressure drop along the anode volume that causes a force to the membrane. To avoid this mechanical stress the control aim is a constant anode pressure during the purge process by supplying additional hydrogen. An Iterative Learning Control is suited for the multiple times executed purge procedure. For this purpose, the nonlinear characteristics of the fuel cell system model are transferred into time-variant, linearized state-space models in discrete-time domain to create learning filters. In order to achieve a fast convergence by a strictly monotonously reduction of the control error, the control problem becomes a minimization problem and therefore an Optimal Iterative Learning Control is applied.

Paper: **6076** **A2L-D**

Hybrid Repetitive Controller Using a Stochastic Evolutionary Search and a Deterministic Iterative Learning Law

Bartlomiej Ufnalski [1], Michal Malkowski [2], Lech Grzesiak [3]

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The paper proposes a significant modification to the plug-in direct multi-swarm repetitive controller. Due to the nature of the particle swarm optimization algorithm used to solve the dynamic optimization problem posed by the repetitive control task in real time, the responsiveness of the original controller was relatively sluggish. On the other hand, the classic P-type iterative learning control law offers fast response. Unfortunately, it does not offer a practical level of robustness if not filter augmented, e.g. a repetitive disturbance can easily destabilize the system. Here a hybridization is proposed to combine the advantages of both approaches.

Poster Session I, A3P-E

Day: Monday, August 29, 2016
Time: 16:30 - 17:50
Room: Poster Area
Chair: Krzysztof Okarma

Paper: **6026** **A3P-E**

Transformation of a Fuzzy Interpreted Petri Net Diagram Into Structured Text Code

Michał Markiewicz [1], Łukasz Surdej [2], Lesław Gniewek [3]

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The use of Petri nets (PNs) to create control systems has many advantages, because of their formalism, graphical presentation and the possibility of parallel processes control. One of the few fuzzy PNs that was used directly in the control system is the fuzzy interpreted Petri net (FIPN). However, there is a long way from a control algorithm in the form of FIPN to its practical implementation. The paper proposes a method of partially automatic program code generation using Structured Text (ST) supported by the IEC 61131-3 from graphical form of FIPN. To carry out the research FIPN Simulator (called the FIPN-SML) was used. This computer tool allows modeling of the graphic form of FIPN and automatic creating PLC program.

Paper: **6042** **A3P-E**

Estimation of the Blood Volume in Pneumatically Controlled Ventricular Assist Device by Vision Sensor and Image Processing Technique

Krzysztof Murawski [1], Tadeusz Pustelny [2], Leszek Grad [3], Monika Murawska [4]

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The paper presents research of measuring the blood chamber volume of a ventricular assist device (VAD) using vision sensor and image processing technique. During research, the modified method was used of measuring the distance to an object based on one image obtained from a motionless camera with a fixed-focus lens. The paper presents the VAD model, measurement station as well as results of experiments.

Paper: **6047** **A3P-E**

Multiple Models Input-Output Adaptive Controller Applied to Ionic Polymer Metal Composite

Jakub Bernat [1], **Jakub Kolota** [2]

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Ionic Polymer Metal Composites(IPMCs) belong to the class of wet Electro-active Polymers (EAPs) and is promising candidate actuator for various potential applications mainly due to its flexible, low voltage-power requirements, small and compact design and lack of moving parts. Among the smart materials available, IPMCs seem to fit nicely in the constraints of robotics because they react mechanically when stimulated by an electrical signal. However, being a widely used material in industry, it requires complex control methods due to its strongly nonlinear nature. This paper presents a novel approach to tuning multiple models adaptive controller. By adding additional filters we significantly improve convergence of the estimates to the true values of the IPMC parameters as compared to conventional adaptive controllers. Numerical results and comparison with experimental data are presented. The effectiveness of the proposed multiple models adaptive control strategy is verified in experiments.

Paper: **6065** **A3P-E**

Robust Tuning for First-Order Reduced Active Disturbance Rejection Controller

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

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In this paper, the robust tuning method for First-Order Active Disturbance Rejection Control based on Reduced-Order Extended State Observer is proposed. Its robustness is ensured by defining gain margin and phase margin constraints and then, for these constraints, the optimal load disturbance rejection is ensured by suggested tuning method in terms of optimal Integral Absolute Error. The D-partition method and virtual gain-phase margin tester is used to determine gain and margin boundaries, while optimization of ADRC tuning parameters is based on Nelder-Mead numerical algorithm. Suggested tuning method is tested by simulation.

Paper: **6073** **A3P-E**

Implementation of Non-Integer $PI^{\lambda}\ D^{\mu}$ Controller for the ATmega328P Micro-Controller

Waldemar Bauer [1]

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Nowadays, non-integer controllers are a widely researched problem. One of questions, that is of great importance, is the design of non-integer order controllers and their approximation. In this paper the author presents an implementation method non-integer order controller of ATmega328P micro-controller. Experiments compared with Matlab Simulink simulation result of non-integer order controller response show consistency of implementation with desired behaviour. The presented approach is promising and can be successfully used in multiple applications.

Paper: **6118** **A3P-E**

Comparison of Real-Time Industrial Process Control Solutions: Glass Melting Case Study

Wojciech Grega [1], **Andrzej Tutaj** [2], **Maciej Klemiato** [3], **Witold Byrski** [4]

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Two solutions supporting advanced control algorithms in real-time are described and compared in the paper: SCADA-based system and a custom QNX-based system. As an implementation example control of the glass melting and conditioning process, which is considered to be difficult and demanding for control applications in glass industry, is given in the paper.

Paper: **6132** **A3P-E**

Recurrent Neural Controller Applied for Two-Mass System

Marcin Kamiński [1]

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In this paper the structure, data processing and adaptation algorithm of neural adaptive controller are described. The topology of the analyzed neural network is similar to the Jordan structure, which contains internal feedback. Fixed parameters of the controller were optimized according to the BAT algorithm. The neural model is applied in a speed control loop of the electrical drive with elastic joint. In order to obtain better damping of state variables oscillations and higher quality of control, applied controller uses two state variables of two-mass system: motor speed and shaft torque. Tests of the designed control structure has been prepared for nominal and disturbed parameters of the plant.

Proposed control structure was analyzed in simulations and experiment (prepared using dSPACE1103card).

Paper: **6136** **A3P-E**

Heading Control System with Limited Turning Radius Based on IMC Structure

Krzysztof S. Kula [1]

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The paper presents a concept of a ship motion control system, which is able to perform a turn along the desired circle. The proposed course control autopilot employs the structure of the cascade system and the Internal Model Control approach, which ensures high quality of operation during course-tracking, obtained by extension to the nonlinear form. The article presents results of simulations illustrating advantages of the tested ship motion control method.

Paper: **6153** **A3P-E**

Optical PMD 3D Sensor Evaluation for Motion Detection and Tracking Application

Tomasz Kłopot [1], **Grzegorz Polaków** [2], **Ireneusz Parysz** [3]

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In this paper the statistical properties and characteristics are investigated and identified of the depth image created by the commercial off-the-shelf ToF PMD (Photonic Mixer Device Time of Flight) 3D sensor. For this purpose, a special application that communicates with the sensor through the XML RPC protocol (eXtensible Markup Language Remote Procedure Call) was developed. Using, the identified sensor characterisics, the boundaries of the applicability of such a sensor in different applications may be determined. As an example, the use of the sensor for detecting and tracking the movement of small parts or animals is presented.

Paper: **6158** **A3P-E**

Analysis of Inverter-Fed Drive of Hydraulic Pump in Volumetric Control System

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

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The problems of inverter-fed drive of hydraulic pump in volumetric control system with use typical motors, i.e.: induction (AC), brushless DC (BLDC) and synchronous permanent magnet (PMSM) have been analysed. Laboratory results of volumetric control were compared with results of throttling control of hydraulic drive system. In the speed and flow control of hydraulic systems the conventional type controllers were used. The tests were carried out for the drives with motors of 2,5 kW.

Paper: **6182** **A3P-E**

Hybrid Excited Claw Pole Electric Machine

Marcin Wardach [1]

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The paper presents the concept and results of simulation and experimental research of a claw pole generator with hybrid excitation. Hybrid excitation is performed with a conventional coil located between two parts of the claw-shape rotor and additional permanent magnets which are placed on claw poles. Within the research first a simulation and next constructed experimental model has been developed on the basis of the mass-produced vehicle alternator. Experimental researches have shown that - at a suitable rotational speed - it is possible to self-excite of the generator without any additional source of electrical power.

Paper: **6196** **A3P-E**

Microgrid Energy Management System

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

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The article presents a flexible, configurable microgrid's resources control system, which executes the task of meeting the electricity demand of local households with regard to economic issues. A decentralized control structure using controllers located in each household, built on open code optimizers and low-cost hardware was developed. A configurable optimization task, which takes into account settlement system between participants, as well as the possible need for withdrawal of the device, e.g. due to damage was defined.

A comprehensive verification was done, using simulations for the sample microgrid with different ways of generating and storing.

Paper: **6217** **A3P-E**

Efficiency Optimal Control System of Hybrid Excited Machines

Michal Bonislawski [1], Ryszard Pałka [2]

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The paper introduces an "a-priori" look-up-table procedure for an efficiency-optimal inverter-machine control system. This method has been applied for a hybrid excited permanent magnet synchronous machine. An exemplary machine model is proposed and a prototype is introduced with stator-located excitation coil. An iterative process for optimal current distribution is described, including multidimensional tables of overall losses and efficiencies. Based on appropriate calculations, an optimization algorithm can be implemented for various target functions, including classic permanent magnet synchronous machines. The proposed approach has been validated using experimental data. Modeling and experimental results are presented, along with corresponding conclusions.

Paper: **6195** **A3P-E**

Real-Time Detection of Hand Gestures

Piotr Muzyka [1], Marek Frydrysiak [2], Elzbieta Roszkowska [3]

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This paper presents an approach to the gesture recognition problem, which might be valuable in development of social robots, companions for deaf-mute people or in design of new control methods. A universal PC application for gesture recognition in image sequence acquired from a simple USB camera in real-time was made. The application recognises hand gestures which indicate chosen letters from the sign language alphabet and can be adjusted to any hand-shape pattern. The algorithm is resistant to most lighting changes, different sizes and shapes of users' hands and background patterns.

Tuesday
August 30th, 2016

Plenary Lecture II Session, B1L-A

Day: Tuesday, August 30, 2016
Time: 09:00 - 10:00
Room: Casino
Chair: Tadeusz Kaczorek

Paper: **6276** **B1L-A**

New Results on Switched Systems with Positivity Constraints

Maria Elena Valcher [1]

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Fractional Order Systems I Session, B2L-A

Day: Tuesday, August 30, 2016
Time: 10:00 - 11:00
Room: Casino
Chair: Piotr Ostalczyk

Paper: **6271** **B2L-A**

Modeling and Identification of Fractional First-Order Systems with Laguerre-Grünwald-Letnikov Fractional-Order Differences

Rafał Stanisławski [1], **Krzysztof Latawiec** [2], **Marian Łukaniszyn** [3], **Wojciech Czuczwara** [4], **Ryszard Kopka** [5]

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This paper introduces a method for modeling and identification of a simple dynamical system described by fractional-order differential equation. The Grunwald-Letnikov fractional-order derivative is approximated by a discrete-time Laguerre-based model, giving rise to a new discrete-time integer-order equation modeling the considered system. An application example involves a supercapacitor charging circuit. High accuracy of parametric identification for the circuit model, under moderate computational effort, is achieved on a real-life experimental data.

Paper: **6219** **B2L-A**

Quadrature Based Approximations of Non-Integer Order Integrator on Infinite Integration Interval

Jerzy Baranowski [1], **Marta Zagórowska** [2]

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Non-integer order systems take an increasing part in science and engineering. Unfortunately for practical applications they posses infinite memory. In order to realize such system one needs to use approximations. In this paper a novel method of approximation of non-integer order integrator $1/s^{\alpha}$ is considered. This method is based on approximating the so called diffusive realization of integrator with quadratures on infinite intervals. In particular convergence and quality of approximation is investigated, with H^{∞} norm used as performance indicator. Merits and weaknesses of the method are analyzed and discussed.

Paper: **6011** **B2L-A**

Parameter Identification for Non Integer Order, State Space Models of Heat Plant

Krzysztof Oprzedkiewicz [1], **Wojciech Mitkowski** [2], **Edyta Gawin** [3]

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In the paper the parameter idetification problem for new, non integer order, state space models of heat transfer proces is presented. The solution of all proposed state equations bases directly onto definitions of suitable non integer order differences. The parameters estimation is done with the use of known cost functions: MSE (Mean Square Error) and FPE (Final Prediction Error). The order of all proposed state-space models is also estimated. Results of experiments show, that all proposed non integer order models are more accurate in the sense of MSE cost function than known integer order model.

Robotics II Session, B2L-B

Day: Tuesday, August 30, 2016
Time: 10:00 - 11:00
Room: Kalman
Chair: Ryszard Beniak

Paper: **6048** **B2L-B**

Link Length Optimization of a Biomimetic Robotic Fish Based on Big Bang - Big Crunch Algorithm

Cafer Bal [1], Deniz Korkmaz [2], Gonca Ozmen Koca [3], Mustafa Ay [4], Zuhtu Hakan Akpolat [5]

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This paper is concerned with the link length optimization method of a biomimetic Carangiform robotic fish with multi-link propulsion mechanism. Motion characteristic of a real fish depends on the body traveling wave and propulsion mechanism of the robotic fish should imitates the traveling wave function. In order to imitate the body traveling wave with minimum error, intersection method is used and Big Bang – Big Crunch (BB-BC) optimization algorithm is adapted to this method. BB-BC algorithm is a heuristic and evolutionary optimization method. BB-BC is preferred in many nonlinear engineering problems because of the low computation time and very fast convergence speed. As a results, optimum link lengths and endpoints of the each joint are determined by using this combined method. Numerical results show that precise fitting effects and link length optimization can improve the propulsion efficiency of the robotic fish. Also, optimum links are proportioned according to actual size of a real Carangiform carp fish in the main axis and free swimming gaits of the real carp are proved.

Paper: **6066** **B2L-B**

Solving the Inverse Dynamics of a Flexible 3D Robot for a Trajectory Tracking Task

Arthur Lismonde [1], Olivier Brüls [2], Valentin Sonneville [3]

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The end-effector trajectory tracking of robotic manipulators with flexible links requires advanced control concepts. In order to compute the feedforward component of the control scheme, the inverse dynamics of such flexible 3D multibody system is solved using an

optimal control method. The robot is modeled using nonlinear finite elements formulated on the SE(3) group. Hence singularity and parameterization issues that can arise from 3D rotations are avoided. A numerical example of a 3D flexible arm is analyzed to demonstrate the capabilities of the method.

Paper: **6092** **B2L-B**

Logical Architecture of Medical Telediagnostic Robotic System

Bartłomiej Stańczyk [1], Adam Kurnicki [2], Krzysztof Arent [3]

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This paper discusses the issue of designing the logical architecture of a control system intended for a complex medical robot. The considered robot is designed for tele-examination of patients. The logical architecture is a part of this work. We present its overall structure and discuss selected components. The logical architecture is presented in the context of applied development methodology, the specifics of the consortium, and control system requirements. On the other hand this architecture is assessed from the perspective of initial experience in system integration and preliminary experiences of the end users.

Identification Session, B2L-C

Day: Tuesday, August 30, 2016
Time: 10:00 - 11:00
Room: Lehar
Chair: Andreas Rauh

Paper: **6010** **B2L-C**

A Random Time-Series Decomposition and its Applications in Time-Series Identification

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In the paper a decomposition of observed mixtures of wide-sense stationary time-series coming from different sources into the corresponding orthogonal components being ARMA time-series is proposed. It starts from calculation/estimation of power spectral density or autocorrelation function for the observed mixture. Models of the mentioned orthogonal components are obtained by an optimisation algorithm utilizing ideas of randomized search. Exemplary applications of the proposed decomposition in identification of ARMA time-series models using ultra low- and ultra high-power measurements obtained with data acquisition system equipped with quantizer having saturation as well as in identification of ARMA components of time-series being outputs of classical Wiener or Hammerstein

systems excited by white noise are discussed. The presented discussion is illustrated by a set of simulated identification experiments.

Paper: **6085** **B2L-C**

Identification of Elastic Boundary Conditions of Light-Weight Device Casing Walls Using Experimental Data

Stanislaw Wrona [1], **Marek Pawełczyk** [2]

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Device and machinery noise can be reduced by controlling vibration of casing walls—such approach, referred to as the active casing approach, has been successfully applied by the authors in previous publications. It was observed that for an effective active control it is crucial to mount sensors and actuators at appropriate locations on the vibrating structure. However, an optimization process of sensors and actuators arrangement requires a precise mathematical model of such structure. In this research a cuboid light-weight casing is considered. A mathematical model describing walls of such casing requires parameters to be defined that cannot be delivered by the producer nor measured directly. The aim of this paper is to develop and evaluate an identification procedure of model parameters basing on experimental data—distinguished natural frequencies and modeshapes. A memetic algorithm is used to find optimal set of model parameters. Automatic classification of simulated modeshapes is employed. Obtained results are validated experimentally for multiple casing walls.

Paper: **6039** **B2L-C**

Identification of a Multivariable Incremental Model of the Vessel

Anna Miller [1]

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In this paper the incremental linear state-space model identification procedure is presented. In contrast to space-state models incremental models are not popular due to their identification complication. Model structure selection, identification and validation procedures are described in details. Accurate prediction model cannot simultaneously be acceptable simulation model. They are identified using different algorithms and are used for different purposes. Proposed methodology shows that simple and good quality prediction incremental model can be obtained and used for future Model Predictive Control purposes.

Invited Session: Control and Optimization of Infinite Dimensional Systems I Session, B2L-D

Day: Tuesday, August 30, 2016
Time: 10:00 - 11:00
Room: Strauss
Chair: Adam Kowalewski

Paper: **6204** **B2L-D**

Sharp Interface Limit in Phase-Field Based Structural Optimization of Variational Inequalities

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Topology optimization of bodies in unilateral contact with a given friction is considered in the paper. The contact phenomenon is governed by the second order elliptic variational inequality. The aim of this optimization problem is to find such distribution of the material density function to minimize the normal contact stress. The original optimization problem is reformulated in terms of Cahn-Hilliard model as well as of material density function. In this approach the interface between phases is dependent on a small parameter. The aim of the present paper is to study the behavior of phase field based optimization problem as the interface parameter tends to zero. The existence result in the space of bounded variations functions for the optimization problem in the sharp interface limit case is shown. The sharp interface limit of the original functional regularized using Ginzburg-Landau energy functional in terms of Gamma-convergence is provided.

Paper: **6200** **B2L-D**

Topological Derivative and Neural Network for Inverse Problems of Coupled Models

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In the paper we consider a new method based on the neural network for finding the location of small holes in the domain, in which the coupled linear and nonlinear boundary value problems are defined. The linear and nonlinear components are connected by the transmission conditions on the interface boundary. We use an artificial neural network, which calculates the locations of hole in some domain based of input data.

Poster Session II, B3P-E

Day: Tuesday, August 30, 2016
Time: 10:00 - 12:00
Room: Poster Area
Chair: Przemyslaw Mazurek

Paper: **6027** **B3P-E**

Design and Implementation of Chaotic System Based Robust Delta Robot for Blending Graphene Nanoplatelets

Ali Emre Kavur [1], Sibel Demiroglu [2], Mehmet Ozgur Seydibeyoglu [3], Ozgun Baser [4], Cuneyt Güzelis [5], Savas Sahin [6]

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In this paper, a new blending method for nanoplatelets were developed. A chaotic system based robust delta robot were designed. Both the robot and DC motor of mixer were chaotically driven. Performance of the systems were evaluated by a material analysis method. The results showed that the proposed method has a better performance than statically mounted mixers.

Paper: **6062** **B3P-E**

Optimal Stopping of Controlled Linear Stochastic Systems

Edward Kozłowski [1]

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The optimal control problem with stopping for a discrete time linear stochastic system is investigated in this paper. Sometimes, in order to optimally realize the aim we need to know how long the system will be controlled. The traditional solutions with fixed terminal time are not enough to control the system optimally. The general aim of optimal control and stopping consists in minimization of a composite cost function. The paper presents two methods of solving this problem. A numerical example is included to illustrate the optimal control with stopping.

Paper: **6115** **B3P-E**

Active Disturbance Rejection Control of a Heat Integrated Distillation Column

Fahad Al-Kalbani [1], Jie Zhang [2], Thomas Bisgaard [3], Jakob Kjøbsted Huusom [4]

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Heat integrated distillation column (HiDC) is the most energy efficient distillation approach making efficient utilization of internal heat integration through heat pump. The rectifying section acts as a heat source with high pressure, while the stripping section operates as a heat sink with low pressure. However, the control of some HiDC processes is generally difficult due to the strong control loop interaction, high purity of the components and undesired disturbances. Active disturbance rejection control (ADRC) is used in this paper to control a simulated HiDC for separating benzene-toluene mixture.

Paper: **6212** **B3P-E**

Temperature Measurements of Turning with WCCo-cBN Composite Cutting Tools Thermographic and Contact Methods

Karol Grochalski [1], Grochalski Jabłoński [2]

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This paper describes measurement methods of temperature measurement of machining with WCCo-cBN composite cutting tools. Both contact and thermographic methods of cutting temperature measurements have been described and compared. As well, methodology of emissivity evaluation of cutting tools materials has been mentioned. This paper also covers influence of anti-wear TiAlN PVD on cutting temperature referring to machining with uncoated tools.

Paper: **6231** **B3P-E**

Comparision of Model Predictive, Input Shaping and Feedback Control for a Lab-Scaled Overhead Crane

Jaroslaw Smoczek [1], Janusz Szpytko [2]

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The paper focuses on comparing the model predictive control, feedback controller and input shaping control for a laboratory scaled overhead traveling crane. The adaptive control of an overhead crane is developed based on the Generalized Predictive Control (GPC)

procedure. Particle swarm optimization is applied to solve the optimal constrained control problem. The recursive least square (RLS) algorithm is applied to real-time estimate parameters of discrete-time model of a crane dynamic system. Feasibility and applicability of the proposed control technique were confirmed during experiments carried out on a laboratory stand. The results of experiments are presented and compared with the performances of the feedback controller and zero vibration derivative (ZVD) input shaper

Paper: **6233** **B3P-E**

Central Heating Temperature Control Algorithm for Systems with Condensing Boilers

Piotr Kaczmarek [1]

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The problem of control of a central heating system in a small residence is considered. It is assumed that the system is based on a condensing boiler. Since the boiler efficiency depends on a returning water temperature, the proposed control goal is to provide proper air temperature in the residence as well as the lowest possible water temperature. The proposed algorithm is applied to two buildings. Both of them have the same heating energy requirements, but the heat capacity of their walls differs. The presented simulation study shows reduction of energy consumption compared to that yielded by the traditional control algorithms.

Paper: **6244** **B3P-E**

Adaptive Deadbeat Current Controller for IPMSM

Rafał Piotuch [1], **Ryszard Pałka** [2]

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This paper presents an idea of adaptive predictive current controller for Interior Permanent Magnet Synchronous Motors (IPMSM). It consists of introduction to predictive control techniques applied for current control, mathematical formulation of a control problem, simulation results and summary. Simulations consider also robustness of classic deadbeat controller to object parameter changes and comparison of control quality of adaptive, classic and hysteresis controller with constant sampling time.

Paper: **6245** **B3P-E**

PLC-PIDTuner: Application for PID Tuning with SIMATIC S7 PLC Controllers

Witold Kolaj [1], **Jakub Możaryn** [2], **Michal Syfert** [3]

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There is presented PLC-PIDTuner application developed for tuning PID controller in S7 Simatic PLCs. It allows plant identification, calculation of controller parameters and verification of the control system using different quality indices. It provides data collection from the real process and computer simulation of designed control system. Such solution allows to customize systems properties without carrying out costly experiments. Proposed application allows user to easily develop different algorithms for each stage of PID control system design. Finally, there is presented example of using developed PLCPIDTuner platform in simulated process described by third order system with delay.

Paper: **6248** **B3P-E**

Simplified Reluctance Equivalent Circuit for Hybrid Excited ECPMS-Machine Modelling

Piotr Paplicki [1]

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The paper presents a simplified reluctance equivalent circuit for a hybrid excited ECPMS machine. The circuit allows determining an air-gap flux control and can be used to estimate the influence of a rotor central core flux barrier on the machine field-weakening capability. The presented equivalent circuit has been based largely on results obtained by predictions using 3D-FEA

Paper: **6255** **B3P-E**

Development of Parallel Manipulator Control System for Simulation of Selected Means of Transport

Maciej Sajkowski [1], **Tomasz Stenzel** [2], **Janusz Hetmańczyk** [3]

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The paper presents the control system of 6-DOF parallel manipulator based on linear actuators driven by PM BLDC motors. The control system of the manipulator has been developed using rapid prototyping approach in Matlab/Simulink environment and xPC Target real time platform. The application of the 6-DOF manipulator for simulation of search and rescue ship motion in order to evaluate the performance of the motion compensation system of electro-optical turret is concerned. The range of the manipulator motion recorded during the test leads to the conclusion that the manipulator can be used as a ship motion simulator.

Paper: **6258** **B3P-E**

Application of 6-DOF Parallel Manipulator for Simulation of Selected Manoeuvres of Emergency Vehicles

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The paper presents application of a 6-DOF parallel manipulator, developed for simulating forces acting on the load of the car. The research focuses on situations during transport when particular shocks appear: when driving over a speed bump and during manoeuvre of avoiding an obstacle. The measurements of the vertical and lateral accelerations have been carried out and then simulations of such motions have been conducted on the 6-DOF platform laboratory stand. Assuming the limited range of motion frequency, it is possible to state that developed parallel manipulator powered by PM BLDC motors could be applied as a vehicle motion simulator.

Paper: **6051** **B3P-E**

An Uncertain Diagnostic System of the Constructional and Technological Preferences

Anna Bryniarska [1]

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In this paper will be defined the diagnostic agent that finds information about the constructional and technological preferences of the customers for a reference technical object. Based on this agent can be implemented an uncertain system that can be used to define customers preferences. For imprecise information from users this system would give their preferences and exact data which can be used to improve production.

Paper: **6156** **B3P-E**

Employment of the MFC/IMC Structure in Robust Velocity Controll of BLDC Motor

Krzysztof Pietrusewicz [1], **Paweł Waszczuk** [2]

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The main purpose of this article is to present and describe the advantages of the MFC/IMC structure utilization in control of BLDC motor. The results of the analysis included in this work compare two-loop control structure containing internal model of the process with classical single-loop structure with PID controller, which is commonly used in control of industrial motors. In the framework of conducted computational and simulation tests the most important features of both structures from BLDC control point of view

such as: sensitivity for load disturbance reduced to the input and output of the plant, tracking the reference value and maximum acceptable perturbations between plant's and model's parameters were compared.

Paper: **6162** **B3P-E**

The Modified MFC Structure for Control of Certain Class of Linear and Nonlinear Plants

Bogdan Grzywacz [1]

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The concept of control of plants with use of modified MFC structure is proposed. The "associated"model in primary loop is controlled by algorithm which makes that generation of consecutive amplitudes of reference response is governed by time-variable time-scale depending on error signal. The algorithm "disconnects" state variable scheme when control error equals zero. This algorithm yields perfect performance of model output process. Using accessible signals one can generate such input signal of real plant that plant output follows the model output.

Stability Analysis Session, B4L-A

Day: Tuesday, August 30, 2016
Time: 11:20 - 13:00
Room: Casino
Chair: Wieslaw Krajewski

Paper: **6003** **B4L-A**

Stability Analysis of Simple Anti-Windup Compensation in Approximate Pole-Placement Control of a Second Order Oscillatory System with Time Delay

Talar Sadalla [1], **Dariusz Horla** [2], **Piotr Kozierski** [3]

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The main purpose of this paper, is to analyze the stability of anti-windup compensation impact on tracking performance for a second order plant with time delay and continuous-time PID controller tuned by pole-placement. The paper is mainly focused on analyzing the stability interplay with open-loop parameters, to show the application limits of the already proposed control law. The control system quality is described on the basis of two quality indices. The main contribution of the paper, is a given rule of thumb that defines the limits of requirements imposed on the dynamics of the closed-loop system with respect to anti-windup compensation.

Paper: **6063** **B4L-A**

Stability and Stabilization of the Subclass of 2D Systems Modeled as Descriptor Systems

Bartlomiej Sulikowski [1], **Krzysztof Gałkowski** [2], **Eric Rogers** [3]

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In the paper stability and stabilization for a subclass of spatially interconnected systems is considered. It starts with the modeling of a physical system (the RLC ladder system) and results in the state space model in the descriptor-like form. In previous works there were presented results regarding the modeling, stability analysis and stabilization of such systems, however, only the preliminary results were obtained for the descriptor-like system models. In this paper results regarding the stability and stabilization for such a subclass are presented.

Paper: **6072** **B4L-A**

Stability Analysis and Tracking Performance of Fractional-Order PI Controller for a Second-Order Oscillatory System with Time-Delay

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

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Themainaimofthispaperistopresenttheanalysis of stability regions and tracking performance for the closed-loop system with second-order plant with time-delay and continuous fractional-order PI controller. It is a trial to extend the results and methodology presented in [1] to non-integer order systems. The tracking performance is based on two quality indices IAE and ISE. The tuning method of fractional PI controller is with respect to Hermite-Biehler and Pontryagin Theorems.

Paper: **6164** **B4L-A**

Stability Analysis in Non-Integer Order Controller Tuning

Marta Zagórowska [1]

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Stability analysis in non-integer order systems is a complex issue and requires detailed analysis. This paper aims to show the stability region for fourth order system with non-integer PD controller. Such system was analysed with use of D-decomposition method. Moreover, we presented stability analysis for implementation in optimization procedure based on system in of form of fractional differential equations.

Paper: **6199** **B4L-A**

Structural Stability of Biological Models with Switchings

Magdalena Ochab [1], Krzysztof Puszynski [2], Andrzej Swierniak [3]

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We analyse properties of the control system with switchings in parameters. We consider biological model of proteins production in three variants of the model structure: a simple model without any autoregulation, the one with negative feedback loop and one with positive. In the system we introduce an action of drug in order to decrease proteins number. The drug application is considered as a step change of the protein degradation parameter. The aim of this work is to analyse stability of the model.

Robotics III Session, B4L-B

Day: Tuesday, August 30, 2016
Time: 11:20 - 13:00
Room: Kalman
Chair: Alexander Winkler

Paper: **6024** **B4L-B**

Challenges in Creating Long Continuum Robots

Ian Walker [1], Dixit Nahar [2], Siddharth Verma [3], Michael Wooten [4], Apoorva Kapadia [5]

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We discuss the design and control issues in creating continuous backbone continuum robots at lengths of multiple meters. At this scale, many of the design techniques and materials properties which have proved advantageous in creating continuum robots at smaller scales are not applicable. This leads to problems with reduced load capacity and poor internal stability. Using two example cases, a thin tendril and an extensible pipe, we illustrate the issues and discuss potential successful design alternatives.

Paper: **6038** **B4L-B**

A Real-Time Strategy for the Management of Kinematic Singularities: New Progresses

Marina Raineri [1], Corrado Guarino Lo Bianco [2], Marco Locatelli [3], Simone Perri [4]

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Industrial processes which use robotic manipulators are progressively asking for the generation of real-time trajectories in order to quickly react to unpredictable events. However, trajectories generated in real-time may violate the kinematic constraints of the system and, therefore, may be unfeasible. Several online methods have been recently proposed for the constraint management. They particularly care about situations in which non-redundant manipulators pass close to kinematic singularities, which represent a critical problem for trajectories planned in the operational space: singular configurations are, in fact, the most difficult to be managed because the available reaction time is always short. In this work, one recently proposed real-time algorithm for the singularity management will be revised to improve its performance.

Paper: **6128** **B4L-B**

Collision-Free Path Planning in Indoor Environment Using a Quadrotor

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This paper presents a path planing algorithm applied in an indoor environment. Path planning or motion planning is an essential part of navigating mobile robots. The goal of path planning is to specify a collision-free trajectory between the start state and the goal state for a mobile agent. The estimation of the absolute position inside the testing environment is performed based on visual ground patterns and image processing technique. A graph search algorithm, A^*, find the shortest path considering not only a distance cost but also an additional cost function for controlling the safety. An illustrative example of a quadrotor is used to evaluate the robustness of algorithm.

Paper: **6206** **B4L-B**

Low-Cost Impedance Controlled Multifinger Gripper

Mateusz Kubat [1], Krzysztof Mianowski [2], Piotr Kmiecik [3], Grzegorz Granosik [4]

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The following article presents our attempt to design and build a simple, low-cost, impedance controlled, multifinger gripper having two phalanges in each finger. The paper discusses two different approaches of creating its mechanical construction, comparing the strengths and weaknesses of both solutions, as well as electronic design and software architecture. The results of basic experiments regarding primitive tasks are provided. Modular structure of our design opens a way to create also grippers with 3 fingers.

Paper: **6260** **B4L-B**

Preliminary Experimental Results of Factitious Force Method Implementation for the Mobile Platform REX

Mateusz Cholewiński [1], Alicja Mazur [2], Wojciech Domski [3]

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Paper presents application of called factitious force method and experiments results using the real mobile skid- steering mobile platform. Due to fact that lateral slippage is needed for changing the orientation, constraints for this phenom- ena cannot be introduced to the system and, thus, the mobile platform is underactuated on dynamics level. Control problem can be solved by expanding relevant components of mathematical model and applying additional, factitious control signal, which is equivalently equal to 0. Described controller is implemented in the form of OROCOS component. Experiments, using this controller, were conducted using Robot Operating System (ROS) and gave the satisfying results

Modelling and Simulation I Session, B4L-C

Day: Tuesday, August 30, 2016
Time: 11:20 - 13:00
Room: Lehar
Chair: Ewa Niewiadomska-Szynkiewicz

Paper: **6267** **B4L-C**

Robust Control of Bicycle Model with CMG

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This paper is extension of previous work, where authors developed nonlinear model and its linear approximation of bicycle (or single track vehicle generally) with controlled moment gyro (CMG) used to stabilization in vertical direction. Also simple stabilization was there proposed. This elaboration concerns on robust controller designed for the cyclist mass perturbation. The controller study and simulation results are presented and discussed.

Paper: **6243** **B4L-C**

Aggregative Modeling of Wiener Systems

Szymon Łagosz [1], Przemysław Śliwiński [2], Paweł Wachel [3]

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In this paper we investigate a Volterra representation of the Wiener system and study an upper bound of an error arising from reducing the model's order as well as its memory length. To overcome the curse of dimensionality we use a recently introduced convex aggregation algorithm. In the main lemma of the paper we utilise error of the model truncation and already known error of the aggregation method to show an asymptotic behaviour of a difference between outputs of the true system and a model obtained from the aggregation algorithm.

Paper: **6224** **B4L-C**

Simplified, Multiregional Fuzzy Model of a Nuclear Power Plant Steam Turbine

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

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The paper presents the developed simplified, multiregional fuzzy model of the steam turbine of a nuclear power plant turbine generator set and compares the results with a full nonlinear model and commonly used linear input-output model of a steam turbine. The

proposed model consist of series of linear input-output models defined for specific steam turbine operating points and one fuzzy switching module with Takagi-Sugeno reasoning interface. Hence steam turbine model in such form may increase the accuracy of developed control algorithms, which use system model for adaptation or prediction purposes.

Paper: **6215** **B4L-C**

Multi-Nodal PWR Reactor Model – Methodology Proposition for Power Distribution Coefficients Calculation

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

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In the paper the multi-nodal Pressurized Water Reactor model of the heat transfer from fuel to coolant in reactor core is presented. Authors expand this model by defining additional coefficients for the heat transfer process. These coefficients approximate the power generation distribution in the PWR reactor core according to the to the control rod bank movement. Authors describe in details proposed methodology for calculation of introduced power distribution coefficients. By introducing these specific coefficients nodal model of heat transfer gains advanced capabilities that can be efficiently used in design and synthesis of more advanced power control system in nuclear reactor.

Paper: **6208** **B4L-C**

Motorcycle Lateral and Longitudinal Dynamic Modeling in Presence of Tyre Slip and Rear Traction

Andrea Bonci [1], Riccardo De Amicis [2], Sauro Longhi [3], Giuseppe Antonio Scala [4], Andrea Andreucci [5]

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This paper proposes a mathematical model of a motorcycle that deals with the lateral and longitudinal dynamics, the tyre slip and the rear wheel traction. The vehicle is considered as an assembly of two rigid bodies. The proposed dynamic formulation is based on Lagrange's equations, it allows to formulate the equations of motion with 7 degrees of freedom (DoF). The model assess the vehicle behavior in response to a propulsion torque applied to the rear wheel and a rider torque applied to the motorcycle handlebar. The model is able to describe the coupling of the in-plane (longitudinal) and out-of-plane (lateral) dynamics taking into account the rear and the front longitudinal tyre slip related to the rear wheel traction. In order to solve the linearized equations of motion, no multibody software was used, only numeric simulation tools such as matlab.

Signal Processing II Session, B4L-D

Day: Tuesday, August 30, 2016
Time: 11:20 - 13:00
Room: Strauss
Chair: Krzysztof Okarma

Paper: **6105** **B4L-D**

An Orthogonal Wavelet Denoising Algorithm for Surface Images of Atomic Force Microscopy

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This paper deals with the noise reduction of discrete AFM surface images using orthogonal wavelets. More in detail, it compares the usefulness of the Daubechies wavelets with different vanishing moments for noise reduction. The work is based upon the discrete wavelet transform (DWT) version of wavelet package transform (WPT). With the help of a seminorm the measurement of noise of a sequence is defined. An algorithm for noise reduction is proposed to detect unavoidable measured noise in topographic surface scans. The denoising wavelet algorithm is used to improve the quality of the scanned images. By taking real measurements in which the measurement and system noise is included, the effectiveness of the proposed denoising algorithm is validated.

Paper: **6177** **B4L-D**

Windowed Local Area Average Reference Filter for Increasing the Spatial Resolution of EEG Signals

Bartosz Binias [1], Henryk Palus [2]

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In this study the influence of applying 2D window function to the neighbourhood of each electrode before removal of local common reference is examined. The Local Spatial Filters focus on removing the common signal of electrodes in a specific neighbourhood of the electrode of interest. The neighbourhood can be defined by either the proximity of electrodes in specified region or the Nearest Neighbours rule. This works assumes that simple averaging of neighbouring channels recordings is not sufficient and therefore weighted sum should be applied. The weights of channels are derived from the 2D Gaussian window function defined a priori to the experiment

Paper: **6223** **B4L-D**

A Time-Varying Filters Approach in Reducing Measurement Time of Multiple Inertial Sensors

Piotr Okoniewski [1], Jacek Piskorowski [2]

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The paper presents an attempt to implement the concept of time-varying IIR filters in an easily accessed microcontrollers. The problem in terms of choosing an efficient sets of coefficients is discussed along with maintaining stability of the time varying structure. The difficulties that arise with the idea of implementation of the optimal solutions are briefly discussed. The experimental part of this paper compares the simulation results of the time-varying IIR filters concept with implementation involving multiple inertial measurement units (IMU) and the STM32F4 microcontroller (Cortex-M4).

Paper: **6209** **B4L-D**

Machine Learning Based Power Quality Event Classification Using Wavelet – Entropy and Basic Statistical Features

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Present study deals with one of the essential part of an electricity grid monitoring system called power quality event classification in a manner of machine learning topic. Power quality events to be processed are generated synthetically by means of a comprehensive software tool. Classification of real-like dataset is executed using extreme learning machine which is an extremely fast learning algorithm applied to single layer neural networks. Basic statistical criteria and wavelet – entropy methods are handled to achieve distinctive features of dataset. As a performance evaluation instrument, conventional artificial neural network structure is run too. Detailed results are discussed to prove the satisfactory performance of proposed pattern recognition model.

Paper: **6192** **B4L-D**

Adaptation in Active Noise Control — a Simulation Case Study

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In the paper properties of adaptive algorithms utilising ideas of stochastic gradient search optimisation applied to noise reduction are discussed. A focus on their average rate of convergence as well as on the obtained noise reduction is given. The presented discussion is based on a simulation case study devoted to noise reduction using a feedforward adaptive active noise control system.

Sliding Mode Control Session, B5L-A

Day: Tuesday, August 30, 2016
Time: 15:00 - 16:20
Room: Casino
Chair: Wojciech Hunek

Paper: **6227** **B5L-A**

Tracking Human Upper-Limb Movements with Sliding Mode Control Type-II Fuzzy Logic

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Exoskeletons are wearable assistive devices used to help humans to perform tasks. The applications of exoskeletons are varied, including military, medical, industry but domestic. However, it is important to have a knowledge of human's upper limb structure and its mechanical function. Therefore, this paper focuses on development and control of upper extremities. The main objective of the paper is to investigate the performance of the Sliding Mode Control with Fuzzy Type-II in controlling the upper extremity human joints. The upper-limb's dynamics are modeled using the Lagrange's method. The results show that the controller is able to track the movement of the user without the need for any bio-sensing mechanism and is further able to eliminate the chattering problem and deal with uncertainties.

Paper: **6052** **B5L-A**

Cascaded Control Design for the Tracking Control of a Hydrostatic Transmission Based on a Sliding Mode State and Disturbance Observer

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This paper presents a tracking control approach for a hydrostatic transmission system. To reduce the effort regarding control design and implementation, a decentralised control structure has been investigated in earlier research that outperformed a central one. In this paper, a new cascaded structure is proposed for the decentralised control of the motor angular velocity. For the design of all control loops, flatnessbased techniques are employed. Moreover, a sliding mode observer is employed to provide a robust reconstruction of the unmeasurable system states and unknown disturbances. The proposed control structure is validated experimentally at a test rig and compared to earlier results. The outstanding results highlight the applicability and the performance of the cascaded approach.

Paper: **6075** **B5L-A**

A New Reaching Law for DSMC Systems with Constraints

Paweł Latosiński [1], Andrzej Bartoszewicz [2]

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In this paper, a new reaching law is proposed and applied to synthesize a discrete time sliding mode control strategy. The strategy ensures at least asymptotic convergence of the state to a layer around the switching plane and guarantees an upper bounded convergence rate. Then, the strategy is applied to a class of continuous time systems with input delays. It is demonstrated that, when applied to the considered systems, the strategy satisfies a priori determined input constraints.

Paper: **6119** **B5L-A**

Nonlinear Modelling and Sliding Mode Control of a Piezo-Hydraulic Valve System

Benedikt Haus [1], **Harald Aschemann** [2], **Paolo Mercorelli** [3], **Nils Werner** [4]

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Camless internal combustion engines offer significant improvements over classical ones with cam-driven valves: a better torque performance, an increased fuel economy as well as reduced emissions and pumping losses. The paper presents a nonlinear model for a hydraulic engine valve, which is regulated by an innovative piezo-hydraulic valve spool described by a linear model. Based on these models, a nonlinear control design is proposed using a combination of feedforward and feedback control. For the positioning of the valve spool, a decoupling feedforward control is employed, whereas a sliding mode control guarantees an accurate tracking of desired trajectories for the engine valve position. Simulation results are provided to point out the performance and the effectiveness of the proposed control strategy.

Control Applications I Session, B5L-B

Day: Tuesday, August 30, 2016
Time: 15:00 - 16:20
Room: Kalman
Chair: Jaroslaw Figwer

Paper: **6004** **B5L-B**

Fractal Measures in Control Performance Assessment

Paweł Domański [1]

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In case of numerous loops control engineers need fast and accurate method finding out loops with the poorest control quality. There exits several measures however, industrial practice reveals their deficiencies. Some of them require introduction of external disturbance into the process (like the step test) that in many cases is considered as a risk or threat. The other group of automatic approaches uses regular process data and is based on the loop Gaussian properties foundation. Analysis of real process data shows that this assumption holds only in a few cases. Both facts initiated research for alternative measures grouped into statistical non-Gaussian indexes and fractal ones based on the properties of R/S plot and Hurst index. The analysis is performed on both simulation and real industrial data revealing interesting properties and proving validity of selected approach.

Paper: **6006** **B5L-B**

Auto-Generation of Advanced Control Algorithms' Code for Microcontrollers Using Transcompiler

Patryk Chaber [1], **Maciej Ławryńczuk** [2]

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This paper presents a new approach to automatic code generation of advanced control algorithms, primarily model predictive control schemes, for microcontroller-based embedded systems. The main part of the developed tools, the transcompiler, makes it possible to effectively translate the algorithms described in a high-level language (MATLAB) into C language code for the chosen hardware platform. Implementation of two control algorithms using the described approach for the STM32 microcontroller is reported, results of the real experiments are discussed.

Paper: **6067** **B5L-B**

Feedback Linearization of Extended Relative Degree Model of Nonlinear Active Magnetic Bearing System

Arkadiusz Mystkowski [1], **Ewa Pawłuszewicz** [2]

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In the paper the nonlinear control strategy based on feedback linearization for nonlinear active magnetic bearing (AMB) system is discussed. In this context, self-sensing AMB dynamics, in affine-form is investigated. The extended relative degree of AMB dynamics model is considered. Since AMB system is strongly nonlinear a modification of the classical geometric control linearization is used. Numerical simulations are carried out to verify the theoretical approach.

Paper: **6058** **B5L-B**

Multiple-Input Multiple-Output Laboratory Stand for Process Control Education

Andrzej Wojtulewicz [1], Patryk Chaber [2], Maciej Ławryńczuk [3]

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This paper presents an original multiple-input multiple-output laboratory stand for process control education developed in the Institute of Control and Computation Engineering, Warsaw University of Technology. It may be used as a benchmark process to test control algorithms, including fault tolerant ones, and to compare effectiveness of model identification algorithms. Mechanical and electronic details are described. Hardware and software interfaces of the process, which enable connection of controllers, are discussed and the versatility of the laboratory stand (resulting from numerous advanced configuration options) are emphasised. A few possibilities of using the laboratory stand during testing control algorithms implemented on Programmable Logic Controllers (PLCs) as well as on embedded systems based on microprocessors and Field-Programmable Gate Arrays (FPGAs) are thoroughly detailed. Finally, an application example is discussed.

Robotics IV Session, B5L-C

Day: Tuesday, August 30, 2016
Time: 15:00 - 16:20
Room: Lehar
Chair: Cosmin Copot

Paper: **6013** **B5L-C**

Power Assistive and Rehabilitation Wearable Robot Based on Pneumatic Soft Actuators

Hassanin Al-Fahaam [1], Steve Davis [2], Samia Nefti-Meziani [3]

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The aim of this paper is to describe the design of a soft, wearable glove for power assisted and rehabilitation, based on pneumatic soft actuators. The extensor bending type of pneumatic soft actuators was used in this study. A proposed solution for a release movement is presented. Elderly, partially disabled and strenuous workers can use this glove. An efficient control algorithm used, depending on signals from sensors located within the glove, that capture the movement type and bending angle to provide appropriate assistance. A wide range of rehabilitation exercises can be carried out using this soft wearable glove.

Paper: **6021** **B5L-C**

Automated Inspection of Door Parts Based on Fuzzy Recognition System

Tomasz Winiarski [1], Włodzimierz Kasprzak [2], Maciej Stefańczyk [3], Michał Walęcki [4]

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The article presents a comprehensive strategy of door parts (locks, handles, doorplates etc.) examination as a paradigm of active sensing. It covers the whole process - from segmentation, through initial hypothesis generation based on fuzzy inference, to final recognition and precise localization of the keyholes in a robot base coordinate system. The strategy is a preliminary stage of a door locks opening procedure. The image analysis process is divided into three steps. First, an initial region of interest is localized using a RGB-D low resolution camera mounted on the robot's head. It is then categorized, based on its properties, as a lock, handle, doorplate etc. Finally it is inspected using 2D camera mounted on the robot's arm. Thanks to the preliminary localization with the head camera the robot can look at the point of interest at sight, without time-consuming thorough inspection of the whole door. The whole system was formally specified as an embodied agent. For that purpose a system modeling language was used to specify embodied agent subsystems behaviors. The proposed strategy is verified experimentally using Velma prototype service robot.

Paper: **6251** **B5L-C**

Design of a Controller for Stabilization of Spherical Robot's Sideway Oscillations

Kacper Landa [1], Adam Piłat [2]

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In this study, the dynamics and control aspects of a spherical rolling robot are investigated. An approximate mathematical model is derived using Lagrange equations to check stability of the system. Utilizing the fusion of sensor data, a precise orientation measurement is achieved. Document focuses on a synthesis of a PID controller reducing sideway oscillations that occur in motion of a spherical robot with internal pendulum mechanism.

Paper: **6015** **B5L-C**

Control System Design Procedure of a Mobile Robot with Various Modes of Locomotion

Dawid Seredyński [1], Maciej Stefańczyk [2], Konrad Banachowicz [3], Bartosz Świstak [4], Vitalii Kutia [5], Tomasz Winiarski [6]

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In this article the design procedure of a control system of a mobile robot with various modes of locomotion has been considered. The procedure is based on an embodied agent theory and focuses on the agent behaviours and transitions between them. The procedure was introduced to speed up and organize the whole controller development process. The effectiveness of the proposed approach is proved through control system development and experimental verification of the custom-built Lynx mobile robot with vertical and horizontal modes of locomotion.

Invited Session: Control and Optimization of Infinite Dimensional Systems II Session, B5L-D

Day: Tuesday, August 30, 2016
Time: 15:00 - 16:20
Room: Strauss
Chair: Adam Kowalewski

Paper: **6057** **B5L-D**

On the Lyapunov Exponents of Infinite-Dimensional Discrete Time-Varying Linear System

Adam Czornik [1], Piotr Jurgaś [2]

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In this paper we consider infinite-dimensional discrete time-varying linear systems with coefficients in fixed set of invertible operators and we describe the set of all possible Lyapunov exponents of the system. We show that the set includes an interval bounded by the generalized spectral subradius and the generalized spectral radius.

Paper: **6090** **B5L-D**

Controllability Problem of Neutral Equation with Nussbaum Fixed-Point Theorem

Jerzy Klamka [1]

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The main objective of this article is to present the fixed-point theorem techniques for neutral equation. We consider an unconstrained controllability problem for semi linear stationary dynamical system. In the paper the appropriate hypotheses are presented. In the proof of the main results we use Nussbaum fixed-point theorem and solution of semi linear neutral equation. The main goal of the paper are the sufficient conditions for the relative controllability on the given time interval for studied dynamical system.

Paper: **6144** **B5L-D**

Approximate Controllability of Stochastic Nonlinear Infinite Dimensional Systems. a Short Survey

Jerzy Klamka [1], **Janusz Wyrwał** [2]

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Controllability is one of the most important qualitative property of dynamical systems. From the mathematical point of view, the problems of exact (strong) and approximate (weak) controllability are to be distinguished. In case of systems whose evolution is described in infinite-dimensional spaces the concept of exact controllability is usually too strong and indeed it has limited applicability. Approximately controllable systems are more prevalent and in addition approximate controllability is very often completely adequate in applications. Therefore, it is important from the practical point of view to study the weaker concept of controllability referred to as approximate controllability.

Paper: **6157** **B5L-D**

Sensitivity of Optimal Controls for Time Delay Parabolic Systems

Adam Kowalewski [1], Zbigniew Emirsajłow [2], Jan Sokołowski [3], Anna Krakowiak [4]

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The first order sensitivity analysis is performed for a class of optimal control problems for time delay parabolic equations in which retarded arguments appear in the integral form with h within (0,b). The optimality system is analyzed with the respect to a small parameter. The directional derivative of the optimal control is obtained as a solution to an auxiliary optimization problem. The control constraints for the auxilary optimization problem are received.

Poster Session III, B6P-E

Day: Tuesday, August 30, 2016
Time: 15:00 - 17:00
Room: Poster Area
Chair: Witold Mickiewicz

Paper: **6041** **B6P-E**

Identification of the Plant Dynamic Using Genetic Algorithms

Sławomir Jaszczak [1], Piotr Nikończuk [2]

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For research, modeling and simulation of control plants the most often a linear models are used. There are many methods of creating linear models of plants dynamic. The methods of artificial intelligence are used in many areas of science and technology. Also are known applications of artificial intelligence in automatic control. Authors developed the method of linear modelling using evolutionary algorithms. Evolutionary algorithms enable searching for optimal values of the transfer function coefficients. For method validation the experiment with real plant was arranged. The paper presents identification of the linear transfer function of the thermal plant.

Paper: **6059** **B6P-E**

Using the Disjunctive Graph for Vessel Scheduling

Waldemar Uchacz [1]

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The article presents a model of vessel scheduling for fairway traffic as a factor enhancing navigational safety. The methods used herein are generally used for job shop scheduling. Problems of this type can be illustrated as disjunctive graphs, applied to depict selected cases of vessel scheduling problem. The solutions obtained by the branch and bound method have been displayed on Gantt charts.

Paper: **6060** **B6P-E**

Comparison of the Disjunctive Graph Model with the MILP Class Model for Vessel Scheduling Applications

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Two different models have been used for scheduling vessels proceeding along a fairway, a factor increasing shipping safety: a model of the mixed integer linear problem class, and a job shop scheduling model. Both models were compared by implementing them in actual operational conditions of the Świnoujście – Szczecin fairway. The two methods proved effective in the dimension of the problem under consideration. Further research will focus on applicability of the models to problems of larger dimensions.

Paper: **6095** **B6P-E**

Simulation Model of a Series DC Motor for Traction Rail Vehicles

Grażyna Barna [1]

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The aim of the paper in presenting a simulation model of a series DC traction motor and its applications. The model has been implemented in Matlab Simulink® simulation environment. Its parameters have been calculated on the basis of the catalogue data. The model can become a component of simulation models of refurbished locomotives, both electric and diesel ones. Those models can in turn be applied for developing control systems of the modernized locomotives, employing DC serial motors.

Paper: **6096** **B6P-E**

Neural Network Contour Error Predictor in CNC Control Systems

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This article presents a method for predicting contour error using artificial neural networks. Contour error is defined as the minimum distance between actual position and reference toolpath and is commonly used to measure machining precision of Computerized Numercially Controlled (CNC) machine tools. Offline trained Nonlinear Autoregressive networks with exogenous inputs (NARX) are used to predict following error in each axis. These values and information about toolpaht geometry obtained from the interpolator are then used to compute the contour error. The method used for effective off-line training of the dynamic recurrent NARX neural networks is presented. Tests are performed that verify the contour error prediction accuracy using a biaxial cnc machine in a real-time CNC control system. The presented neural network based contour error predictor was used in a predictive feedrate optimization algorithm with constrained contour error.

Paper: **6103** **B6P-E**

Selected Properties of the Adiabatic Model of the Stirling Engine Combined with the Model of the Piston-Crankshaft System

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This work presents the ideal adiabatic model of the Stirling engine which was combined with the dynamic model of the piston-crankshaft system with three degrees of freedom. On the basis of the conducted thermodynamic analysis for the working space in the Stirling engine, and on the basis of the physical model of the working mechanism (constructed with the assumption of the static mass reduction), a multidomain simulation model has been developed, using the Matlab&Simulink software.

Paper: **6112** **B6P-E**

Evolving Neural Network as a Decision Support System – Controller for a Game of "2048" Case Study

Arkadiusz Kwasigroch [1], **Michał Grochowski** [2]

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The paper proposes an approach to designing the neuro-genetic self-learning decision support system. The system is based on neural networks being adaptively learned by evolutionary mechanism, forming the evolved neural network. Presented learning algorithm enables for a selection of the neural network structure by establishing or removing of connections between the neurons, and then for a finding the feasible values of network weights and biases. The algorithm was validated on problem of learning to play the game of "2048". In the result, the controller has obtained results at a level similar to medium advanced human player. It is interesting that strategies developed by the controller are similar to the strategies that are applied by experienced human players. The paper provides an overview and an analysis of the impact of the main system factors on obtained results.

Paper: **6121** **B6P-E**

Mathematical Models Database (MMD ver. 1.0) Non-Commercial Proposal for Researchers

Wojciech Giernacki [1], **Dariusz Horla** [2], **Talar Sadalla** [3]

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Mathematical Models Database (MMD) is an on-line repository of mathematical models that can be easily used for research purposes, in teaching or in performing comparative tests. In a single free-of-charge, freely accessible internet service all the data from the database is available with an expected (in its final form) several ready-to-use models, either purely mathematical or physics-based. Apart from the models themselves there are also documents describing the background of their derivation included, references to bibliography for further reading where they have been used and numerous attachments, e.g. parts of the code, time plots, results of simulations, ready handouts, etc.

Paper: **6133** **B6P-E**

Neural Estimators of Two-Mass System Optimized Using the Levenberg-Marquardt Training and Genetic Algorithm

Marcin Kamiński [1]

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This paper presents application of neural networks for state variables estimation of two-mass system. Two stages of applied design process can be distinguished: the Levenberg-Marquardt method was implemented for weights adaptation, moreover topologies of the neural models were optimized using genetic algorithm (number of the nodes in each hidden layer was determined). Analyzed estimators were tested in structure with state space controller. Simulation results, presenting robustness against changes of the plant parameters, are presented. Furthermore, implementation of neural estimators in programmable device (dSPACE1103 card) was done and experimental tests were prepared.

Paper: **6137** **B6P-E**

An Architecture for a Cached Policy-Based Decision Making Systems

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Nowadays, majority of systems that involve some kind of decision-making process use policy-based computing where decisions are being made as a result of a policy evaluation. Policies are usually formed by system experts who describe in a specified Policy Definition Language how the system should respond to a change of a its context information. However, depending on the policy complexity the needed to make a decision may become an issue, especially when embedded or real-time control systems are concerned. In such systems certain level of policy complexity may result in ability of the control system to return a valid decision before a deadline. Hence any architectural solution that would resolve or at least minimise the issue would be more than welcome. In this paper we propose an architecture for a policy-based decision making system in application to an embedded control systems. In our solution add to a typical policy-based system an intermediate component - a cache memory which ultimately leads to increasing of the whole system performance. A number of scenario-based performance tests show potential performance gains.

Paper: **6190** **B6P-E**

Jade Environment Performance Evaluation for Agent-Based Continuous Process Control Algorithm

Grzegorz Polaków [1]

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This paper is a part of work on the attempt to implement the continuous control system which dynamically derives the control law during its operation, on basis of a model-based control algorithm. The measurements obtained from the sensors are dynamically included or excluded depending on the availability of individual sensors. The prototype application was developed in the JADE environment, and its feasibility for continuous time-determined control is tested. The relations between the number of sensors, message processing times and available processing power are determined in order to estimate the boundaries for which the task is possible. Additionally, the stability of sampling time was tested, for the case when the time sampling is delegated entirely to agent system without any additional real-time hardware.

Paper: **6213** **B6P-E**

Real-Time Simulation in Non Real-Time Environment

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

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Real-time simulator for a mass audience must be made with widely accessible environment e.g. Windows OS or Web browser. So we have here a paradoxical expectation: real-time simulator in non real-time environment. Authors developed soft real-time solver that is able to adapt its time step to actual computational effort of the system. It also has the ability to determine the number of real-time violations during the simulation. Execution of a priori simulation benchmark allows to determine which step of the simulation will meet the requirements of real-time simulation.

Paper: **6220** **B6P-E**

Dynamic Model of a Free-Piston Stirling Engine with Four Degrees of Freedom Combined with the Thermodynamic Submodel

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

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The work presents a dynamic model of the Stirling engine with a free piston, which was combined with a thermodynamic model taking into account isothermal heat exchange in the compression and expansion spaces. On the basis of the performed thermodynamic analysis for the Stirling engine working space, and of the physical model of the system with a free piston, a multidomain simulation model was developed, using the Matlab&Simulink software. On the basis of the derived equations of energy conservation for the thermodynamic model and equations of motion for the mechanical submodel, the influence of the selected thermodynamic and mechanical parameters, including: the influence of the mass of the displacer and piston on the p(V) closed-loop diagram was analysed and the influence of the thermodynamic parameters, including: temperature of the upper heat source on the theoretical work gain and the theoretical work. As a result of the conducted simulations, flow of the working gas mass at the control boundaries and also the curves of the heat fluxes, among other things, were additionally presented.

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

L^1 and L^2 Norms in Sensitivity Analysis of Signaling Pathway Models

Malgorzata Kardynska [1], Jaroslaw Smieja [2]

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Sensitivity methods have been originally developed for analysis of technical systems and recently have gained increasing importance in systems biology. Among others, they provide means to rank parameters of mathematical models describing complex systems, according to their influence on system behavior. Parameter rankings can be derived using different sensitivity measures. This paper is focused on two types of norms, most often used in such analysis. Using simple, illustrative dynamical models as well as models of signaling pathways, it shows how much the results of sensitivity analysis depend on the choice of the norm.

Paper: **6266** **B6P-E**

Modelling of Bike Steered by CMG

Maciej Różewicz [1], **Adam Piłat** [2]

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This elaboration presents an idea for stabilization of single track vehicle. It is based on Control Moment Gyro (CMG) as an actuator generating the stabilizing torque. The main problem to satisfy the formulated goal is to develop the mathematical model of system: bike plus CMG. Additionally influence of perturbation of some parameters on system stability was observed.

Predictive Control I Session, C1L-A

Day: Tuesday, August 30, 2016
Time: 16:40 - 18:00
Room: Casino
Chair: Ryszard Palka

Paper: **6035** **C1L-A**

A Fault-Tolerant Approach to the Control of a Battery Assembly System

Paweĺ Majdzik [1], **Anna Akielaszek-Witczak** [2], **Lothar Seybold** [3]

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The paper concerns fault-tolerant control of a real battery assembly system. The proposed framework is based on an interval analysis approach, which along with max-plus algebra, allows describing uncertain discrete event system such as the production one being considered in this paper. Having a mathematical system description, a model predictive control-based fault tolerant strategy is developed which can cope with both processing, transportation and mobile robot faults. As a result, a novel robust predictive fault-tolerant strategy is developed that is applied to the advanced battery assembly system. The final part of the paper shows the implementation and experimental validation of the proposed strategy. The proposed approach is tested against single as well as simultaneous faults concerning processing, transportation and mobile robots.

Paper: **6044** **C1L-A**

Model Predictive Control as a Service - Concept and Architecture for Use in Cloud-Based Robot Control

Axel Vick [1], **Jan Guhl** [2], **Joerg Krüger** [3]

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This paper presents the concept and architecture of a model predictive feedback control system to be used for compensating communication delays in networked industrial robot control. This approach follows the ideas given by the paradigms of Industrie 4.0 that demand for highly networked production devices and functions on different machine layers and IT hierarchy levels. We push the concept of fully outsourced control systems to a point, where even real-time critical feedback processes are driven from cloud-based services over uncertain public networks.

Paper: **6186** **C1L-A**

Supervised Model Predictive Control of Wastewater Treatment Plant

Michał Grochowski [1], **Tomasz Adam Rutkowski** [2]

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Optimizing control of wastewater treatment plant allowing for cost savings over the long time period and fulfilling the effluent discharge limits at the same time, requires application of advanced control techniques. MPC is a suitable control technology for a synthesis of such a multivariable controller that can handle constraints and accommodate model-based knowledge combined with hard measurements. As it is impossible to efficiently control the plant by one universal control strategy under all possible influent conditions, it is proposed in the paper to on-line adapt the nonlinear MPC control strategy in order to best adopt the control actions to actual and predicted WWTP conditions. Adjusting the MPC control strategy is carried out by suitable manipulating the components of the performance index and the constraints. This process is supervised by Mamdani reasoning system. The supervised MPC controller performance was tested by simulations within large range of plant operating conditions and then compared with classic MPC without such mechanism.

Paper: **6151** **C1L-A**

Secondary Control with Thermostatically Controlled Loads Using MPC Based on Extended Bin State Transition Model

Jaroslav Hlava [1], **Nikita Zemtsov** [2]

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This paper deals with providing the secondary control using a large population of thermostatically controlled loads, in particular electrical space heaters. Model predictive control approach is used for control system design. The controller is based on extended 1D bin state transition model, which is designed to be linear parameter varying model in order to include possibility to control the temperature setpoints. Unlike other systems for performing ancillary services, this controller performs two functions simultaneously: secondary control itself and the function of heaters' thermostats. This extended functionality of the controller gives more possibilities for optimization of the population performance. The obtained results show that the designed control system meets the requirements on the secondary control. The proposed ideas can further be used to develop a control system based on 2D bin state transition model that will provide possibility to take into account more accurate dynamics of the second order equivalent thermal parameters model.

Ship Modelling and Control Session, C1L-B

Day: Tuesday, August 30, 2016
Time: 16:40 - 18:00
Room: Kalman
Chair: Janusz Szpytko

Paper: **6029** **C1L-B**

Method of Considering the Dynamics of a Ship in the Process of Determining a Safe Trajectory Using an Algorithm Based on Ant Colony Optimization

Agnieszka Lazarowska [1]

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The aim of this paper is to introduce a method of taking into account the dynamic properties of a ship in the algorithms for determining the safe ship trajectory. The developed methodology of the ship's dynamics implementation in the safe ship trajectory determination algorithm in the form of a parameter called the maneuver time is presented for an exemplary vessel. A method for computation of a family of characteristics showing the relationship of the maneuver time as a function of course change value for different values of a rudder angle and for different values of ship's speed is introduced. After that a description of the computed maneuver time implementation in the safe ship trajectory

planning algorithm is introduced and results of an exemplary test case are presented and summarized.

Paper: **6019** **C1L-B**

Hybrid Real-Time Way-Point Controller for Ships

Mirosław Tomera [1]

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The paper presents a hybrid controller that controls the movement of a ship in various operating modes. The developed controller integrates a number of operational modes, such as: precise maneuvering the ship at low speeds, steering the ship at different speeds along the trajectory or on the course, and stopping the ship on the route. The implementation of these modes requires the use of five controls, which have been collected in the set of alternative continuous controllers. The developed control system was tested on the training ship Blue Lady, in the Ship Handling Research located on the lake Silm, Poland.

Paper: **6138** **C1L-B**

Computational Intelligence Method for Ship Trajectory Planning

Mostefa Mohamed-Seghir [1]

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This paper addresses the problem of ship trajectory planning in a collision situation. The objectives of this paper are twofold. The first objective is to propose the optimal safe ship trajectory in collision situation is presented as multistage decision-making in a fuzzy environment. The second objective is to use method based on the neural network to determine a safe ship trajectory planning. The maneuverability parameters of the ship and the navigator's subjective assessment in making a decision are taken under consideration in the process model.

Paper: **6275** **C1L-B**

The Structure of the Control System for a Dynamically Positioned Ship

Roman Smierzchalski [1]

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The article discusses functions and tasks of dynamic positioning (DP) systems for ships. The analysed issues include ship steering, in particular stabilisation of ship position and direction of motion (real course) at low manoeuvring speeds, and commonly used DP ship models. Requirements imposed by classification societies on DP ships are quoted. A multi-layer structure of the DP control system is presented, with special attention being

paid to such issues as signal filtering, estimation of measured and non-measured quantities, selecting the control method and DP controller, and rudder and drive allocation. The article has a form of an overview of basic problems of DP ship control.

Robotics V Session, C1L-C

Day: Tuesday, August 30, 2016
Time: 16:40 - 18:00
Room: Lehar
Chair: Janusz Jakubiak

Paper: **6016** **C1L-C**

Graph–Based Potential Field for the End–Effector Control Within the Torque–Based Task Hierarchy

Dawid Seredyński [1], Konrad Banachowicz [2], Tomasz Winiarski [3]

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In the article, a reactive torque–based hierarchical task–space control for a robot with multiple redundant DOFs is presented that is suitable to plan, validate and execute a humanoid upper-body motion in human oriented environment. The strategy consists of: (i) joint limit avoidance, (ii) self–collision avoidance using repulsive force fields with additional environment collision avoidance, (iii) end–effector task with a specified discrete potential field with tricubic interpolation and (iv) a posture task on the lowest priority. The proposed approach is verified for Velma – a robot with a humanoid upper-body.

Paper: **6020** **C1L-C**

Multibehavioral Position–Force Manipulator Controller

Tomasz Winiarski [1], Konrad Banachowicz [2], Michał Walęcki [3], Jonathan Bohren [4]

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In the article the whole process of a manipulator controller development is presented. The controller is designed for the execution of various benchmark tasks in the field of service robotics. Initially, a set of system behaviors is presented as the base of the universal controller structure. For that purpose the embodied agent theory and the System Modeling Language are utilized. The execution and switching between the behaviors relies on a particular algorithm. The control system is verified on a two arm robotic system, that consists of position-controlled industrial manipulators and a number of extra force/torque sensors and cameras.

Paper: **6252** **C1L-C**

Towards Control Development for Flexibly Automated Systems in High-Level Programming Environments

Elzbieta Roszkowska [1], **Kamil Mowinski** [2]

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The paper presents an approach to control development for FMSs with mobile-robot transport systems. The proposed architecture of the system comprises two loosely coupled DFSA based controllers that can cooperate with both real and simulated plants. The formal representation of the control concept ensures its correctness, while the modular architecture of the system allows development and testing of different control policies for both supervisory control and motion control of the mobile robots. The proposed approach is illustrated by its example implementation in the Matlab/Simulink/Stateflow programming environment.

Paper: **6055** **C1L-C**

Factitious Force Method in Control of Skid-Steering Platforms with Rare Constraints in Motion

Wojciech Domski [1], **Alicja Mazur** [2], **Mateusz Cholewiński** [3]

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In the paper new control algorithm for skid-steering mobile platforms has been presented. This control law is based on mathematical model of such object. In the model it has been assumed that wheels of the skid-steering platform are not coupled by tracks and that they can move without some slipping effects, namely with lack of longitudinal slipping of selected wheels and lack of lateral slipping of rear axis. Because skid-steering platform is nonholonomic system, underactuated on dynamic level, therefore new control method of underactuated systems has been applied: method of using “factitious forces”.

Distributed Parameter Systems Session, C1L-D

Day: Tuesday, August 30, 2016
Time: 16:40 - 18:00
Room: Strauss
Chair: Johannes Reuter

Paper: **6014** **C1L-D**

Optimal Control of a Non-Isothermal Catalytic Packed-Bed Reactor Model

Ilyasse Aksikas [1], Amir Alizadeh Moghadam [2], Fraser Forbes [3]

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This work deals with the linear-quadratic control problem for a non-isothermal packed-bed catalytic reactor, which is described by coupled hyperbolic and parabolic partial differential equations model. The classical Riccati equation approach, in the infinite-dimensional setting, is adopted. An optimal LQ-feedback is computed via the eigenvalues and the eigenfunctions of the parabolic subsystem, while a differential Riccati equation is derived for the hyperbolic subsystem. Numerical simulations are performed to show the performance of the designed controller on non-linear reactor system.

Paper: **6070** **C1L-D**

An Easily Trained Neural Model of a Distributed Parameter System

Maciej Ławryńczuk [1]

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This paper is concerned with black-box modelling of a distributed parameter thermal system (a long duct) by means of neural networks. A new model structure is discussed which consists of a set of local neural sub-models and a neural interpolator. The local sub-models calculate temperatures for a number of predefined locations of sensors. They are trained independently, using limited data sets. Next, the neural interpolator, using the local temperatures modelled by the sub-modes, calculates the value of the temperature for any sensor location. The interpolator is also trained independently. This paper also discusses the method of choosing which local sub-models should be actually used. It is shown that for the initial structure with 10 sub-models as many as 6 or 7 of them may be removed without significant deterioration of overall model accuracy.

Paper: **6087** **C1L-D**

Multivariable Trajectory Tracking Control for a Heated Rod Based on an Integro-Differential Approach to Control-Oriented Modelling

Harald Aschemann [1], Georgy Kostin [2], Vasily Saurin [3]

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In this contribution, a model-based tracking control design is proposed for the temperatures at two selected points of a spatially one-dimensional iron rod. The rod is equipped with four Peltier elements on the lower surface, of which the first and the third ones serve as distributed control inputs. For a semi-discretisation of the partial differential equation, the method of integro-differential relations is combined with a projection approach. Introducing four finite elements, a state-space representation of order nine is obtained and used for the subsequent design of a tracking control structure that involves a decoupling dynamic feedforward control as well as proportional-integral state feedback control. Furthermore, an optimal observer is designed that provides estimates for the complete state vector as well as four additional disturbance variables. Simulations and experimental results at a test rig at the Chair of Mechatronics, University of Rostock, show that a decoupling of both outputs and an accurate tracking of desired trajectories is achievable.

Paper: **6142** **C1L-D**

Sensitivity-Based Approaches for an Efficient Design of Feedforward Controllers and Parameter Estimators for a Distributed Heating System

Andreas Rauh [1], Harald Aschemann [2]

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A combination of feedforward and feedback control is typically employed to guarantee accurate tracking of desired trajectories. These two degrees of freedom are usually exploited in such a way that the feedback control part guarantees asymptotic stability of the closed-loop system. The feedforward control depends on the desired trajectory and guarantees, in the ideal case, perfect tracking properties. For that purpose, feedforward control signals are computed in many cases by means of an analytic inversion of the system dynamics. This is, however, only possible in symbolic form if a relation between the flat outputs of a dynamic system and the desired outputs can be established. In many practical scenarios either the considered system is not differentially flat or the system inversion becomes prohibitively complex. Then, sensitivity-based approaches are still applicable. The focus of this paper is on a numerically efficient implementation of the feedforward control design of high-dimensional system models. Besides piecewise constant control inputs, piecewise

smooth input representations are considered for the control of multi-input multi-output systems.

Wednesday
August 31st, 2016

Plenary Lecture III Session, C2L-A

Day: Wednesday, August 31, 2016
Time: 09:00 - 10:00
Room: Casino
Chair: Krzysztof Kozłowski

Paper: **6278** **C2L-A**

Collaborative Robotics: from Workspace Sharing to Physical Interaction

Vincent Padois [1]

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Control and Systems Theory II Session, C3L-A

Day: Wednesday, August 31, 2016
Time: 10:00 - 11:00
Room: Casino
Chair: Krzysztof Galkowski

Paper: **6229** **C3L-A**

Desensitization of the Time-Optimal Trajectories

Andrzej Turnau [1], **Adam Piłat** [2], **Dawid Knapik** [3]

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The time-optimal trajectories are very sensitive to disturbances. The use of optimal strategy in real-time inevitably results in a departure from the optimal path. A return to the trajectory is no longer possible. When the time-optimal is replaced to the fix horizon problem then the real system moves from the optimal to nearing trajectories. Moreover, a further desensitization is possible by a proper shifting. The nearing desensitized trajectories are robust to disturbances at the cost of a slight increase in the control time.

Paper: **6191** **C3L-A**

On Assignability of Lyapunov Spectrum of Discrete Linear Time-Varying System with Control

Artur Babiarz [1], Irina Banshchikova [2], Adam Czornik [3], Evgenij Makarov [4], Michał Niezabitowski [5], Svetlana Popova [6]

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In this paper we study discrete linear time-varying system with control and bounded coefficients. For such systems we consider problems of the proportional global assignability and proportional local assignability of the Lyapunov spectrum of the discrete linear time-varying system with control. This is a generalization of the pole placement theorem, which is well-known in the theory of time-invariant system. The main results present sufficient conditions for considered types of assignability.

Paper: **6272** **C3L-A**

Existence of Reachable Pairs (A,B) of Discrete-Time Linear Systems

Tadeusz Kaczorek [1], Kamil Borawski [2]

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The problem of existence of reachable pairs (A,B) of discrete-time linear systems is formulated and solved. Necessary and sufficient conditions for the reachability of standard and positive full order and fractional order discrete-time linear systems are recalled. The existence of the reachable pairs (A,B) of the systems is investigated. Considerations are illustrated by numerical examples.

UAVs Session, C3L-B

Day: Wednesday, August 31, 2016
Time: 10:00 - 11:00
Room: Kalman
Chair: Bogdan Kreczmer

Paper: **6034** **C3L-B**

Thrust Pulse Control for UAV Control System Reconfiguration

Marcin Żugaj [1], Przemysław Bibik [2], Karolina Józefowicz [3]

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A new reconfiguration method using thrust pulse control is proposed in this paper. A reconfigurable closed-loop control system is established for control of a UAV fixed wing aircraft pitch angle via a pulse excitation of thrust in case of elevator failure. The pulse signal parameters are determined by analysis of a nonlinear dynamic model of a UAV aircraft. The model is also used to demonstrate the proposed method. Simulation results show that the aircraft pitch control via thrust pulse excitation can be carried out and satisfactory system performance may be achieved.

Paper: **6100** **C3L-B**

Robust Estimation Algorithm of Altitude and Vertical Velocity for Multirotor UAVs

Przemysław Gąsior [1], Adam Bondyra [2], Stanisław Gardecki [3], Wojciech Giernacki [4]

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This paper describes the process of the development and improvement of the altitude and vertical velocity estimation algorithm. The previous method was developed by authors two years back. After a diagnosis of pressure temperature drift caused by the main IMU, the additional barometric sensor was introduced. Based on readings from this reference component, three main modifications were developed to the algorithm's structure. In addition, three experimental sequences are presented to compare the previous approach with new ones. Results showed that new methods achieve better performance and are free from pressure drift caused by sensor's heating.

Paper: **6203** **C3L-B**

Software Environment for Simulation of UAV Multi-Agent System

Zbyněk Obdržálek [1]

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At the Institute of Computer Science at Silesian University in Opava is developed multi-agent system (MAS) in the form of a swarm of unmanned aerial vehicles (UAV). For the simulation of the multi-agent system was proposed double-layer software environment. As the presentation layer was selected the simulation tool Webots that enables detailed parameter settings of an individual agent (flying device model). For the function of multi-agent layer was selected simulation tool JADE used for testing large multi-agent systems. This document describes the use of the simulation environment and tools in the area of agents communication in developed UAV multi-agent system.

Signal Processing III Session, C3L-C

Day: Wednesday, August 31, 2016
Time: 10:00 - 11:00
Room: Lehar
Chair: Przemyslaw Ignaciuk

Paper: **6140** **C3L-C**

Observer and Filter Approaches for the Frequency Analysis of Speech Signals

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

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Language disorders can be classified into the three major linguistic levels of lexicon, grammar, and pronunciation. Most patient-oriented sessions at therapists' offices involve an enormous amount of work that is related to the analysis of spoken language. Therefore, it is desired to develop a software-based assistance system allowing a therapist to focus his/her valuable time on the actual therapy work. For that reason, a joint research project — bringing together the fields of signal processing and speech therapy — has been started recently. It consists of the following aims: (i) automatic transcription and preprocessing of spoken text involving erroneous pronunciation, (ii) automatic classification of pronunciation disorders, (iii) grammatical analysis of freely spoken language. This paper is related to the first project aim by providing an observer and filter-based substitute for the offline frequency analysis that is currently used in many state-of-the-art language recognition systems. Test cases of natural spoken language show the benefits and advantages of the

proposed technique in comparison with the widely used offline Fourier transformation for frequency analysis.

Paper: **6141** **C3L-C**

Stochastic Filter Approaches for a Phoneme-Based Segmentation of Speech Signals

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Computer-assisted systems for the automatic classification of disorders in the linguistic levels of lexicon, grammar, and pronunciation are currently under development in a joint research project bringing together the fields of signal processing and speech therapy. In a related publication, the authors have already demonstrated how deterministic observer techniques as well as stochastic filtering approaches can be applied to trace the individual formant frequencies included in a spoken language. These formants are characteristic for phonemes that can be classified into either voiced or unvoiced sounds. With respect to a reliable transcription of freely spoken text, it is however also necessary to classify the related phonemes. Especially when therapeutic aspects are investigated, a computer-assisted system needs to be able to automatically find the boundaries between subsequent phonemes in an audio stream. Such kind of boundary detection needs to be reliable against a wrong pronunciation. This especially holds when related disorders are dealt with in a therapeutic context. For this reason, a novel algorithm for the segmentation of speech signals is presented.

Paper: **6031** **C3L-C**

A Stochastic Approach to Contrast Detection Autofocusing. a 2D Case Analysis

Adrian Gałęziowski [1], **Przemysław Śliwiński** [2], **Paweł Wachel** [3]

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We present a 2D stochastic model of a contrast detection autofocus and we consider the influence of noise reduction on the focus measure function. Furthermore, we analyse formal properties of presented autofocus algorithm along with assumptions, which have to be fulfilled by noise reduction methods.

Biological Modelling and Simulation Session, C3L-D

Day: Wednesday, August 31, 2016
Time: 10:00 - 11:00
Room: Strauss
Chair: Jozef Korbicz

Paper: **6008** **C3L-D**

Valuable Experimental Model of Contraction Pneumatic Muscle Actuator

Alaa Al-Ibadi [1], Samia Nefti-Meziani [2], Steve Davis [3]

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modelling of pneumatic muscle actuators "PMA" is one of the valued challenges in soft robotic researches. Accurate force, length and position models allow for the wide use of make the continuum robot arm in industrial and medical applications. Moreover, accurate control can be achieved. This paper presents new formulas to model the length of contraction PMA. Furthermore, we modified the existing force model by calculating the most affected parameters. Then we are modelling the angle of arm. The three proposed models make it easy to track the length (position), force of PAMs and position angle of PMA arm

Paper: **6236** **C3L-D**

Cell Structures Modeling Using Fractal Generator and Torus Geometry

Przemyslaw Mazurek [1]

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Cell structures are observed in numerous types of images and there are a lot of structural estimators. Artificially generated images allow testing of them, because many of them are heuristic and sensitive to small structure changes. Coupling effect occurs additionally between them is important in pattern recognition application design. Proposed model gives sequence of images for evaluation purposes of estimators, starting from fractal or random to the regular (honeycomb like) using local stochastic optimization, and preserving fixed number of cells using torus geometry.

Paper: **6154** **C3L-D**

A Control-Theoretic Approach for Human Postural Control Modeling

Karim Tahboub [1]

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Although classically-adopted PID-cascade postural control schemes are adequate for describing effects of external disturbances acting on upright stance, it is shown in this article that they fall short to address the issue of voluntary motion due to the inherent instability of uncontrolled upright posture. A novel alternative, "hybrid cascade-feedback scheme," is presented and shown to be equivalent to the PID-cascade scheme in terms of external disturbances but overcome its shortcomings related to voluntary motion. This proposed scheme is based on a well-established robust tracking and disturbance rejection control method. It can be modularly extended to cover multiinput- multi-output scenarios through employing state-space tools.

Poster Session IV, C4P-E

Day: Wednesday, August 31, 2016
Time: 10:00 - 12:00
Room: Poster Area
Chair: Rafal Stanislawski

Paper: **6045** **C4P-E**

A Simulation Investigation Into the Signal Reconstruction Accuracy of the Transducer with Pulse Frequency Output

Eligiusz Pawłowski [1]

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The article discusses assessing the reconstruction accuracy of a signal in systems using transducers with a frequency output. A Voltage-to-Frequency Converter VFC working in a dynamic state was considered. The frequency signal obtained in this manner is particularly disadvantageous from a dynamic perspective. A simulation algorithm was developed that makes it possible to obtain digital samples of instantaneous values of a frequency signal from a VFC for the input signal provided in analytical form. The results of conducted simulation studies are presented. The influence of input signal parameters on the obtained Effective Number of Bits ENOB value of the tested converter has been analyzed.

Paper: **6074** **C4P-E**

Bayesian Analysis of EEG Signal Frequency Components

Jędrzej Chiliński [1], Waldemar Bauer [2], Jerzy Baranowski [3]

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Electroencephalography is one of the most common electrophysiological methods. Regardless of its ubiquity, the problem of automatic EEG data processing and analysis is a topic of an ongoing research. In this paper we discuss an algorithm for detection of frequency components in EEG signal with the use of Bayesian statistics. Proposed approach creates a model of a signal, which consists of only statistically relevant components. Model parameters are estimated in a way that avoids getting stuck in local minima. Operation of the algorithm is illustrated with examples of real and artificial signals.

Paper: **6108** **C4P-E**

Cameras Vibrations Influence on Efficiency of Teleoperated Unmanned Ground Vehicle

Agnieszka Dąbrowska [1], Mirosław B. Jaskółowski [2], Arkadiusz Rubiec [3]

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This paper presents research results of cameras vibrations influence on efficiency of teleoperated Unmanned Ground Vehicle (UGV) use. Research was being made on special prepared terrain test stand, which has been fully described in this article. Based on results it has been made proposal for UGVs suspension systems evaluation criteria. It has been specified four levels of suspension systems efficiency. This criteria enable developed suspension systems of teleoeprated UGVs correctly.

Paper: **6131** **C4P-E**

Input Shaping Tuning with Usage of Particle Swarm Optimization

Maciej Gniadek [1], Stefan Brock [2]

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Input shaping is one of the most common methods of preventing oscillations in electromechanical systems. The tuning of input shaping may be problematic in black boxes, systems with non-linarites, and more complicated plants. The autotuning algorithms using bioinspired methods are capable to solve those problems. The main idea of its usage is presented in the paper. The comparison with classical algorithms is presented as well.

Paper: **6148** **C4P-E**

Detection of Facial Gestures Artefacts Created During an EEG Research Using Artificial Neural Networks

Arkadiusz Kubacki [1], Lukasz Sawicki [2], Piotr Owczarek [3]

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The article concerns detecting artefacts created by facial expressions in an EEG with the use of artificial neural networks. During the EEG research may appear some interferences which are called artefacts caused for example by muscle activity. This article will focus on some of them, namely eyeballs movements to the right and left, opening the mouth, smile, lifting eyebrows, opening and closing eyes. In order to record the electrical activity of the brain a device called Emotiv EPOC+ was used. One of the aims of the research was to find a suitable activation function for the artificial neural networks.

Paper: **6175** **C4P-E**

No-Reference Quality Assessment of 3D Prints Based on the GLCM Analysis

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Quality assessment of 3D prints is one of the newest challenges for machine vision. As the 3D printing is relatively new technology, it is still far from perfection and there are many static or dynamically changing factors which can affect the quality of the final 3D prints. Considering the relatively long time necessary for printing, it may be reasonable to interrupt the printing process in order to save the filament (or another material) and time in the case of decreased quality of already printed fragment of an object. Such monitoring requires the use of the video feedback with appropriate image analysis methods which should allow a reliable quality assessment of the printed object's part. Typically such assessment should not be based on the comparison with a reference image, as in many image quality assessment methods, because such an image is usually unavailable. Therefore in this paper an approach for the no-reference quality assessment of the 3D prints based on the analysis of the Gray-Level Co-occurrence Matrix (GLCM) and chosen Haralick features is proposed and investigated. Obtained experimental results demonstrate the validity and usefulness of the proposed approach.

Paper: **6194** **C4P-E**

RT/FPGA Implementation of the IEEE 1451 Standard in Sensors for Machine Conditioning Systems

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IEEE 1451.4 standard introduced the full "plug and play" for sensors and actuators thanks to TEDS – Transducer Electronic Datasheet. This paper present the implementation of the IEEE 1451.4 standard in custom made vibration transducers, based on MEMS accelerometers. The transducers were calibrated and the results of calibration are stored in TEDS added to the sensor. Than the transducers with TEDS were utilized in experimental machine conditioning system based on embedded RT/FPGA platform.

Paper: **6201** **C4P-E**

Evaluation of Calibration Results Using the Least Median of Squares Method in the Case of Linear Multivariate Models

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Application of the least median of squares (LMS) method to determine the calibration curves of measuring instruments involves the need to evaluate the obtained results. This paper proposes the method of estimating the variance of the LMS regression coefficients, which allows the evaluation of the quality of the set regression coefficients. The concept of a priori estimation consists in performing an estimation before the measurement experiment. A posteriori estimation uses the data from the previously conducted measurement experiment. Simulation tests were carried out to compare the estimation results with the ones obtained in the course of the simulated experiment.

Paper: **6261** **C4P-E**

Particle Filter in Multidimensional Systems

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The article presents studies on the estimation quality of a particle filter applied to small multidimensional objects. For the purposes of the article, a new type of network has been proposed, in which each node is associated with one state variable. Based on performed simulations it has been found that particle filter implemented for small systems (1- or 2-dimensional) is a good choice. However, for larger objects Kalman filter may return better results (it depends on the chosen particles number). This is due to the exponential dependence of needed particles number to the object dimension. It has been also observed that the particle filter, in comparison to the Extended Kalman filter, better estimates the state variables which are well metered, and simultaneously worse estimates the state variables which are worse metered. Possible approaches for objects with a greater number of state variables also have been adduced, including the dispersed particle filter.

Paper: **6262** **C4P-E**

Allophones in Automatic Whispery Speech Recognition

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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 whether the extended set of articulatory units (allophones have been used instead of phonemes) improves quality of whispery speech recognition. Experimental results show that the small changes in the allophone set may provide better speech recognition quality than using phonemes approach. The authors also made available the trained g2p (grapheme-to-phoneme) model of Polish language for the Sequitur toolkit.

Paper: **6269** **C4P-E**

Digital Filter Design for Compensating the Nonlinear Behavior of Sound Intensity Probe

Witold Mickiewicz [1]

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The paper addresses a problem of the measurement of an acoustic energy flow using

sound intensity pressure-velocity probes. Nowadays this technique has become more and more popular in modern sound field investigation. Using a so called 3D SI probe there is possible to visualize sound energy flow of real sources in real objects. In the paper the metrological problem of amplitude-phase frequency characteristics compensation is presented, what is crucial for that kind of probes. A compensation routine using digital filter is proposed as an alternative to analog compensation and digital routine in frequency domain. The routine will be included in the postprocessing block of the fully automated sound intensity measurement system.

Paper: **6116** **C4P-E**

Novel Rough Neural Network for Classification with Missing Data

Robert Nowicki [1], **Rafal Scherer** [2], **Leszek Rutkowski** [3]

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The paper presents a new feedforward neural network architecture. Thanks to incorporating the rough set theory, the new network is able to process imperfect input data, i.e. in the form of intervals or with missing values. The paper focuses on the last case. In contrast to imputation, marginalisation and similar solutions, the proposed architecture is able to give an imprecise answer as the result of input data imperfection. In the extreme case, the answer can be indefinite contrary to a confabulation specific for the aforementioned methods. The results of experiments performed on three classification benchmark datasets for every possible combination of missing values showed the proposed solution works well with missing data with accuracy dependent on the level of missing data.

Paper: **6187** **C4P-E**

Reconstructing Method of Nonlinear Dynamic Surfaces

Volodymyr Khoma [1], **Wojciech Hunek** [2], **Anna Khoma** [3]

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In this paper reconstructing method of spherical and variable in time surface based on estimation of the instantaneous values phase with imaginary part of complex white light interferogram logarithm is presented. An accuracy analysis of the above-mentioned method in terms of reconstruction of spherical surface is done here. The methodology of research concerns the synthesis of surface through the mathematical model of interferogram as well as an estimate the error of profile reconstruction. The effectiveness of the method is verified through the reconstruction of surface obtained from interferogram of white light under monitoring the pressure sensor membrane.

Paper: **6205** **C4P-E**

Fractional Order Controller in a Servo Drive - Case of Cogging Moment

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

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Results of using fractional order PI current controller, and classical one, in case of cogging effect in servo drive are presented in the paper. The general cascade control system of the servo drive and motor model with dry friction are presented. The most significant result in case of using fractional order current controller (FOCC) observed for starting servo drive in the presence of cogging moment are presented and commented.

Fractional Order Systems II Session, C5L-A

Day: Wednesday, August 31, 2016
Time: 11:20 - 13:00
Room: Casino
Chair: Krzysztof Latawiec

Paper: **6160** **C5L-A**

Extensions of the Cayley-Hamilton Theorem to Fractional Descriptor Linear Systems

Tadeusz Kaczorek [1]

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The classical Cayley-Hamilton theorem is extended to the fractional descriptor continuous-time linear systems. First the theorem is extended to fractional descriptor linear systems with commuting matrices and next to any pair of matrices of the descriptor linear systems. The extension is based on the application of the Lagrange-Sylvester formula of the function of matrices.

Paper: **6246** **C5L-A**

Implementation Issues in Discretization of Fractional-Order Derivative Using the Al-Alaoui Operator

Rafał Stanisławski [1], **Marek Rydel** [2], **Marcin Gałek** [3]

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This paper presents new results in simulation analysis of Al-Alaloui-based discretization scheme for fractional-order derivative. The analysis is performed both in frequency and time domains. A series of simulation analyses provide to formulation of some implementation highlights related to approximation of fractional-order derivative with the Al-Alaloui operator.

Paper: **6007** **C5L-A**

Relative Observability, Duality for Fractional Differential-Algebraic Delay Systems with Jumps Within Riemann-Liouville Fractional Derivatives

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In the paper relative R-observability is considered for linear stationary fractional differential-algebraic delay system with jumps (FDADJ). FDADJ system consists of fractional differential equation in the Riemann-Liouville sense and difference equations. We present the determining equation systems and their properties. We derive solutions representations into series of their determining equation solutions and obtain effective parametric rank criteria for relative R-observability. A dual controllability result is also formulated.

Paper: **6061** **C5L-A**

A New Variant of Adams - Bashforth - Moulton Method to Solve Sequential Fractional Ordinary Differential Equation

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In the paper we present a numerical method to solve sequential fractional differential equation (SFDE) with Caputo derivatives of order in the range (0,1] in sequential sense. The proposed scheme is a new variant of predictor - corrector method. Predictor is received by calculating the integrals of integral equation using rectangle method. To determine the corrector we use alternately two methods to calculate the integrals: Simpson's rule or trapezoidal rule depending on an odd or even number of nodes in the integration interval. In the final part, examples of numerical results are discussed.

Paper: **6173** **C5L-A**

The Second Form of the Variable–, Fractional–Order Discrete–Time Integrator

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The paper investigates the second form of the linear discrete-time integrator characterised by the variable, fractional order of integration. An equation of such dynamic element is given. A special vector–matrix description is proposed. Relations between the order functions and element responses are given in a numerical example.

Fault Detection Session, C5L-B

Day: Wednesday, August 31, 2016
Time: 11:20 - 13:00
Room: Kalman
Chair: Andreas Rauh

Paper: **6023** **C5L-B**

Fault Monitoring and Fault Tolerant Control in Distillation Columns

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An investigation of fault tolerant control of distillation columns under faulty sensors and actuators is presented in this work. Real-time sensor and actuator fault detection, propagation and accommodation are all investigated. Dynamic principal components analysis is used to promptly and effectively detect and isolate actuator and sensor faults. Alternative control strategy is then implemented to accommodate the faults. Specifically, fault tolerant inferential control is employed to accommodate sensor fault using soft sensor developed through dynamic principal component regression. Dual composition control strategy used for normal column operation is switched to one-point control to accommodate actuator fault utilizing the remaining healthy actuator. The main contributions of this paper is the application of fault tolerant inferential control and one-point control strategy to accommodate sensor and actuator faults respectively in the distillation column operation. The effectiveness of the proposed approaches were demonstrated on a simulated methanol-water separation column.

Paper: **6098** **C5L-B**

Fault-Tolerant Control and Diagnosis for a Non-Linear System with an Unknown Input Observer

Marcel Luzar [1]

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An Unknown Input Observer design for the sensors fault diagnosis of a non-linear system is the aim of this paper. To detect the faulty sensor, the method based on output residual is used. To obtain such a residual signal, an observer-based approach is proposed. How to design such observer is explained in details. Moreover, the two-tank system fault-tolerant control method is proposed. An experimental verification, which presents the performance of the proposed approach is given in the final section of this paper.

Paper: **6165** **C5L-B**

Towards Robust Process Fault Estimation for Uncertain Dynamic Systems

Marcin Pazera [1], **Marcin Witczak** [2]

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The paper deals with the problem of simultaneous state and process fault estimation for uncertain dynamic systems. Contrarily to the approaches presented in the literature, the nonlinear estimation problem is reduced to the linear one by introducing a suitable system reparameterization and new estimator structure. Instead of estimating the fault directly, its product with state and the state itself are estimated. To tackle this problem, a robust design procedure is proposed that takes into account uncertainties acting onto the system being diagnosed. The approach is based on the quadratic boundedness approach allowing convergence analysis of uncertain systems with bounded uncertainties. Subsequently, a simple algebraic approach is proposed to derive the fault estimate. The final part of the paper shows a numerical example concerning state and pitch actuator component fault estimation of a wind turbine.

Paper: **6166** **C5L-B**

A Quadratic Boundedness Approach to Adaptive Simultaneous Sensor and Actuator Fault Estimation

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The paper tackles the problem of designing a simultaneous actuator and sensor fault estimator with an adaptive threshold. In general, the work is focused on developing an adaptive estimation strategy with a quadratic boundedness approach. This method guarantees the convergence of the estimator under ounded disturbances. The main novelty lies in the simultaneous estimation of actuator and sensor faults, while these problems are usually treated separately. Another appealing advantage of the proposed approach is the fact that it provides a confidence interval of the state and faults, which supports diagnostic decisions. The final part of the paper portrays an illustrative example concerning laboratory DC motor, which confirms the effectiveness of the proposed strategy

Paper: **6184** **C5L-B**

Towards a Practical Reachability Test for Dynamic Systems Under Process Faults

Marcin Witczak [1], Józef Korbicz [2], Michał de Rozprza-Faygel [3], Damiano Rotondo [4], Vicenç Puig [5]

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The main objective of this paper is to provide a practical test for checking system reachability under process faults. Taking into account the unappealing phenomenon of faults, it is assumed that the knowledge about them is limited, i.e. they are known up to some confidence interval. Thus, the main objective of this paper is to provide a computational algorithm that can be used for settling such a robust reachability challenge. For that purpose, very useful mathematical tools are recalled, which are called P- and block P-matrices. Subsequently, a new tool is developed, which is able to check if a given matrix is P- or block P-one. The proposed approach is characterized by low computational burden comparing to those presented in the literature. Based on it, a new reachability test is developed for systems under process faults. The final part of this paper shows experimental results, which clearly expose the effectiveness of the proposed approach.

Modelling and Simulation II Session, C5L-C

Day: Wednesday, August 31, 2016
Time: 11:20 - 13:00
Room: Lehar
Chair: Joachim Horn

Paper: **6198** **C5L-C**

Adaptive Position-Dependent Friction Characteristics for Electromagnetic Actuators

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An approach for an adaptive position-dependent friction estimation for linear electromagnetic actuators with altered characteristics is proposed in this paper. The objective is to obtain a friction model that can be used to describe different stages of aging of magnetic actuators. It is compared to a classical Stribeck friction model by means of model fit, sensitivity, and parameter correlation. The identifiability of the parameters in the friction model is of special interest since the model is supposed to be used for diagnostic and prognostic purposes. A method based on the Fisher information matrix is employed to analyze the quality of the model structure and the parameter estimates.

Paper: **6179** **C5L-C**

Model of the Air Stream Ratio for an Electromagnetic Mill Control System

Szymon Ogonowski [1], Zbigniew Ogonowski [2], Marek Pawełczyk [3]

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The paper presents a model of the air stream ratio in the dry grinding and classification circuit with the electromagnetic mill. The concept of the grinding system is described along with indirect measurement methodology. Model structure and identification problems are discussed and a supervisory control algorithm based on the model is derived

Paper: **6159** **C5L-C**

Dynamic Modeling and Simulation of a Bicycle Stabilized by LQR Control

Adam Owczarkowski [1], Dariusz Horla [2], Piotr Kozierski [3], Talar Sadalla [4]

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In this paper, we present a new approach to mathematical modeling of the bicycle. It is based on the detailed nonlinear Whipple scientific description. We are focused on the state space representation which we use to solve the control law and we test the optimal linear quadratic control which finally gives satisfactory results. The article includes a several computer simulations of the single-track vehicle motion. We indicate when the bicycle is self-stable. The results are useful to make further research on the bicycle modelling.

Paper: **6126** **C5L-C**

Reproduction of Equipment Wear Characteristics with Kernel Regression

Karol Koniuszewski [1], Paweł Domański [2]

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Predictive maintenance task is of crucial role for any plant equipment supervision and scheduling of service activities. For this purpose it should be known what is current aging status of any equipment. Presented approach assumes that we know the nominal (starting) element curve and a damage one as well. It is also assumed that the aging course progresses according to some good practice aging Lorentz attrition (wear) curve. Kernel Regression algorithm is used to perform curve adaptation and then enabled to identify current element status and varying aging curve. The approach is tested on SISO and two-dimensional examples proving its ability to reproduce equipment aging characteristics.

Paper: **6122** **C5L-C**

Estimation of Internal Exhaust Gas Recirculation and Scavenging Gas in an Engine with Variable Valve Lift

Daniel Schwarz [1], Harald Aschemann [2], Robert Prabel [3], Thorsten Schmidt [4]

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This paper presents an average value model for the real-time estimation of residual and reaspirative gas in a cylinder of an innovative diesel engine with variable valve lift. Based

on a mean-value-model over a combustion cycle, the oxygen mass fraction before the combustion is calculated with information of an oxygen sensor in the intake and a lambda sensor in the exhaust manifold. Furthermore, a model for the residual and reaspirative gas mass is introduced that employs information of the cylinder gas mass, the fuel mass and the intake oxygen. The model equations are validated at an engine with a series high pressure line. Finally, a method for estimating the scavenging mass is introduced. Experimental results point out the benefits of the proposed estimation scheme.

Robotics VI Session, C5L-D

Day: Wednesday, August 31, 2016
Time: 11:20 - 13:00
Room: Strauss
Chair: Ian Walker

Paper: **6170** **C5L-D**

Simulation-Based Comparison of 2D Scan Matching Algorithms for Different Rangefinders

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A scan matching technique is a key component for rangefinder-based Simultaneous Localization and Mapping (SLAM). A lot of scan matching techniques have been developed, and normally when a new scan matching technique is developed, it will be compared with existing techniques, but normally there is only one specified type of rangefinder is used, which cannot fully demonstrate the improvement. Nowadays there are plenty types of rangefinders, which differ in maximal range, field of view, accuracy and of course price. In this work, different rangefinders with different scan matching techniques are examined, and a benchmarking system is developed for measuring the performance of each combination. The result of this work can provide suggestions for which kind of rangefinder works best with which kind of scan matching techniques in indoor environment, and therefore can be used as guidelines for the choosing of rangefinder in indoor SLAM application to reduce the price of the system.

Paper: **6238** **C5L-D**

A Hierarchical Global Path Planning Based on Multi—Objective Particle Swarm Optimization

Thi Thoa Mac [1], **Cosmin Copot** [2], **Trung Tran Duc** [3], **Robin De Keyser** [4]

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In this study, a novel hierarchical global path planning approach for mobile robot navigation in a clutter environment is proposed. This approach has a three-level structure to obtain a feasible, optimal and safe path. In the first level, the triangular decomposition method is used to quickly establish a geometric free configuration space of the robot. In the second level, Dijkstra's algorithm is applied to find a collision-free path used as input reference for the next level. Lastly, a proposed particle swarm optimization called constrained multi- objective particle swarm optimization (CMOPSO) with an accelerated update methodology is employed to generate the global optimal path with the focus on minimizing the path length and maximizing path smoothness. The simulations illustrates the superiority of this method in terms of solution quality and actual execution time.

Paper: **6274** **C5L-D**

Saddle Point Detection of the Navigation Function in Nonholonomic Mobile Robot Control

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This paper presents navigation function saddle point detection and avoidance for a unicycle robot in sphere worlds. The detection is based on the gradient and Hessian analysis. The avoidance algorithm was numerically tested for two scenarios and various values of the parameter connected with the sensitivity of the saddle point detection.

Paper: **6037** **C5L-D**

Distributed NAO Robot Navigation System in the Hazard Detection Application

Wojciech Dudek [1], Konrad Banachowicz [2], Wojciech Szynkiewicz [3], Tomasz Winiarski [4]

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Contemporary robots control algorithms, that takes from sensor data fusion and processing, require high computational power. Hence, most of the robots have their own highly efficient computers. It makes the service and assistant robots costly and still unavailable for the most of the home users. In the article the navigation system of the humanoid NAO robot is presented that is distributed through the robot and the cloud. It reduces the cost of the particular robot and makes it affordable for customers. Furthermore, the multi embodied agent task specification and implementation method is proposed and illustrated on hazard detection - the assistant robot application to help the elderly people to dwell at home.

Paper: **6127** **C5L-D**

Advanced Control Techniques to Mitigate the Stop-and-Go Waves on a Highway Traffic with Different Vehicles

Cosmin Copot [1], Constantin Florin Caruntu [2], Robin De Keyser [3]

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In this paper we investigate the behavior of stop-and- go waves present on highways using different type of mobile robots. The paper illustrates the way to find a solution to mitigate the stop-and-go waves by implementing and testing in simulation different control strategies from simple PI controllers to more advanced model based predictive controllers. A comparison between the designed controllers and a driver based controller was considered. The revealed results shows that by using a suitable control strategy, the stop-and-go waves can be diminished.

Nonlinear Control Session, C6L-A

Day: Wednesday, August 31, 2016
Time: 15:00 - 16:00
Room: Casino
Chair: Andrzej Bartoszewicz

Paper: **6113** **C6L-A**

Nonlinear Robust Backstepping Control Method Approach for Single Phase Inverter

Elif Kolbasi [1], Murat Seker [2]

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Single phase inverters are commonly used to transfer energy from a source to the crucial appliances or emergency power system. In this study a new model based robust controller for a single phase inverter under the constraint that the output filter parameters are not exactly known is presented. The nonlinear robust controller ensures the output voltage with lowest distortion, desired amplitude and frequency. The stability of proposed control method and the boundedness of the closed loop system are established via Lyapunov based tools with a robust backstepping procedure. Simulation results are given in order to demonstrate performance and effectiveness of the proposed robust controller.

Paper: **6188** **C6L-A**

Design and Implementation of the Air/Water Heat Pump Controller with Increased Coefficient of Performance

Piotr Tatjewski [1], Maciej Ławrynczuk [2], Piotr Marusak [3], Marian Rubik [4], Piotr Ziętek [5], Maciej Szumski [6], Michał Szumski [6]

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A control algorithm design to increase the economic performance of the air/water heat pump is described. The heat pump itself has very fast dynamics when compared with the heated object; therefore the controller uses static pump modeling to derive the control action. The algorithm controls the compressor in order to stabilize the temperature of water flowing out of the condenser, and the expansion valve in order to minimize superheat and fulfill the superheat constraints. The algorithm provides stable operation of the heat pump and ensures increase of the Coefficient of Performance (COP) for different conditions

in which the controlled device operates (in a wide range of air temperature). An average 10

Paper: **6189** **C6L-A**

Comparison of Linear and Nonlinear Feedback Control for a Half-Car Model with MR Dampers

Piotr Krauze [1], **Jerzy Kasprzyk** [2]

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The paper deals with linear and nonlinear feedback control for a half-car model including Spencer model of the magnetorheological damper. All control schemes were assessed using a ride-comfort quality index. For the linear state-feedback control different variants of LQ problem was solved. Also, nonlinear separate suspension control schemes based on squared or cubic front and rear vehicle body velocities or accelerations were validated. The well-known separate Skyhook and ADD (acceleration-driven damping) were treated as the reference algorithms. It was shown that the enhanced LQ-based state-feedback control offers better control quality in comparison to the classical Skyhook and ADD algorithms.

Optimization I Session, C6L-B

Day: Wednesday, August 31, 2016
Time: 15:00 - 16:00
Room: Kalman
Chair: Ewa Pawluszewicz

Paper: **6146** **C6L-B**

Heuristic Solving Some Discrete-Continuous Project Scheduling Problems with Discounted Cash Flows

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

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A discrete-continuous project scheduling problem with discounted cash flows is considered. Each activity requires for its processing discrete resources and an amount of a continuous resource. Processing rate of an activity is a concave 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. Two heuristics for allocating the continuous resource are proposed, and compared to optimum on a basis of a computational experiment.

Paper: **6263** **C6L-B**

Optimal Allocation of Power - Graphical Interpretation of Some Scheduling Problem

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

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We consider a practical makespan minimization problem that arises in a multiprocessor computer system where some processors may be shut down during computation to save some amount of shared power. The system consists of m processors driven by a common power source. Moreover, we consider a set of n independent, nonpreemptive jobs which model a given set of computational tasks. A processing time of a jobs is unknown a priori, but each job is characterized by a size, determined by a number of CPU cycles necessary to complete this job. The processing rate of a job depends on an amount of power allotted to this job at a moment. In the "power on" state an idle machine uses a constant amount of power. A machine uses no power in the power off state. We identify some cases of optimal solutions for the simplest situation of two machines and jobs characterized by the same processing rate function.

Paper: **6176** **C6L-B**

Multi-Objective Control Optimization for Congestion Avoidance in Computer Networks

Sławomir Grzyb [1], **Przemysław Orlowski** [2]

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This paper focuses on avoiding and alleviating network congestions using multi-objective optimization for gain setting of used controllers. Unlike in other presented approaches, it this case the non-stationary, discrete, dynamical model is used. This reflects delay conditions in real environment, which are varying in time. Proposed control strategy tunes the presented model of communication channel to alleviate the results of sudden, unexpected network state changes. It is obtained by maximization of available bandwidth usage combined with minimization of buffer utilization. This supports avoiding undesirable congestion effects like packet dropping, retransmissions, high delay and low network throughput.

Predictive Control II Session, C6L-C

Day: Wednesday, August 31, 2016
Time: 15:00 - 16:00
Room: Lehar
Chair: Harald Aschemann

Paper: **6242** **C6L-C**

Non-Linear System Predictive Control Based on PWARX Models

Olfa Yahya [1], Zeineb Lassoued [2], Kamel Abderrahim [3]

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In this paper, hybrid control strategy is applied for a nonlinear plant identified by PWARX (piecewise autoregressive with exogenous input) models allowing to model different operating modes of the system. The identification stage is based on Density-Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm. We proposed using MPC (Model Predictive Control) methodology to control the system. Different features must be taken into account and the optimization problem is transformed into mixed-integer quadratic programming problem (MIQP). By minimizing tracking error, practical implementation results show the efficiency of the proposed methodology for modelling the behavior of nonlinear process and its control.

Paper: **6256** **C6L-C**

Embedded Model Predictive Control of Unmanned Micro Aerial Vehicles

Tomás Baca [1], Giuseppe Loianno [2], Martin Saska [3]

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We propose a lightweight embedded system for stabilization and control of Unmanned Aerial Vehicles (UAVs) and particularly Micro Aerial Vehicles (MAVs). The system relies solely on onboard sensors to localize the MAV, which makes it suitable for experiments in GPS-denied environments. The system utilizes predictive controllers to find optimal control actions for the aircraft using only onboard computational resources. To show the practicality of the proposed system, we present several indoor and outdoor experiments with multiple quadrotor helicopters which demonstrate its capability of trajectory tracking and disturbance rejection.

Paper: **6264** **C6L-C**

Complex Manoeuvres of Heterogeneous MAV-UGV Formations Using a Model Predictive Control

Vojtech Spurny [1], Tomás Baca [2], Martin Saska [3]

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A problem of motion planning and coordination of compact formations of ground and aerial robots will be tackled in this paper. The scenarios when the formation composed from Unmanned Ground Vehicles (UGVs) and Unmanned Aerial Vehicles (UAVs), in particular Micro Aerial Vehicles (MAVs), has to reverse the direction of movement to fulfil task of collision-free motion to a target zone will be solved. The presented motion planning and stabilization approach provides an effective technique to enable deployment of closely cooperating teams of robots in outdoor as well as indoor environment. The formation to target region problem is solved using a Model Predictive Control (MPC) methodology and the formation driving concept is based on a virtual-leader-follower approach. The mentioned MPC based process is used for trajectory planning and control of a virtual leader and also for control and stabilization of followers (MAVs and UGVs). The proposed approach is verified with numerous simulations and hardware experiments.

Modelling and Simulation III Session, C6L-D

Day: Wednesday, August 31, 2016
Time: 15:00 - 16:00
Room: Strauss
Chair: Roman Smierzchalski

Paper: **6053** **C6L-D**

Mobile Ad Hoc Network for a Heavy Gas Cloud Boundary Estimation and Tracking

Mateusz Krzysztoń [1], Ewa Niewiadomska-Szynkiewicz [2]

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Mobile wireless ad hoc network (MANET) can significantly enhance the capability to monitor contaminated areas, detect gas clouds and support rescue teams working in the emergency areas. This paper investigates the problem of estimation of boundary of discovered heavy gas cloud. We describe a three-phase strategy for construction a sensing system, in which mobile sensors explore the region to detect the gas cloud, create preliminarily network topology and finally, adapt this topology to detect the cloud boundary maintaining the permanent communication with the central operator. We evaluate the performance of the proposed strategy based on the results of simulations.

Paper: **6147** **C6L-D**

Application of Sampling-Based Path Planning for Tunnel Detection in Dynamic Protein Structures

Vojtěch Vonásek [1], Barbora Kozlíková [2]

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Behavior and properties of proteins as well as other bio-macromolecules is influenced by internal void space such as tunnels or cavities. Tunnels are paths leading from an active site inside the protein to its surface. Knowledge about tunnels and their evolution in time provides an insight into protein properties (e.g. stability or resistance to a co-solvent). Tunnels can be found using Voronoi diagrams (VD). To consider protein dynamics, that is represented by a sequence of protein snapshots, correspondences between VD in these snapshots need to be found. The computation of these correspondences is however time and memory consuming. In this paper, we propose a novel method for tunnel detection in dynamic proteins based on Rapidly Exploring Random Tree (RRT). The method builds a single configuration tree describing free space of the protein. The nodes of the tree are pruned according to protein dynamics. The proposed approach is compared to CAVER 3.0, one of the widely used freely available tools for protein analysis.

Paper: **6161** **C6L-D**

On Significance of Second-Order Dynamics for Coupled Tanks Systems

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

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Coupled tanks systems play an important role in control teaching. Although, due to existence of two independent storages, they are second order systems, it has been shown that one time constant is at least 6 time greater than the other. In normal operation conditions this ratio is about 10-20. Therefore special attention is necessary to explain their properties.

Thursday
September 1st, 2016

Plenary Lecture IV Session, D1L-A

Day: Thursday, September 01, 2016
Time: 09:00 - 10:00
Room: Casino
Chair: Jozef Korbicz

Paper: **6277** **D1L-A**

Intelligent Fault Monitoring of Critical Infrastructure Systems

Marios M. Polycarpou [1]

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Adaptive Control I Session, D2L-A

Day: Thursday, September 01, 2016
Time: 10:00 - 11:00
Room: Casino
Chair: Maciej Lawrynczuk

Paper: **6193** **D2L-A**

Adaptive Control of Torsional Oscillations in Drill Strings Using a Continuous-Discrete Extended Kalman Filter

Farooq Kifayat Ullah [1], **Franklyn Duarte** [2], **Christian Bohn** [3]

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An indirect adaptive control strategy is developed to deal with self-excited torsional oscillations in drilling rig setups caused by friction during cutting action of the drill bit. The main contribution is the use of an online parameter estimator i.e. a state augmented continuous to discrete extended Kalman filter which is used to estimate parameters of the plant and adaptively update a robust backstepping controller in closed loop. The control strategy is simulated using parameters matching a real drill rig.

Paper: **6218** **D2L-A**

Comparison of Various Barrier Lyapynov Functions for Adaptive Control of Nonlinear Systems

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

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The impact of the selected Lyapunov function on the performance of a nonlinear system designed by adaptive backstepping is considered. Special attention is paid to the comparison of various Barrier Lyapunov Functions, which assure preservation of hard state constraints during any transient. The differences in the system operation are discussed and some recommendations the Lyapunov function selection are given.

Control and Systems Theory III Session, D2L-B

Day: Thursday, September 01, 2016
Time: 10:00 - 11:00
Room: Kalman
Chair: Tadeusz Kaczorek

Paper: **6079** **D2L-B**

Dynamic Quasi-Soft VSC of Discrete-Time Systems with Magnitude-Constrained Inputs

Przemysław Ignaciuk [1]

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In order to improve convergence rate while retaining smooth control action soft Variable Structure Control (VSC) can be considered. The classical formulation of soft VSC in continuous time domain assumes smooth switching among an infinite number of controllers. In now commonplace digital implementation changing the control structure is limited to sampling instances, leading to a quasi-soft control system. This paper explores the possibility of extending the favorable characteristics of dynamic soft VSC to the input-constrained systems with finite sampling. The design procedure and stability analysis are conducted directly in discrete time domain. The properties of the proposed controller are formally proved and illustrated in numerical tests. Comparison with discrete sliding-mode control is provided.

Paper: **6117** **D2L-B**

An Unconditionally Stable Approximation of a Circular Flexible Plate Described by a Fourth Order Partial Differential Equation

Petr Augusta [1], **Blazej Cichy** [2], **Krzysztof Gałkowski** [3], **Eric Rogers** [4]

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An unconditionally stable finite difference scheme for systems whose dynamics are described by a second-order partial differential equation is developed with use of regular hexagonal grid. The scheme is motivated by the well-known Crank-Nicolson discretization which was developed for first-order systems. The stability of the finite-difference scheme is analyzed by von Neumann's method. Using the new scheme, a discrete in time and space model of a deformable mirror is derived as the basis for control law design. The convergence of this scheme for various values of the discretization parameters is checked by numerical simulations.

Paper: **6054** **D2L-B**

On the Lyapunov, Perron, Bohl and General Exponents of Discrete Linear Time-Varying Diagonal Systems

Artur Babiarz [1]

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In the paper definitions and main properties of the Lyapunov, Perron, Bohl and general exponents of the discrete time-varying linear system are presented. In addition, the relations between these exponents and different types of stability of the considered system are discussed. Finally, a conjecture is formulated.

Control Applications II Session, D2L-C

Day: Thursday, September 01, 2016
Time: 10:00 - 11:00
Room: Lehar
Chair: Marian Blachuta

Paper: **6211** **D2L-C**

Control and Robust Tower Oscillation Damping for a Wind Turbine Equipped with a Hydrostatic Drive Train and a Synchronous Generator

Harald Aschemann [1], Julia Kersten [2]

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In this paper, a model-based control is proposed for an innovative 5 MW wind turbine with a hydrostatic transmission and a synchronous generator. The proposed control is derived by solving Linear Matrix Inequalities (LMIs) so that given parameter uncertainties and state-dependent matrices can be considered adequately. It comprises both a SISO control for the rotor angular velocity by adjusting the hydrostatic transmission as well as an active oscillation damping of tower bending oscillations, where the pitch angle serves as control input. The control is capable to operate within the whole operating range from low to very high wind speeds. A disturbance observer is used to estimate the aerodynamic rotor torque as well as leakage effects in the hydrostatic transmission. Here, the wind speed can be reconstructed from the estimated rotor torque. The overall control performance is illustrated by realistic simulation results, which show an improved damping of tower oscillations and an excellent tracking behaviour for the controlled variables.

Paper: **6228** **D2L-C**

Time-Optimal Control for Reaction Wheel Pendulum

Maciej Rosół [1], Adam Piłat [2], Andrzej Turnau [3]

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A control numerical algorithm solving the time-optimal problem for the reaction wheel pendulum system, fully effective in the open loop, is examined in the real-time system. There are two control tasks. The first is to transfer the pendulum from the lower to the upper equilibrium point. The second is to transfer the pendulum from the upper to the lower equilibrium point. Both motions are accomplished in the minimal time. Simulated and real-time trajectories are compared. The time-optimal control strategy is concluded.

Paper: **6169** **D2L-C**

Geometric Path Following Control for an Omnidirectional Mobile Robot

Jian Wang [1], Sergey Chepinskiy [2], Aleksandr Krasnov [3], Botao Zhang [4], Huimin Liu [5], Yifan Chen [6], Denis Khvostov [6]

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The paper describes an approach to the development of the geometric path following control for an omnidirectional mobile robot. Desired path of movement in the space is represented by an intersection of two implicit surfaces. Path following control problem is posed as a problem of maintaining the holonomic relationships between the system outputs. Control is synthesized using the differential geometrical method through nonlinear transformation of initial dynamic model. The main results presented are the nonlinear control algorithms and experimental approbation result.

Robotics VII Session, D2L-D

Day: Thursday, September 01, 2016
Time: 10:00 - 11:00
Room: Strauss
Chair: Przemyslaw Mazurek

Paper: **6018** **D2L-D**

Application of Vision Information to Planning Trajectories of Adept Six-300 Robot

Tadeusz Szkodny [1]

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The experimental studies have confirmed the correctness of algorithms presented in this work. The research shows that the calculation error coordinates of the object is not greater than 0.8 mm. Presented here algorithms for computation coordinates of the position and orientation of the manipulation object observed by the system 2 cameras create the vision feedback of the Adept Six-300 robot. Thanks to this feedback the external computer (acting as a server) can (with the participation of the robot controller) control the movement of the gripper to the observed manipulation object, without human intervention. Thus, these algorithms are the components of computational intelligence of the robot.

Paper: **6268** **D2L-D**

Phase Shift Determination for Azimuth Angle Estimation of Echo Arrival Direction

Bogdan Kreczmer [1]

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The paper presents a method of echo azimuth angle estimation for ultrasonic range finders. The method is based on phase shift determination. Because of size of applied transducers it is not possible to determine the shift in a direct way. This problem is discussed and error analysis is presented as well as some experimental results.

Paper: **6273** **D2L-D**

Three-Dimensional Mapping for Data Collected Using Variable Stereo Baseline

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

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The paper describes a system of 3D mapping of data collected with due regard for variable baseline. This solution constitute another extension to a VisRobot sub-system developed as a subsystem necessary for implementing the generic idea of using mobile robots to explore an indoor static environment. This subsystem is to acquire stereo images, calculate the depth in the images and construct the sought 3D map. The stereo images are obtained at various stereo baselines, result in an enhanced resolution of depth, especially for distant objects. The length of each baseline is obtained by currently measuring the actual location and angular pose of a robotic carrier of the camera. Measurement errors bring about inaccuracies in depth. Therefore, we propose an innovative procedure that suitably combine the depth maps gained at variable baselines. The paper presents the resulting improfed 3D-map visualization in terms of higher precision considering two cases: static and cumulative localization errors.

Poster Session V, D3P-E

Day: Thursday, September 01, 2016
Time: 10:00 - 12:00
Room: Poster Area
Chair: Pawel Dworak

Paper: **6032** **D3P-E**

Utilization of Textured Stereovision for Registration of 3D Models of Objects

Tomasz Kornuta [1], **Maciej Stefańczyk** [2]

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RGB-D sensors triggered a rapid progress in the field of robot visual perception. A typical visual perception subsystem relies on finding the correspondences between features extracted from RGB-D images retrieved from robot sensors and models of objects. In this paper we introduce a multi-camera setup supplemented with an additional pattern projector used for registration of high-resolution images of objects. The objects are placed on a fiducial board with two dot patterns enabling robust extraction of masks of the placed objects and estimation of their initial poses. The acquired dense point clouds constituting subsequent object views undergo pairwise registration and at the end are optimized with a graph-based technique derived from SLAM. The combination of all those elements resulted in a system for generation of consistent 3D models of objects. We present details of the developed system and conclude the paper with discussion of the achieved results.

Paper: **6056** **D3P-E**

Stability Analysis of a Tri-Wheel Mobile Robot

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

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This paper presents a solution to the stability problem for a tri-wheel mobile robot with non-slip castor wheel. It is assumed that the robot is moving on a flat ground. No model linearization were used. The stability analysis is conducted for a nonholonomic robot model by means of the Lyapunov's direct method.

Paper: **6080** **D3P-E**

Semiautonomous Wheelchair Human-Aware Navigation in Crowded Environments Based on Long-Term Pedestrians Motion Prediction

Krzysztof Skrzypczyk [1]

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This paper addresses the problem of controlling an electric powered wheelchair motion in dynamic, crowded environments. Navigating the vehicle effectively in such environmental conditions requires two issues to be considered: Relatively long term prediction of pedestrians' motion and an influence of the vehicle motion on the people behaviour in its vicinity. The purpose of this study is to develop a method that allows the wheelchair navigating safely in dynamic environments by taking into account human-vehicle interactions. The method presented in this paper utilize a deterministic model-based prediction strategy to generate the wheelchair motion which is acceptable by the patient being transported by the wheelchair. Using the long-term people motion prediction the minimal risk control strategy is computed and then applied. The method performance was evaluated in a simulated environment. Relevant simulations are presented and discussed.

Paper: **6089** **D3P-E**

Comparing Control Algorithms of Quadrocopters to Implement Their Atypical Maneuvers

Ryszard Beniak [1], **Oleksandr Gudzenko** [2]

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This paper compares three different control methods of quadrocopters: linear-quadratic regulator, the method of inverse dynamics and full state feedback. The aim of this paper is to compare examined methods of control in respect of quadrocopter's energy consumption and accuracy of obtained trajectories. We evaluate efficiency of these methods, based on an example of quadrocopter's motion along an "eight shaped" trajectory, and recommend the best control method for regulator synthesis.

Paper: **6093** **D3P-E**

Bilateral Control of Nonlinear Teleoperation System Using Parallel Force/Position Control Approach and Online Environment Estimation

Outayeb Adel [1], Ferguene Farid [2], Redouane Toumi [3]

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In this work we propose a new adaptive bilateral control scheme of teleoperation system based on four channels structure. This scheme is organized on two control strategies, the first one consists on a force/Impedance control approach applied to the master robot, whereas the second one consists on a parallel force/position control approach applied to the N-degrees of freedom nonlinear slave robot. An online environment estimation is used to estimate the unknown stiffness characteristics of the environment while a neural network (NN) compensator is applied to eliminate the effects of uncertainties in dynamic model of the slave robot. Simulation results using Labview show the effectiveness of the proposed scheme in force / position trajectories of both master and slave manipulators assuring system stability and achievable transparency performance.

Paper: **6094** **D3P-E**

Invasive Weed Optimization Algorithm Optimized Fuzzy Logic Scaling Parameters in Controlling a Lower Limb Exoskeleton

Ghasaq Al-Rezage [1], Hyreil Kasdirin [2], Siti Khadijah Ali [3], M.Osman Tokhi[4]

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This paper describes a new modified versions of invasive weed optimization algorithm with exponential seeds-spread factor. The modified invasive weed optimization algorithm (MIWO) is employed to optimize the fuzzy input-output scaling factors of lower limb exoskeleton. A fuzzy logic control (FLC) system with the (MIWO) are evolved for reference tracking control. The exoskeleton is developed to enhance and upgrade the lower limb capability and augment the torque of knee and hip of elderly people during the walking cycle. Invasive weed optimization is a bio-inspired search algorithm that mimics how weeds colonize a certain area in nature. The algorithm is modified by applying local knowledge during distribution of seeds that depends on their cost function value in each generation to narrow the accuracy and improve the local search ability. The obtained results from the modified invasive weed optimization algorithm are compared with heuristic gain values to improve the performance of the exoskeleton system.

Paper: **6150** **D3P-E**

Robotic Arm Control System for Mars Rover Analogue

Piotr Czaplicki [1], Maciej Rećko [2], Justyna Tołstoj-Sienkiewicz [3]

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Article's focus is set on improvements of mobile robot's arm control system. First part of an article describes implementation of inverse kinematics, to perform smooth, precise movements in Cartesian coordinate system. Second part describes a Phantom device that allows an operator to control arm in real time or to program it through teaching. Paper is concluded with an review of presented advancements in systems development and prediction of future improvements that may be beneficial to achieve authors main goal - easy, intuitive and precise robot's manipulator control system.

Paper: **6163** **D3P-E**

Manipulator Path Control with Variable Order Fractional Calculus

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In this paper an application of the fractional calculus to path control is studied. The integer-order derivative and integral are replaced with the fractional-order ones in order to solve the inverse kinematics problem. The proposed algorithm is a modification of the existing one. In order to maintain the accuracy and to lower the memory requirements a history limit and varying α order for derivation are proposed. An impact of the parameters upon a generated path is studied. Obtained results prove that using the fractional calculus may improve well known methods of solving the inverse kinematics problem.

Paper: **6185** **D3P-E**

Modelling of Spur Gear Cutting Kinematics for Multipurpose Milling Center

Rafał Talar [1], Piotr Jabłoński [2]

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This paper describes process of kinematics modelling for new method of gears cutting with milling center. Need for usage of mufti-purpose machines and tools in gear cutting is described. Known methods of gear cutting with machining centers is presented. Disadvantages and problem with known methods are introduced, as well need for new method is mentioned. Preparation of kinematical model of new method of gear cutting is followed

by estimation of theoretical roughness of tooth flank. In last paragraphs requirements for machines and tools prepared for application of this method are discussed, as well technological characteristics of this method is presented.

Paper: **6259** **D3P-E**

Development of a Mobile Platform for a Remote Medical Teleoperation Robot

Janusz Jakubiak [1], Michał Drwięga [2], Adam Kurnicki [3]

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The paper presents a development of a mobile platform for a robot dedicated for remote USG examination. The design process uses a component based approach for system development and platform functions are implemented within the Xenomai-OROCOS-ROS (XOR) software framework. The paper presents how the testbed platform Carol evolved to the new ReMeDi platform prototype and elaborates the new low level controller and changes in mechanical and sensory systems.

Paper: **6081** **D3P-E**

Ballbots Rolling Elements Shape Determination

Paweł Żak [1]

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This paper presents a mathematical method of determination of optimal shape of co-operating rolling elements of spherical shape, i.e. the ones used for drive transmission in ballbots. The presented method takes all geometric parameters of such devices into account and can be easily adjusted to a wider selection of devices.

Paper: **6110** **D3P-E**

Influence of an EOD Engineer Robot Manipulator Structure on the Effector's Accuracy Using Intuitive Control System

Adam Bartnicki [1], Piotr Krogul [2], Kacper Spadło [3]

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In this article was presented a research of two kinematic structures of EOD (Explosive Ordnance Disposal) engineer robot manipulator using intuitive control system. Based on vertical and horizontal trajectories the models of manipulators were compared. The simulation studies included investigation of nonlinearities and dynamics of an electrohydraulic proportional valve as a hydraulic control element of manipulator hydraulic drive system

Paper: **6125** **D3P-E**

Concept and Preliminary Research of Anthropomorphic Manipulator with Hydrostatic Drive System for Mobile Robot

Karol Cieślik [1], Stanislaw Konopka [2]

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In this paper was presented the concept of construction of anthropomorphic manipulator with hydrostatic drive system. Furthermore there were shown structural assumptions, spaces of application and kinematics structure anthropomorphic manipulator. The preliminary research of manipulator was realized. The research concerned determining the minimum number of actuators necessary to the accomplishment of an established movement of manipulator. Three types of moves were considered: vertical and horizontal in two kind of direction. This research considered also determining the minimum oil flow for hydraulic actuators for different speed a gripper, when the manipulator does the assumed movements.

Paper: **6210** **D3P-E**

Extreme Learning Machine Based Robotic Arm Modeling

Ömer Faruk Alçin [1], Ferhat Uçar [2], Deniz Korkmaz [3]

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Robotic arms are very powerful machines that can be used in many various applications in industry. So that, a suitable dynamic model is derived to verify that performs the tasks. But, dynamic equation is an important issue due to its complexity. Thus, an alternative model can be derived for the robotic arms. This paper is proposed Extreme Learning Machine (ELM) model for the angular acceleration of a robotic arm. The performance of the ELM model is performed by using Pumadyn datasets. At the same time, the validation of the proposed model is compared with Artificial Neural Network (ANN). Experimental results show that the proposed model is suitable and it provides low computation complexity.

Paper: **6270** **D3P-E**

Model and Analysis of Pedals Ergonomic Load Torque Angular Distribution in the Pedaling-by-Wire System

Bogdan Fabianski [1], **Bartlomiej Wicher** [2]

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A model of pedal ergonomic load torque angular distribution by cyclist for use in unique pedaling by wire system was presented. The motivation of the research was to obtain parametric model to use it in the pedaling by wire control system to minimize pedal speed fluctuation. Kinematics formulas were confirmed in three ways. Parameters adaptation system based on the Gauss-Newton method was described and used. It may be noticed that the obtained model convergence is good and would be the base for the further implementation of autoadaptation system of ergonomic load torque angular distribution.

Adaptive Control II Session, D4L-A

Day: Thursday, September 01, 2016
Time: 11:20 - 13:00
Room: Casino
Chair: Krzysztof Latawiec

Paper: **6077** **D4L-A**

Cascade Balance-Based Adaptive Control of Heating System - Simulation Validation

Michal Fratczak [1], **Rafal Czubasiewicz** [2]

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This paper is dedicated to simulation validation of cascade control structure for heating system consisting of single heat source and single heat receiver. In this structure, two Balance-Based Adaptive Controllers are applied. One of them has the conventional form while the second one (so-called distributed parameter B-BAC operating in primary loop) is derived based on simplified distributed parameter modeling of plate heat exchanger. Modeling of heating system is based on measurement data collected from real laboratory plant and the simulation validation shows significant superiority of the suggested control approach in terms of control performance.

Paper: **6091** **D4L-A**

Adaptive Tracking Control of a Duffing Oscillator with Hard Error Constraints

Jacek Kabziński [1]

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A general tracking control problem is solved for a chaotic system (Duffing oscillator) with unknown parameters, under the additional requirement that the tracking error must remain inside an imposed hard constraint. The barrier Lyapunov functions technique is applied in an adaptive backstepping scheme. Several system properties are investigated and benefits coming from state variable constraints are discussed. The same approach may be used for chaos synchronization and chaotification.

Paper: **6099** **D4L-A**

Practical Verification of Adaptive Dynamic Matrix Control with Interpolated Parameters

Tomasz Kłopot [1], **Piotr Skupin** [2]

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The paper presents the experimental studies of the adaptive dynamic matrix control (DMC) algorithm with interpolated parameters. The adaptation mechanism is to determine the controller parameters that appear in the control law equation for several operating points of the system. In turn, the parameter values between the two consecutive operating points are calculated by using linear spline interpolation. The effectiveness of the adaptive DMC algorithm is studied for the electric flow heater for various number of operating points (interpolation nodes) in the presence of step changes in the set point and mean power of the electric heater.

Paper: **6114** **D4L-A**

The Design of Ship Autopilot via Robust Adaptive Feedback Linearization

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 model is highly nonlinear and some of the state vector coordinates are unavailable, the control system synthesis is performed by means of output feedback linearization method combined with a nonlinear observer. Due to considerable parameter variations typical of the problem and other substantial uncertainties an robust-adaptive version of the method has been applied. The whole control system is able to ensure tracking performance on the H^∞ optimal attenuation level. This is the so-called H^∞ tracking problem in an adaptive system. Simulations of the ship course-changing process have confirmed a good performance of the proposed controller.

Paper: **6178** **D4L-A**

Performance Enhancement for GPS/INS Fusion by Using a Fuzzy Adaptive Unscented Kalman Filter

Setareh Yazdkhasti [1], **Jurek Z Sasiadek** [2], **Steve Ulrich** [3]

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Kalman filter requires that the process noises to be zero mean white noise; otherwise, the divergence will occur. Adaptive tuning of a Kalman filter via fuzzy logic has been one of the promising strategies to cope with divergence when dealing with non-white noise. The fuzzy logic adaptive controller (FLAC) will continually adjust the noise strengths in the filter's internal model and tune the filter. This paper presents a new INS/GPS sensor fusion scheme based on Fuzzy Adaptive Unscented Kalman Filter (FAUKF). The FAUKF is based on the combination of the unscented Kalman filter and the fuzzy logic controller which performs adaptation task for dynamic characteristics. Results obtained by FAUKF were compared to the Extended Kalman filter (EKF), Unscented Kalman Filter (UKF) and Fuzzy Adaptive Extended Kalman Filter (FAEKF). This comparative study has demonstrated that the FAUKF leads to very promising results as compared the other three Kalman filters.

Optimization II Session, D4L-B

Day: Thursday, September 01, 2016
Time: 11:20 - 13:00
Room: Kalman
Chair: Andrzej Myslinski

Paper: **6022** **D4L-B**

PSO Based Feedrate Optimization with Contour Error Constraints for NURBS Toolpaths

Krystian Erwinski [1], Marcin Paprocki [2], Andrzej Wawrzak [3], Lech Grzesiak [4]

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Generation of a time-optimal feedrate profile for CNC machines has recieved significant attention in recent years. Most methods focus on achieving maximum allowable feedrate with constrained axial acceleration and jerk without considering manufacturing precision. Manufacturing precision is often defined as contour error which is the distance between desired and actual toolpaths. This paper presents a method of determining the maximum feedrate for NURBS toolpaths while constraining velocity, acceleration, jerk and contour error. Contour error is predicted during optimization by using an artificial neural-network. Optimization is performed by Particle Swarm Optimization with Augmented Lagrangian constraint handling technique. Results of a time-optimal feedrate profile generated for an example toolpath are presented to illustrate the capabilities of the proposed method.

Paper: **6002** **D4L-B**

Lyapunov Matrices Approach to the Parametric Optimization of a Time Delay System with a PI Controller

Jozef Duda [1]

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In the paper a Lyapunov matrices approach to the parametric optimization problem of a time delay system with a PI-controller is presented. The value of a quadratic performance index of quality is equal to the value of the Lyapunov functional at the initial state of a time delay system. The Lyapunov functional is determined by means of the Lyapunov matrix.

Paper: **6143** **D4L-B**

Guaranteed Cost Estimation and Control for Nonlinear System Using LMI Optimization

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In the paper, a methodology for the guaranteed cost estimation and control for nonlinear system discrete-time systems is proposed. To solve such a challenging problem, the article starts with a general description of the system and assumptions regarding its nonlinearities. The subsequent part of the paper describes the design methodology of the robust observer and controller for the predefined cost function using linear matrix inequalities. The final part of the paper presents an illustrative example oriented towards a practical application to the multiple tank system, which illustrates the performance of the proposed approach.

Paper: **6068** **D4L-B**

On Evaluating Hinf and H2 Performance of Uncertain Systems

Vladimir Pozdyayev [1]

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In this paper we consider optimization problems related to calculating Hinf and H2 performance of linear systems with structured uncertainty. A way to transform these problems that reduces computational power required to find their solutions is presented. The resulting approach allows finding performance lower bounds using an optimization method proposed earlier by the author. Its properties include being reasonably easy to use, and its search space coverage being adjustable via the algorithm's settings.

Paper: **6250** **D4L-B**

Battery State Observation and Condition Monitoring Using Online Minimization

Johannes Reuter [1], **Enrico Mank** [2], **Harald Aschemann** [3], **Andreas Rauh** [4]

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In this paper, the performance of a particular state observer algorithm is investigated for concurrently estimating the state of charge of a Li-Ion battery and the deviation of characteristic parameters from their initial values in order to diagnose the aging behavior of the system. The estimation is based on an online minimization approach that has

been found to be appropriate in particular due to the significant nonlinear behavior of the battery dynamics. The method has firstly been introduced as the 'Newton-Step Observer' and more recently phrased 'sensitivity-based estimation'. The analysis is first made by simulations for comparison with known reference values. Here, we also compare the performance of Newton-type, Gauss-Newton-type and gradient-based optimization. In a second step, experimental data from a battery that has been aged over about 400 charging/discharging cycles are used. Despite the fact that for the battery actual reference parameters are unavailable, the results show physically plausible trends. Moreover, the estimated capacity fading is particularly in very good agreement with the data provided by the manufacturer.

Modelling and Simulation IV Session, D4L-C

Day: Thursday, September 01, 2016
Time: 11:20 - 13:00
Room: Lehar
Chair: Wojciech Hunek

Paper: **6005** **D4L-C**

A Concept of a Decision Support System for the Selection of a Knowledge Management Tool for a Manufacturing Company

Justyna Patalas-Maliszewska [1], **Irene Krebs** [2]

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This article analyzes the management of critical knowledge within a manufacturing company whose workers should be supported by a knowledge management tool based on a data obtained from 69 Polish Manufacturing Enterprises from Lubuskie region and from 23 German Manufacturing Enterprises from Brandenburg region. It focuses on the approach of the use of an FAHP (Fuzzy Analytic Hierarchy Process) method for the creation of an objective decision in the selection process of a knowledge management tool, especially in regards to qualitative and immeasurable criteria. The concept of the decision-support system presented in this paper serves then as foundations for guidelines for the improvement of knowledge management processes in a manufacturing company.

Paper: **6009** **D4L-C**

Adapting State–Space Reduction Techniques to Match Steady–State Responses

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

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Many popular model–reduction techniques do not ensure matching the steady–state response of the original system to canonical inputs (harmonic and singularity inputs). This paper shows that steady–state response retention can simply be achieved by decomposing the forced response into a transient and a steady–state component and by applying the reduction method only to the first, which also ensures that the transient term is optimal with respect to the chosen criterion. The suggested reduction procedure refers to state–space representations which are often the only available when the systems to be reduced are of very high order (so that the computation of their transfer functions is not reliable). To this purpose, the aforementioned components of the forced response are expressed directly in terms of the original state–space representation. Two benchmark examples of very high dimensions are worked out to show that the performance of the resulting reduced–order models compares favourably with the performance of the models of the same order determined in the usual way, i.e., without explicit consideration of their steady–state response.

Paper: **6030** **D4L-C**

Model of Optimal Maneuver Used in Tactical Decision Support System

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This paper deals with the model of optimal maneuver of units and its implementation in the Tactical Decision Support System (TDSS). The model is designed to be used for planning movement of units (soldiers, vehicles, unmanned robots) on the battlefield. The paper is separated into three main parts. Firstly, the model of maneuver is discussed; it is divided into five independent layers: topographic layer, elevation data layer, weather layer, hostile units layer, and friendly units layer. Impact of each layer on the model is then analyzed. Secondly, experiments used for verification of the model are presented. Finally, the implementation of the model in the TDSS is shown. TDSS is used to support commanders in their decision-making processes.

Paper: **6043** **D4L-C**

The Emergence on Isolated Time Scales

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In the paper the Cucker-Smale model on isolated time scales is studied. This dynamical system models a consensus of emergence in a population of autonomous agents. The results establishing conditions under which such consensus occurs are presented.

Paper: **6101** **D4L-C**

Modelling of a Post-Combustion CO2 Capture Process Using Extreme Learning Machine

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This paper presents modelling of a post-combustion CO2 capture process using bootstrap aggregated extreme learning machine. Extreme learning machine (ELM) randomly assigns the weights between input and hidden layers and obtains the weights between the hidden layer and output layer using regression type approach in one step. This paper proposes using principal component regression to obtain the weights between the hidden and output layers. Due to the weights between input and hidden layers are randomly assigned, ELM could have variations in performance. This paper proposes combining multiple ELMs to enhance model prediction accuracy and reliability. The bootstrap re-sampling of training data was applied for each single ELM and then the individual ELMs are stacked, thereby enhancing the model accuracy and reliability. The bootstrap aggregated extreme learning machine (BA-ELM) can provide fast learning speed and good generalization performance, which will be used to optimize the CO2 capture process.

Signal Processing IV Session, D4L-D

Day: Thursday, September 01, 2016
Time: 11:20 - 13:00
Room: Strauss
Chair: Rafal Stanislawski

Paper: **6257** **D4L-D**

Development of Electrochemical Measurement System Using Cyclic Voltammetry Method

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In the paper the results of our development of impedance measurement instrument are presented. The document covers the most important aspects of the hardware and software solutions used with presented device. Example measurements using Cyclic Voltammetry method are also introduced in comparison with similar measurements made with commercial, professional measurement machine AutoLab from MetroOhm.

Paper: **6254** **D4L-D**

Scatter Measure for Trajectory Estimation of Periodic Signals Using Track–Before–Detect Approach

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Tracking of low SNR signals is challenging task. The algorithm for tracking of single object observed as line in single image is proposed in this paper. The object signal signature is periodic with unknown pattern. Proposed algorithm uses multidimensional scatter with variable parameters for exhaustive search of solution. Example results are provided for the simplified 1D case using Monte Carlo approach.

Paper: **6249** **D4L-D**

Evaluation of Copper Ore Granularity and Flow Rate Using Vibration Measurements

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The research presented in this paper aims at developing a vibration-based method for online measurement of granularity and flow of loose solids. This information is essential for control of industrial milling processes when specific product characteristics is desired. The vibration-measuring approach seems to be a candidate for a cheap and reliable technique among the not-so-many contactless online methods. Experiments were carried out using four granularity classes of milled copper ore and a dedicated test rig. Signal processing was performed in the frequency domain with an algorithm, which takes into account the needs of continuous, real-time measurements. As demonstrated in the paper, the proposed algorithm allows for estimation of grain size and flow rate of the particles that caused the vibrations.

Paper: **6171** **D4L-D**

Research of the Defects in Pet Preform

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Image technologies nowadays are used not only for keeping personal events safe, but also are widely applied in conjunction with automated electronic systems. Computer vision is widely used for inspection of the production quality in industries. Food industry is not an exception. Containers for food industry are made in very large quantities. This article contains of defect analysis of both external and side area of the bottleneck. Defects were divided into groups according to which the filters are created. For the control of PET preparation quality an automated computer vision algorithms were developed. The algorithms and methods were used for the detection of defective products mainly based on the image segmentation, digital production, erosion, smoothing. The most effective filters for the defect detection of the workpieces have been determined. It was carried out that efficiency of algorithms are close to 100

Paper: **6172** **D4L-D**

Computer Vision System for Defects Detection in PET Preform

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The computer vision systems are mainly devoted for production monitoring in quality inspection systems. It is the fastest growing and most popular non-invasive product defects detection method. The productivity of electronic components growth and their prices decline creates favorable conditions for the development of image processing systems for industrial production. The food industry is one of the main industries. Production volumes grow along with human population growth. Containers for food industry are made in very large quantities and demand on quality inspection system plays important role. An automated computer vision system was developed for the control of PET preparation quality. The implementation of the designed system was presented in this article. The system used for image processing algorithms to inspect the lateral and upper parts of the workpiece. The system is designed according to its operating parameters. Reached throughput is 10,000 workpieces per hour.

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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.