

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
Institute of Information Engineering, Automation, and Mathematics
Faculty of Chemical and Food Technology

Summaries Volume



June 14 – 17, 2011, Tatranská Lomnica, Slovakia

Sponsors:



Honeywell

i n v e n s i s
Operations Management

Media Partners:



AUTOMA

CHEMagazín
Časopis pro chemicko-technologický a laboratorní proud

AT&P JOURNAL



Co-organisers:

**Department of Process Control, Faculty of Electrical Engineering and Informatics
University of Pardubice**

**Slovak Society for Cybernetics and Informatics
National Member Organisation of IFAC**

<http://www.kirp.chtf.stuba.sk/pc11>

***The aim of the conference** is to exchange the recent advances and experience in the various areas of Control Theory between the researchers from industry, research institutes, project organisations, academies of sciences, and universities.*

***The program of the conference will be focused on** all aspects of Control and Systems, and ranges from fundamental research to applications in process control. Topics of interest include linear and non-linear control, optimisation, robust, adaptive and intelligent control, identification, modelling and simulations, real-time systems, new trends in application of industrial computer control, and education of qualified experts.*

INTERNATIONAL PROGRAM COMMITTEE

Chairman: Fikar M. (SK)

Albertos P.	(ESP)	Krokavec D.	(SK)
Bars R.	(HU)	Kučera V.	(CZ)
Bobál V.	(CZ)	Latifi M. A.	(F)
Dostál P.	(CZ)	Masár I.	(D)
Gerke M.	(D)	Mészáros A.	(SK)
Haber R.	(D)	Mikleš J.	(SK)
Henrion D.	(F)	Ogonowski Z.	(PL)
Hippe P.	(D)	Prokop R.	(CZ)
Huba M.	(SK)	Veselý V.	(SK)
Hulkó G.	(SK)	Strmčnik S.	(SLO)
Jørgensen S. B.	(DK)	Šebek M.	(CZ)
Jurišica L.	(SK)	Taufer I.	(CZ)
Košťial I.	(SK)	Vrancic D.	(SLO)
Kozák Š.	(SK)	Zítek P.	(CZ)

NATIONAL ORGANISING COMMITTEE

Chairman: Kvasnica M. (SK)

Čirka E.	(SK)	Karšaiová M.	(SK)
Fikar M.	(SK)	Taufer I.	(CZ)
Kalmárová A.	(SK)	Vagač S.	(SK)

EDITORS

Fikar M.
Kvasnica M.



EPP Group
in the European Parliament

The 18th Conference on Process Control is sponsored by

Alajos Mészáros

from the Europeans People's Party Group in the European Parliament



Reap the benefits of Honeywell's powerful UniSim Design Process Simulation tools for non-commercial usage – at no cost.

The license fee is waived, complements of Honeywell Process Solutions.*

Please contact the program leaders at Honeywell to find out how to get started:

- USA: Reaz Kabir reaz.kabir@honeywell.com
- Canada: Peter De Jonge peter.dejonge@honeywell.com
- Latin America: Dario Pohl dario.pohl@honeywell.com
- Europe, Middle East and Africa (EMEA): Susan Middleton susan.middleton@honeywell.com
- Asia Pacific: Xi Li li.xi@honeywell.com

*Honeywell standard terms and conditions apply



Performance

Under pressure to meet skyrocketing demand, today's multi-plant power providers need to improve availability and real-time capacity monitoring to deliver the juice. All without paying outrageous spot rates while operating at the lowest cost point.

Optimized

Invensys customers have saved up to \$5 million per year by reducing trips, outages and engineering time. We've linked as many as 32 stations, reduced spot price spikes by 12x and improved personnel productivity by 3x. With 44% fewer nuisance alarms, we've reduced operator demand four-fold. See how at iom.invensys.com/power — **Let's collaborate.**

Real Collaboration. Real-Time Results. TM

i n v e n s y s
Operations Management TM

Avantis Eurotherm Foxboro IMServ InFusion SimSci-Esscor Skelta Triconex Wonderware

Invensys Operations Management · Eastern Europe · Roznavska 24, Bratislava 821 04, Slovakia
Tel: +421 2 322 00 100 · eastern.europe@invensys.com



ProCS, s.r.o.

Kráľovská 8, 927 01 Šaľa

Tel.: +421 31 773 11 11

Fax: +421 31 773 11 01

E-mail: procs@procs.sk

<http://www.procs.sk>



**Komplexné
služby a riešenia**
v oblasti automatizácie,
merania a regulácie
**technologických
procesov.**

člen skupiny **VINCI**
ENERGIES 

Program

Tuesday

14:00–22:00 Registration

15:00–18:00 **Workshop – Hall A – Matlab & Simulink: Model-Based Design**
Jirkovský, J. 17

18:00–21:00 Dinner

Wednesday

08:30–08:45 **Opening**

08:45–09:20 **Pl-We-1 – Hall A – Plenary Lecture**

Chairman: Fikar, M.

08:45 Real-Time Optimization in the Presence of Uncertainty
Bonvin, D. 19

09:30–10:50 **Le-We-2 – Hall A – Lectures: Linear and Non-linear Control System Design**

Chairman: Krokavec, D.

09:30 Regular Design Equations for the Reduced-Order Kalman Filter
Hippe, P. 19

09:50 Nonlinear Control of a Chemical Reactor
Dostál, P., Bobál, V., Vojtěšek, J. 20

10:10 H_∞ Control of Time-Delay Systems with Time-Varying Delays
Filasová, A., Krokavec, D. 20

10:30 Fault Accommodation in Nonlinear Time Delay Systems
Zhirabok, A., Shumsky, A., Bobko, Y. 21

09:30–10:50 **Le-We-3 – Hall B – Lectures: Applications and Case Studies**

Chairman: Závacká, J.

09:30 An Application of Model Predictive Control to a Gasoline Engine
Behrendt, S., Dünow, P., Lampe, B.P. 21

09:50 Hybrid Methods for Traffic Lights Control
Makýš, M., Kozák, Š. 21

10:10 Robust Controller Design for a Laboratory Process with Uncertainties
Závacká, J., Bakošová, M. 22

10:30 Prediction of Critical Processes in Nuclear Power Plant Using Genetically Trained Neural Networks
Petrík, M., Kozák, Š. 22

10:50–11:10 Coffee Break

11:10–12:30 Le-We-4 – Hall A – Lectures: Linear and Non-linear Control System Design

Chairman: Dostál, P.

11:10	Dual Kalman Estimation of Wind Turbine States and Parameters <i>Mateljak, P., Petrović, V., Baotic, M.</i>	23
11:30	Linear Matrix Inequalities Based H_∞ Control of Gantry Crane using Tensor Product Transformation <i>Iles, S., Kolonic, F., Matusko, J.</i>	23
11:50	Design of Feedback Control for Unstable Processes with Time Delay <i>Vrancic, D., Huba, M.</i>	23
12:10	Equivalent Representations of Bounded Real Lemma <i>Krokavec, D., Filasová, A.</i>	24

11:10–12:30 Le-We-5 – Hall B – Lectures: Software Tools and Toolboxes

Chairman: Kvasnica, M.

11:10	Matlab toolbox for PWA identification of nonlinear systems <i>Števek, J., Kozák, Š.</i>	24
11:30	MATLAB Toolbox for Automatic Approximation of Nonlinear Functions <i>Szucs, A., Kvasnica, M., Fikar, M.</i>	24
11:50	PIDTOOL 2.0 – Software for Identification and PID Controller Tuning <i>Oravec, J., Bakošová, M.</i>	25
12:10	Segmentation of Colour Regions from Printing Sheets <i>Fribert, M.</i>	25

12:30–14:00 Lunch

14:00–18:00 Workshop – Hall A – Recent Development in Real-Time MPC

	<i>Jones, C.N., Zeilinger, M.</i>	25
--	---	----

14:00–15:40 Le-We-6 – Hall B – Lectures: Algebraic Methods in Control (Invited)

Chairman: Halás, M.

14:00	Disturbance Decoupling of Discrete-time Nonlinear Systems by Static Measurement Feedback <i>Kaldmäe, A., Kotta, Ü.</i>	26
14:20	Transfer Matrix and Its Jacobson Form for Nonlinear Systems on Time Scales: Mathematica Implementation <i>Belikov, J., Kotta, Ü., Leibak, A.</i>	26
14:40	Relationship Between Two Polynomial Realization Methods <i>Kotta, Ü., Tõnso, M.</i>	26
15:00	Accessibility and Feedback Linearization for SISO Discrete-Time Nonlinear Systems: New Tools <i>Kotta, Ü., Mullari, T., Shumsky, A., Zhirabok, A.</i>	27

15:20	Discrete-Time Solution to the Disturbance Decoupling Problem of Coupled Tanks <i>Halás, M.</i>	27
15:40–16:00	Coffee Break	
16:00–18:00	Le-We-7 – Hall B – Lectures: UAVs Development and Control (Invited) Chairman: Gerke, M.	
16:00	Ultrasonic Hybrid Map for Navigation of Mobile Robot <i>Jurišica, L., Duchoň, F.</i>	27
16:20	Control of an RC Helicopter Model Through USB Interface <i>Pestun, I., Halás, M., Kurčík, P.</i>	28
16:40	3D Off-Line Path Planning for Autonomous Airships in Restricted Known Environments. <i>Al-Rashedi, N., Gerke, M.</i>	28
17:00	Data Management Architecture for Tele-operated UAV System <i>Bahník, P., Pilka, J.</i>	28
17:20	Gain-Scheduled LQR-Control for an Autonomous Airship <i>Masar, I., Stöhr, E.</i>	29
17:40	Experience in Designing Autonomous Airplane <i>Schochmann, R., Pilka, J., Suchý, M., Pestun, I., Huba, M.</i>	29
18:00–20:00	Dinner	
20:00–22:00	Po-We-8 – Hall A – Poster Session	
1	Bioproduction of mcl-PHAs Biopolymers – Process States and Control <i>Hrnčířik, P., Černý, F., Náhlík, J., Vovsík, J., Mareš, J., Lovecká, P.</i>	30
2	Structure and Parametric Definition of Linear Dynamic Object via Identification Based on Real Interpolation method <i>Alexeev, A., Zamyatin, S., Pushkarev, M.</i>	30
3	Mathematical Model of Differentially Steered Mobile Robot <i>Dušek, F., Honc, D., Rozsival, P.</i>	30
4	Identification of Nonlinear Systems with General Output Backlash <i>Vörös, J.</i>	31
5	On-Line Identification Simulation of Forgetting Methods to Track Time Varying Parameters Using Alternative Covariance Matrix <i>Vachálek, J.</i>	31
6	Simulation of 2D Physics of Objects Captured by Web Camera Using OpenCV and Box2D <i>Sedlák, M.</i>	31
7	Reactor Furnace Control – PID and Predictive Methods Comparison <i>Mareš, J., Doležel, P., Dušek, F., Procházka, A.</i>	32
8	MPC-Based Approximation of Dual Control by Information Maximization <i>Rathouský, J., Havlena, V.</i>	32

9	On-line Recognition of Autonomous Robot Position via Camera DragonFly <i>Mareš, J., Procházka, A., Doležel, P.</i>	32
10	Hough Transform Use in Image Processing of Microscopic Alloy Images <i>Slavíková, P., Mudrová, M., Michalcová, A., Procházka, A.</i>	33
11	Software Background of the 'Mechatronics-Based Rehabilitation at Home' Concept <i>Sobota, J., Severa, O., Kocánek, M., Čech, M., Balda, P.</i>	33
12	State Feedback Control Design Using Eigenstructure Decoupling <i>Fonod, R., Kocsis, P.</i>	33
13	Application of Mathematical Morphology on Nanostructure Image Pro- cessing <i>Petrová, J., Mudrová, M., Procházka, A., Fojt, J.</i>	34
14	Safety Verification of Rule-Based Controllers <i>Paulovič, M., Kvasnica, M., Szucs, A., Fikar, M.</i>	34
15	The Empirical Mode Decomposition in Real-Time <i>Trnka, P., Hofreiter, M.</i>	34
16	Control of the Laboratory Helicopter Simulator <i>Macháček, J., Havlíček, L.</i>	34
17	Piecewise-Linear Neural Models for Process Control <i>Doležel, P., Taufer, I., Mareš, J.</i>	35
18	PI/PID Controller Design for FOPDT Plants Based on the Modulus Opti- mum Criterion <i>Cvejn, J.</i>	35
19	Signal Shapers for BWB Aircraft Control <i>Kucera, V., Hromčík, M.</i>	35
20	Time Sub-Optimal Control of Triple Integrator <i>Bisták, P.</i>	36
21	Robust Decentralized Controller Design for Performance <i>Kozáková, A., Veselý, V., Osuský, J.</i>	36
22	Solution of a Robust Stabilization Problem Using YALMIP and Robust Control Toolboxes <i>Bakošová, M., Oravec, J., Kačur, M.</i>	36
23	Lateral Flight Dynamic Controller for Flexible BWB Aircraft <i>Haniš, T., Hromčík, M.</i>	37
24	Control of a Tubular Heat Exchanger <i>Bakošová, M., Kačur, M., Oravec, J.</i>	37
25	Robust Control of a Hydraulic System with Unstructured Uncertainties <i>Karšaiová, M., Bakošová, M., Vasičkaninová, A.</i>	37
26	Virtual Laboratory of Process Control <i>Kalúz, M., Čírka, L., Fikar, M.</i>	38
27	Bode Plots in Maxima Computer Algebra System <i>Gajdošík, D., Žáková, K.</i>	38
28	Neuro-Fuzzy Control of the Three Tank System <i>Blahová, L., Dvoran, J.</i>	38

29	Neuro-fuzzy Control of a Chemical Reactor with Uncertainties <i>Vasičkaninová, A., Bakošová, M., Karšaiová, M.</i>	38
30	Transplant Evolution for Optimization of General Controllers <i>Ošmera, P.</i>	39
31	Tests of Various Types of Residuals in Regression Diagnostics <i>Javůrek, M., Taufer, I.</i>	39
32	Predictive Control Using Neural Network Applied on Semi-batch Reactor <i>Macků, L., Sámek, D.</i>	39
33	Pole Placement Controller with Compensator Adapted to Semi-Batch Re-actor Process <i>Novosad, D., Macků, L.</i>	40
34	Real-Time Model Predictive Control of a Fan Heater via PLC <i>Rauová, I., Valo, R., Kvasnica, M., Fikar, M.</i>	40
35	H_∞ Controller Design for Active Suspension System <i>Zuščiková, M., Belavý, C.</i>	40

Thursday

08:45–09:20 PI-Th-1 – Hall A – Plenary Lecture

Chairman: Šebek, M.

08:45	Decoupling Optimal Controllers <i>Kučera, V.</i>	41
-------	---	----

09:30–10:50 Le-Th-2 – Hall A – Lectures: Model Predictive Control

Chairman: Ogonowski, Z.

09:30	Two-State Bilinear Predictive Control for Hot-Water Storage Tank <i>Ogonowski, Z.</i>	41
09:50	NMPC for Stiff, Distributed Parameter System: Semi-Automatic Code Generation and Optimality Condition Evaluation <i>Noga, R., Ohtsuka, T.</i>	42
10:10	Improvement of the Decoupling Effect of the Predictive Controllers GPC and PFC by Parameter Adaptation <i>Zabet, K., Haber, R., Schmitz, U., Bars, R.</i>	43
10:30	Separating Functions for Complexity Reduction of Explicit Model Predictive Control <i>Rauová, I., Kvasnica, M., Fikar, M.</i>	43

09:30–10:50 Le-Th-3 – Hall B – Lectures: Modelling, Simulation, and Identification of Processes

Chairman: Huba, M.

09:30	Lifetime Estimation of Heat Exchangers with Consideration of On-line Cleaning <i>Friebel, T., Haber, R., Schmitz, U.</i>	43
-------	---	----

09:50	New Mathematical Tools for Analysis and Control of Platoons of Cars in Future Automated Highway Systems <i>Šebek, M., Hurák, Z.</i>	44
10:10	Use of Cross Wavelet Transform for Diagnosis of Oscillations Due to Multiple Sources <i>Sivalingam, S., Hovd, M.</i>	44
10:30	Relay Identification Analyzing Non-symmetrical Oscillations for Optical Plant <i>Huba, M., Ľapák, P.</i>	44
10:50–11:10	Coffee Break	
11:10–12:30	Le-Th-4 – Hall A – Lectures: Model Predictive Control Chairman: Haber, R.	
11:10	Real-time Air/Fuel Ratio Model Predictive Control of a Spark Ignition Engine <i>Kopačka, M., Šimončič, P., Csambal, J., Honek, M., Wojnar, S., Polóni, T., Rohal'-Ilkiv, B.</i>	45
11:30	Wind Turbine Power Control for Coordinated Control of Wind Farms <i>Spudic, V., Jelavić, M., Baotic, M.</i>	45
11:50	Advanced Process Control of the BGHT7 Desulphurization Unit <i>Čížniar, M., Puna, D.</i>	46
11:10–12:30	Le-Th-5 – Hall B – Lectures: Modelling, Simulation, and Identification of Processes	
11:10	Laboratory for Renewable Energy Sources and Identification of the Laboratory Wind Turbine Model <i>Bobanac, V., Brekalo, M., Vašak, M., Perić, N.</i>	46
11:30	Mathematical Modeling and Implementation of the Airship Navigation <i>Jelenčiak, F.</i>	46
11:50	Robust Decentralized PID Controller Design for the 3D Crane Process <i>Nguyen, Q.T., Veselý, V.</i>	47
12:10	Comparison of Two Methods for Determining the Optical Flow <i>Seibold, P.</i>	47
12:30–14:00	Lunch	
14:00–18:00	Workshop – Hall A – Polynomial Optimisation, LMI and Dynamical Systems <i>Henrion, D.</i>	47
18:00–19:00	Dinner	
20:00–01:00	Conference Party	

Friday

08:45–09:20 PI-Fr-1 – Hall A – Plenary Lecture

Chairman: Kvasnica, M.

08:45	Model Predictive Control for Industrial Applications <i>Papafotiou, G.</i>	49
-------	---	----

09:30–10:50 Le-Fr-2 – Hall A – Lectures: Robust and Adaptive Control

Chairman: Veselý, V.

09:30	Application of Quantitative Feedback Theory for Wind Turbine Controller Design <i>Bencic, G., Jelavic, M., Peric, N.</i>	49
09:50	Robust PID Controller Design for Coupled-Tank Process <i>Holic, I., Vesely, V.</i>	50
10:10	Robust Tuning of PI Controller for IPDT Plant <i>Huba, M.</i>	50
10:30	Robust Decentralized Controller Design with Specified Phase Margin <i>Osuský, J., Veselý, V.</i>	50

09:30–10:50 Le-Fr-3 – Hall B – Lectures: Process Optimisation

Chairman: Fikar, M.

09:30	Sensitivity Analysis of Hyperbolic Optimal Control Systems with Boundary Conditions Involving Time Delays <i>Kowalewski, A., Sokolowski, J.</i>	51
09:50	Tighter Convex Relaxations for Global Optimization Using alphaBB Based Approach <i>Paulen, R., Fikar, M.</i>	51
10:10	Real-time Dynamic Optimisation by Integrated Two-Time-Scale Scheme <i>Podmajerský, M., Fikar, M.</i>	51
10:30	Optimal Control via Initial State of an Infinite Order Time Delay Hyperbolic System <i>Kowalewski, A.</i>	52

10:50–11:10 Coffee Break

11:10–12:30 Le-Fr-4 – Hall A – Lectures: Robust and Adaptive Control

Chairman: Bobál, V.

11:10	Digital Self-tuning Smith Predictor Based on Pole Assignment Approach <i>Bobál, V., Chalupa, P., Dostál, P., Brázdil, M.</i>	52
11:30	Robust PSD Controller Design <i>Veselý, V., Rosinová, D.</i>	52
11:50	The Robust Motion Control of a Robot Manipulator <i>Kardoš, J.</i>	53

12:10	Robust Elimination Lemma: Sufficient Condition for Robust Output Feed-back Controller Design <i>Veselý, V., Rosinová, D.</i>	53
11:10–12:30	Le-Fr-5 – Hall B – Lectures: Control Education Chairman: <i>Žáková, K.</i>	
11:10	Online design of SciLab/Xcos block schemes <i>Janík, Z., Žáková, K.</i>	54
11:30	Remote Control Software for Thermo-Optical Plant <i>Kalúz, M., Čirka, L., Fikar, M.</i>	54
11:50	Comparison of Supervisory and Networked Control in Remote Laboratories <i>Folvarčík, P.</i>	54
12:10	ABS/TCS Simulator <i>Juhás, M., Seman, P., Bodi, S.</i>	55
12:30–14:00	Lunch	
14:00–14:15	Bus Departure to Bratislava	

Workshop

Matlab & Simulink: Model-Based Design

Time: 15:00–18:00

Jirkovský, J.

Humusoft, Prague

In Czech: Využití metody Model-Based Design k návrhu, verifikaci a validaci algoritmů pro řídicí systémy. Testování algoritmů v prostředí MATLAB&Simulink s jednotným testovacím rámcem. Využití stejných testů pro model algoritmu v Simulinku, pro jeho softwarovou implementaci v jazyce C, i pro hardwarovou implementaci algoritmu umístěnou na cílovém procesoru. Automatické generování testů se 100% pokrytím prověřovaných algoritmů (model coverage). Snadné ověření kvality finálního výrobku prostřednictvím hardware-in-the-loop simulace.

Pl-We-1 Plenary Lecture

Chairman: *Fikar, M.*

Time: 08:45

Real-Time Optimization in the Presence of Uncertainty

Bonvin, D.

EPFL Lausanne

This presentation discusses real-time optimization (RTO) strategies for improving process performance in the presence of uncertainty in the form of plant-model mismatch, drifts and disturbances. RTO typically uses a plant model to compute optimal inputs. In the presence of uncertainty, selected model parameters can be estimated and the updated model used for optimization. Although very intuitive, this two-step approach suffers from the fact that the model is almost invariably inadequate, which prevents from reaching the plant optimum. Other approaches have been developed in the last two decades to overcome this difficulty. Recently, a generic formalization of these ad hoc fixes has been proposed under the label modifier adaptation. The basic idea is to leave the model parameters unchanged but to use the plant measurements to "appropriately" modify the optimization problem. The modifier-adaptation approach will be presented and compared to the two-step approach, in particular with regard to model adequacy. We will then go beyond this comparison and discuss different ways of using plant measurements for process improvement in the presence of uncertainty. There are many questions to be addressed: (i) what can be done off-line prior to process operation, and what should be performed in real time, (ii) how much of the optimization effort is model-based and how much is data-driven, (iii) what to measure, what to adapt, how to adapt? We will then see that there exists another class of measurement-based optimization approaches that implements direct input adaptation. This class of methods includes NCO tracking, extremum-seeking control and self-optimizing control. A case study will illustrate the applicability of the various approaches.

Le-We-2 Lectures: Linear and Non-linear Control System Design

Chairman: *Krokavec, D.*

Time: 09:30

Regular Design Equations for the Reduced-Order Kalman Filter

Hippe, P.

Universität Erlangen-Nürnberg

Reduced-order Kalman filters yield an optimal state estimate for linear dynamical systems, where parts of the outputs are not corrupted by noise. The design of such filters can either be carried out in the time domain or in the frequency domain both for continuous-time and for discrete-time systems. Here, the continuous-time case is discussed. Different from the full-order case with all measurements corrupted by noise, the design equations of the reduced-order filter are not regular. This is due to the rank deficient measurement covariance matrix, which also

gives rise to a rank deficient solution of the Riccati equation. This causes problems when using standard software. By an adequate transformation of the system equation, the Riccati equation can be subdivided into a regular part and a vanishing part, so that standard software becomes applicable. The regular (reduced-order) design problem also allows a formulation of the conditions for the stability of the filter and it is shown, what they mean for the original system. In the frequency domain spectral factorization of the non-regular polynomial matrix causes no problems. The known proof of optimality of the factorization result, however, also requires a regular measurement covariance matrix. Starting from the regular reduced-order design problem in the time domain also a reduced-order regular frequency domain design can be formulated. The regular design equations in the frequency domain then allow a formal proof of optimality of the result of the spectral factorization and it turns out, that this result coincides with the known one obtained from the non regular polynomial matrix equation. Presented are also the conditions on the matrix fraction description of the system guaranteeing a stable filter in the frequency domain.

Time: 09:50

Nonlinear Control of a Chemical Reactor

Dostál, P., Bobál, V., Vojtěšek, J.

Tomas Bata University in Zlin

The paper deals with continuous-time nonlinear adaptive control of a continuous stirred tank reactor. The control strategy is based on an application of the controller consisting of a linear and nonlinear part. The static nonlinear part is derived in the way of a inversion and consecutive polynomial approximation of a measured or simulated input-output data. The design of the dynamic linear part is based on approximation of nonlinear elements in the control loop by a continuous-time external linear model with parameters estimated using a corresponding delta model. In the control design procedure, the polynomial approach with the pole assignment method is used. The nonlinear adaptive control is tested by simulations on the nonlinear model of the CSTR with a consecutive exothermic reaction.

Time: 10:10

H_∞ Control of Time-Delay Systems with Time-Varying Delays

Filasová, A., Krokavec, D.

Technical University of Kosice

The linear matrix inequality (LMI) based memory-less controller design approach for continuous time systems with time-varying delays is presented in the paper. If the time-delay variation is from the specified range the design conditions are formulated as feasibility problem and expressed over a set of LMIs with the matrix rank constraints implying from integral quadratic constraints. The proposed method is demonstrated using a system model example.

Time: 10:30

Fault Accommodation in Nonlinear Time Delay Systems

Zhirabok, A., Shumsky, A., Bobko, Y.

Far Eastern Federal University, Vladivostok

Solution to the problem of fault accommodation in nonlinear time delay dynamic systems is related to constructing the control law which provides full decoupling with respect to fault effects. Existing conditions are formulated and calculating relations are given for the control law.

Le-We-3 Lectures: Applications and Case Studies

Chairman: *Závacká, J.*

Time: 09:30

An Application of Model Predictive Control to a Gasoline Engine

Behrendt, S.¹, Düinow, P.¹, Lampe, B.P.²

¹ Hochschule Wismar, University of Applied Sciences

² University of Rostock

The number of the actuators in modern gasoline engines increases due to rising requirements regarding emissions and fuel consumption. The coordination of the available actuators (e.g. throttle, ignition plug, exhaust gas recirculation and turbo charging) is a challenging task. An available scheme for efficient and model-based coordination that respects the actuator constraints is model predictive control, but it is commonly perceived to be limited to processes with slow dynamics due to the necessary solution of an incorporated optimisation problem in each sampling instance. In this paper, it is presented that model predictive control on a production electronic control unit (ECU) for gasoline engine control is feasible. The numerical properties of the applied optimisation algorithm are obtained by Hardware-In-The-Loop simulation and the practical applicability is shown by controlling the engine of a Volkswagen T5 transporter in idle running and on a test track.

Time: 09:50

Hybrid Methods for Traffic Lights Control

Makýš, M., Kozák, Š.

Slovak University of Technology in Bratislava

The paper deals with modeling and design of hybrid control using HYSDEL modeling language and MPT toolbox for MATLAB, respectively. We created optimal structure model using hybrid systems theory and designed predictive control of traffic lights of three interconnected intersections. Considered intersections are in detail described in proposed article.

A model has been built describing the evolution of the queue based on number of incoming and outgoing cars and traffic lights. A realistic intersections model has been built and achieving optimal traffic lights control was successfully verified on many model variations.

Advantage of this approach is that it computes with actual lengths of car queues so it is able to adapt to changes in amount of cars coming to intersection as it was shown.

Modelling and simulation obtained results proved that the proposed approach is suitable for real intersections.

Time: 10:10

Robust Controller Design for a Laboratory Process with Uncertainties

Závacká, J., Bakošová, M.

Slovak University of Technology in Bratislava

The paper presents a method for design of robust PI controllers for systems with interval uncertainty. The method is based on plotting the stability boundary locus in the (k_p, k_i) -plane and sixteen plant theorem. The stability boundaries obtained for interval plants split the (k_p, k_i) -plane in stable and unstable regions. The parameters of robust PI controllers are chosen from the stable region.

The designed robust PI controller is used for control of a laboratory chemical continuous stirred tank reactor (CSTR). The reactor is used for preparing of NaCl solution with desired concentration. The conductivity of the solution is the controlled variable and the volumetric flow rate of water is the control variable.

Time: 10:30

Prediction of Critical Processes in Nuclear Power Plant Using Genetically Trained Neural Networks

Petrík, M., Kozák, Š.

Slovak University of Technology in Bratislava

Neural network is one of many models used in power engineering process prediction. In most cases, the accuracy of prediction models is critical in operational safety or is used to support human irreversible decisions. We use neural network, when the real model of process is unknown, or it is too difficult to identify them in domain specific environment. Neural networks training algorithms are different. Typically, measured data are divided into 2 sets called train and test set. On the train set, algorithms set neural network parameters so that network simulate process on train interval. On the test set is network tested if it can generalize the process from train set. We take a look on special genetic training and compare it with algorithm used today to generalize the process.

Le-We-4 **Lectures: Linear and Non-linear Control System Design**

Chairman: *Dostál, P.*

Time: 11:10

Dual Kalman Estimation of Wind Turbine States and Parameters

Mateljak, P., Petrović, V., Baotic, M.

University of Zagreb

Modern wind turbines operate in a wide range of wind speeds. Power contained in the wind is proportional to the third power of wind speed and therefore increases rapidly with increase of wind speed. To enable wind turbine operation in such a variety of operating conditions, sophisticated control and estimation algorithms are needed. In this paper, a method for wind turbine state and parameter estimation is proposed. The described estimation is experimentally tested on laboratory wind turbine.

Time: 11:30

Linear Matrix Inequalities Based H_∞ Control of Gantry Crane using Tensor Product Transformation

Iles, S., Kolonic, F., Matusko, J.

University of Zagreb

This paper describes a Hinf controller design procedure for tensor product based model of gantry crane augmented with friction model in order to minimize friction effects. The Tensor Product (TP) model transformation is a recently proposed technique for transforming given Linear Parameter Varying (LPV) state-space models into polytopic model form, namely, to parameter varying convex combination of Linear Time Invariant (LTI) systems. Hinf controller guarantee stability and L2 norm bound constraint on disturbance attenuation. Hinf controller is found using relaxed LMIs which have proof of asymptotic convergence to the global optimal controller under quadratic stability. Control algorithm is experimentally tested on single pendulum gantry (SPG).

Time: 11:50

Design of Feedback Control for Unstable Processes with Time Delay

Vrancic, D.¹, Huba, M.²

¹ J. Stefan Institute, Ljubljana

² STU in Bratislava, FernUniversität in Hagen

In this paper, the tuning method, based on characteristic areas and Magnitude Optimum (MO) criterion for some unstable processes is presented. The proposed approach is to use inner compensator, of the first or the second order, to stabilise the process. The stabilised process is controlled by 2-DOF PI controller, tuned by using MOMI or DRMO tuning method (depending on desired tracking or disturbance-rejection performance). The proposed method was tested

on five linear process models. The responses were relatively fast and without oscillations, all according to the MO criterion.

Time: 12:10

Equivalent Representations of Bounded Real Lemma

Krokavec, D., Filasová, A.

Technical University of Kosice

The paper concerns the problem of the bounded real lemma for linear continuous-time systems. Using free weighting matrices to express the relationship between the terms of the system state equation a modified equivalent LMI approach to bounded-real-lemma representation is presented. Immediate extension to design method of a memory-free feedback controller, which performs Hinf properties of the closed-loop system, is formulated as a feasibility problem and expressed over a set of LMIs. Numerical example is included to illustrate the feasibility and properties of the proposed representations.

Le-We-5 Lectures: Software Tools and Toolboxes

Chairman: *Kvasnica, M.*

Time: 11:10

Matlab toolbox for PWA identification of nonlinear systems

Števek, J., Kozák, Š.

Slovak University of Technology in Bratislava

This paper is dedicated to issue of approximation of nonlinear functions and nonlinear dynamical systems by Piecewise Affine (PWA) linear model. The article presents new identification Matlab toolbox for modelling and simulation of nonlinear systems. Functions of the toolbox together with GUI application simplified and accelerates identification of so called PWA OAF model. Identification of nonlinear systems is based on novel method of PWA modelling by generalized Fourier series. The approach provides identification of nonlinear functions of an arbitrary number of variables and identification of nonlinear dynamical systems in ARX model structure fashion from input-output data.

Time: 11:30

MATLAB Toolbox for Automatic Approximation of Nonlinear Functions

Szucs, A., Kvasnica, M., Fikar, M.

Slovak University of Technology in Bratislava

Given a nonlinear dynamical system in analytic form, the paper proposes a novel method for approximating the system by a suitable hybrid model such that the approximation accuracy is maximized. Specifically, the problem of approximating generic nonlinear functions by piecewise

affine (PWA) models is considered. We show that under mild assumptions, the task can be transformed into a series of one-dimensional approximations, for which we propose an efficient solution method based on solving simple nonlinear programs. Moreover, the paper discusses a software implementation of the proposed procedure in form of a MATLAB toolbox.

Time: 11:50

PIDTOOL 2.0 – Software for Identification and PID Controller Tuning

Oravec, J., Bakošová, M.

Slovak University of Technology in Bratislava

The main aim of this paper is to present a new version of software for PID controller tuning called PIDTOOL 2.0. The software represents a user friendly tool for simple step-response-based identification of a process model, fast PID controller tuning, and effective checking the quality of control. It has been developed in the MATLAB-Simulink programming environment using its graphic user interface and can be used as useful and visual software for teaching purposes. In PIDTOOL 2.0, user can easily change a language of the graphic user interface. Nowadays, there is a possibility to choose between English and Slovak.

Time: 12:10

Segmentation of Colour Regions from Printing Sheets

Fribert, M.

University of Pardubice

The print characteristics of optical density, dot area and ink trapping are suitable to control of printing process. To evaluate print characteristics on the basis of scanned micro-samples of printing sheets, it is necessary to carry out the segmentation of colour regions, printed with process inks. The accuracy of the evaluation of these print characteristics strongly depends on the sufficient accurate segmentation of colour regions involved in the print sample. This paper describes the thresholding method of segmentation, combined with edge detection between colour regions.

Workshop

Recent Development in Real-Time MPC

Time: 14:00–18:00

Jones, C.N., Zeilinger, M.

EPFL Lausanne

This tutorial workshop provides an in-depth overview of state-of-the-art and recent development in the field of real-time implementation of Model Predictive Control. After a concise introduction to theoretical aspects of MPC, focus will be put on solving MPC problems parametrically as to obtain the solution in a form of a lookup table. Various methods aimed at reducing the size of the table will be described, followed by discussion of recent advances in the field of fast on-line

approach to MPC. The theoretical concepts will be supported by a large number of illustrative case studies.

Le-We-6 Lectures: Algebraic Methods in Control (Invited)

Chairman: *Halás, M.*

Time: 14:00

Disturbance Decoupling of Discrete-time Nonlinear Systems by Static Measurement Feedback

Kaldmäe, A., Kotta, Ü.

Tallinn University of Technology

This paper addresses the disturbance decoupling problem (DDP) for nonlinear systems extending the results for continuous-time systems into the discrete-time case. Sufficient conditions are given for the solvability of the problem. The notion of the rank of a one-form is used to find the static measurement feedback, that solves the DDP whenever possible. Moreover, necessary and sufficient conditions are given for single-input single-output systems as well as for multi-input single-output systems under the additional assumption.

Time: 14:20

Transfer Matrix and Its Jacobson Form for Nonlinear Systems on Time Scales: Mathematica Implementation

Belikov, J., Kotta, Ü., Leibak, A.

Tallinn University of Technology

This paper suggests a detailed algorithm for computation of the Jacobson form of the polynomial matrix associated with the transfer matrix describing the multi-input multi-output nonlinear control system, defined on homogeneous time scale. The algorithm relies on the theory of skew polynomial rings.

Time: 14:40

Relationship Between Two Polynomial Realization Methods

Kotta, Ü., Tõnso, M.

Tallinn University of Technology

The aim of the paper is to show that two different polynomial realization methods, one of them based on adjoint polynomials and the other on the polynomial quotients, are equivalent. It is proved that both methods provide exactly the same set of basis vectors of the subspace determining the differentials for the state coordinates.

Time: 15:00

Accessibility and Feedback Linearization for SISO Discrete-Time Nonlinear Systems: New Tools

Kotta, Ü.¹, Mullari, T.¹, Shumsky, A.², Zhirabok, A.²

¹ Tallinn University of Technology

² Far Eastern Federal University, Vladivostok

The tools of the algebra of functions are applied to readdress the accessibility and static state feedback linearization problems for discrete-time nonlinear control systems. These tools are also applicable for nonsmooth systems. Moreover, the close connections are established between the new results and those based on differential one-forms.

Time: 15:20

Discrete-Time Solution to the Disturbance Decoupling Problem of Coupled Tanks

Halás, M.

Slovak University of Technology in Bratislava

Mathematical technicalities, involved in the modern theory of non-linear control systems, many times prevent a wider use of the impressive theoretical results in practice. Attempts to overlap this gap between theory and practice are usually more than welcome and form the main scope of our interest in this work. An important control problem given by the disturbance decoupling is studied for a real laboratory model of coupled tanks. Since the theoretical solution to the disturbance decoupling problem does not satisfy practical control requirements it is modified accordingly. Experiments on the real plant are included as well and show that the disturbances practically do not affect the system output.

**Le-We-7
Lectures: UAVs Development and Control (Invited)**

Chairman: *Gerke, M.*

Time: 16:00

Ultrasonic Hybrid Map for Navigation of Mobile Robot

Jurišica, L., Duchoň, F.

Slovak University of Technology in Bratislava

Paper deals with principles of ultrasonic hybrid map proposed for indoor mobile robot system. This map is applied in navigation of mobile robot. At the beginning, paper presents brief description of indoor mobile robot system used for testing and developing of algorithms. Major section of paper deals with map creating. In the first step, it is local metric map with probabilistic model of ultrasonic sensor. In the second step, it is global metric map, which is created by connection of local metric maps. In the last step, it is simplification of environment representation from global metric map to topological map. In this manner ultrasonic hybrid map is created and it can be used in both reactive and global navigation of mobile robot.

Time: 16:20

Control of an RC Helicopter Model Through USB Interface

Pestun, I., Halás, M., Kurčík, P.

Slovak University of Technology in Bratislava

This paper presents interface between personal computer and radio controlled helicopter model through an electronic component – microcontroller board. The communication is established through USB interface. The paper describes philosophy of manual RC model control and exploitation of a classical RC model transmitter for controlling an RC model through the computer. Collection of feedback data and GUI for controlling the helicopter are also described.

Time: 16:40

3D Off-Line Path Planning for Autonomous Airships in Restricted Known Environments.

Al-Rashedi, N., Gerke, M.

FernUniversität in Hagen

The paper presents a Genetic Algorithm (G.A.) for off-line path planning of Autonomous Small Airships in known 3D environments with special consideration of restricted areas. The algorithm assumes that the airship is used in Fire Fighting and Mine Detection projects, so the aircraft will fly only a few meters above the ground, which means there is a high possibility of collision with obstacles. The task of the Off-Line Path Planner algorithm is to find an optimal route to visit all the predefined locations for airborne measurement exactly once per mission, without any collisions with environmental obstacles and to avoid fly over a defined restricted area. The planner task posed here is an NP problem. This paper proposes a 3D Off-Line Path Planner using G.A. including chromosome representation, G.A. crossover and collision avoidance with known obstacles. The proposed algorithm is implemented using MATLAB with Genetic Algorithms and Mapping Toolboxes. The proposed algorithm is tested using real maps of our research airfield and the result shows that the algorithm finds a near-optimal collision free path for the airship.

Time: 17:00

Data Management Architecture for Tele-operated UAV System

Bahník, P.¹, Pilka, J.²

¹ FernUniversität in Hagen

² Slovak University of Technology in Bratislava

Nowadays, more frequently than ever, the unmanned aerial vehicles (UAVs) are used effectively as mobile sensor platforms. The UAV system equipped with an airborne camera and special sensors is a valuable source of various important information helping to build an actual overview of an environment. It can take place like an observer in disaster situations as well as a special mobile monitoring device which is able to collect required data from a predefined area. This paper introduces our approach to design effective data management architecture to be able

to manage, reliably distribute and represent different types of measured data with taking many aspects and limitations of the tele-operated UAV system to consideration.

Time: 17:20

Gain-Scheduled LQR-Control for an Autonomous Airship

Masar, I., Stöhr, E.

FernUniversität in Hagen

In the past two years, an autonomous airship was developed at our department as a flying sensor platform. Our main research areas during this period were navigation, modelling and automatic control of the airship. In this article, we present a gain-scheduled LQR control design for the airship. First, the mathematical model of the system and its linearization will be introduced. After that, we split the linearized system in a lateral and a longitudinal subsystem. With the combined gain-scheduled controlled subsystems, a high-level navigation system allows the airship to follow an appropriate flight trajectory.

Time: 17:40

Experience in Desingning Autonomous Airplane

Schochmann, R.¹, Pilka, J.¹, Suchý, M.¹, Pestun, I.¹, Huba, M.²

¹ Slovak University of Technology in Bratislava

² STU in Bratislava, FernUniversität in Hagen

In this paper we present experience gathered in our work on UAV design. UAVs (Unmanned Autonomous, or Aerial Vehicles) are radio controlled flying vehicles, e.g. airplanes equipped with RF communication systems, cameras and sensors (e.g. accelerometers, gyros, temperature and pressure sensors, a GPS module etc.) enabling to be capable of autonomous flight. Currently UAVs are mostly used in the military area to safely watch areas of potential risk without endangering the lives of people otherwise needed to provide information on such areas. Lately UAVs have begun to make their way into civil applications as well. Possible uses include monitoring of forest fires, following fleeing suspects by the police, scanning of ground surface to create maps on a local level and so on, or simply for fun.

Po-We-8 Poster Session

Poster: 1

Bioproduction of mcl-PHAs Biopolymers – Process States and Control

Hrnčířík, P.¹, Černý, F.¹, Náhlík, J.¹, Vovsík, J.¹, Mareš, J.², Lovecká, P.¹

¹ Institute of Chemical Technology, Prague

² University of Pardubice

The presented paper deals with the experimental and theoretical work related to mcl-PHAs biopolymer production process using fed-batch cultivations of the bacterium *Pseudomonas putida* KT2442. The focus is on the definition and identification of process states in the form of physiological situations relevant to intracellular biopolymer production as well as the design of appropriate process control strategies.

Poster: 2

Structure and Parametric Definition of Linear Dynamic Object via Identification Based on Real Interpolation method

Alexeev, A., Zamyatin, S., Pushkarev, M.

Tomsk Polytechnic University

The paper considers identification problem of linear dynamic object based on real interpolation method. It is provided the solution of raised problem that gives formalized algorithm for structure and parameters definition using as input data step-response function. Suggested approach gives possibility to build transfer function of analyzed object with pre-determinate level of relevant error in time domain. Efficiency of proposed identification algorithm is demonstrated by numerical example.

Poster: 3

Mathematical Model of Differentially Steered Mobile Robot

Dušek, F., Honc, D., Rozsival, P.

University of Pardubice

Paper deals with dynamic mathematical model of an ideal differentially steered drive system (mobile robot) planar motion. The aim is to create model that describes trajectory of a robot's arbitrary point. The trajectory depends on supply voltage of both drive motors. Selected point trajectory recomputation to trajectories of wheels contact points with plane of motion is a part of the model, too. The dynamic behaviour of engines and chassis, form of coupling between engines and wheels and basic geometric dimensions are taken into account. The dynamic model will be used for design and verification of a robot's motion control in MATLAB / SIMULINK simulation environment.

Poster: 4

Identification of Nonlinear Systems with General Output Backlash

Vörös, J.

Slovak University of Technology in Bratislava

The paper deals with identification of nonlinear cascade systems with general output backlash, where instead of the straight lines determining the upward and downward parts of backlash characteristic general curves are considered. A new form of general backlash description is leading to the mathematical model, which has all the model parameters separated. The identification based on this model is solved as a quasi-linear problem using an iterative algorithm with internal variables estimation.

Poster: 5

On-Line Identification Simulation of Forgetting Methods to Track Time Varying Parameters Using Alternative Covariance Matrix

Vachálek, J.

Slovak University of Technology in Bratislava

The paper compares abilities of forgetting methods to track time varying parameters of two different simulated models with different types of excitation. The observed parameters in simulations are the integral sum of the Euclidean norm of a deviation of the parameter estimates from their true values and a selected band prediction error count. As supplementary information we observe the eigenvalues of the covariance matrix. In the paper we used modified method of Regularized Exponential Forgetting with Alternative Covariance Matrix (REFACM or REZAKM) along with Directional Forgetting (DF or SZ) and three regularized methods has been selected: Regularised Exponential Forgetting (REF or REZ), Stabilised Linear Forgetting (SLF or SLZ) and Praly Forgetting (PF or PZ).

Poster: 6

Simulation of 2D Physics of Objects Captured by Web Camera Using OpenCV and Box2D

Sedlák, M.

Slovak University of Technology in Bratislava

The paper presents one approach to simulation of physics applied on objects captured by web camera. Introduced approach utilise OpenCV library for image capturing and contour detection. Objects detected by OpenCV are reconstructed from its outlines in Box2D environment so the physics can be applied to it. Because of restrictions of Box2D was needed to do approximation and scaling of outlines and tessellation of objects with Delaunay triangulation algorithm.

Poster: 7

Reactor Furnace Control – PID and Predictive Methods Comparison

Mareš, J.¹, Doležel, P.¹, Dušek, F.¹, Procházka, A.²

¹ University of Pardubice

² Institute of Chemical Technology, Prague

Paper deals with different techniques of nonlinear reactor furnace control. The first part briefly describes the real system (reactor furnace), which is a nonlinear system because of different heat transport mechanisms. Then different approaches to the system control are described. Firstly standard technique using PID controller, and secondly two predictive control strategies (Generalized Predictive Controller and Neural Network Predictive Controller).

Poster: 8

MPC-Based Approximation of Dual Control by Information Maximization

Rathouský, J., Havlena, V.

Czech Technical University in Prague

This paper proposes multiple-step active control algorithms based on MPC approach that approximate persistent system excitation in terms of the increase of the lowest eigenvalue of the parameter estimate information matrix. It is shown how the persistent excitation condition is connected with a proposed concept of stability of a system with uncertain parameters. Unlike similar methods, the proposed algorithms predict the information matrix for more than one step of control. The problem is formulated as an MPC problem with an additional constraint on the information matrix. This constraint makes the problem non-convex, thus only locally optimal solutions are guaranteed.

Poster: 9

On-line Recognition of Autonomous Robot Position via Camera DragonFly

Mareš, J.¹, Procházka, A.², Doležel, P.¹

¹ University of Pardubice

² Institute of Chemical Technology, Prague

Contribution deals with one possible applications of image processing – recognition of moving object position. Traced object is robot MINDSTORM NXT, which is described in the first part of the paper. The methodology of image processing and object recognition is discussed in the second part of the paper. The third part describes the application example.

Poster: 10

Hough Transform Use in Image Processing of Microscopic Alloy Images

Slavíková, P., Mudrová, M., Michalcová, A., Procházka, A.

Institute of Chemical Technology, Prague

Presented paper presents principle of Hough transform on fundamental geometric forms and algorithm of its application. Fundamental geometric forms are used to explain core of this method. These statements are expanded on more complex simulated image and critical aspects of using Hough transform are discussed. Tested methods were applied on microscopic images of Al Alloy which were treated by conditions of Vickers indentation test.

Poster: 11

Software Background of the 'Mechatronics-Based Rehabilitation at Home' Concept

Sobota, J., Severa, O., Kocánek, M., Čech, M., Balda, P.

University of West Bohemia in Pilsen

In this paper the concept of 'Mechatronics-based Rehabilitation at Home' is presented. The idea is to transfer as much rehabilitation care as possible from hospitals and rehabilitation centres to patients' homes while keeping the effectiveness and quality of rehabilitation process as we know it today. Such concept naturally heavily relies on technological innovation, especially on control systems and communication technologies. Only then is it possible that the patients perform the rehabilitation exercises remotely and autonomously and the rehabilitation specialists and physiotherapists still have enough information about the progress in the patient to adjust or change the treatment as necessary. Software tools addressing the challenging requirements are presented.

Poster: 12

State Feedback Control Design Using Eigenstructure Decoupling

Fonod, R., Kocsis, P.

Technical University of Kosice

In this paper the design of controlling a class of linear systems via state feedback eigenstructure assignment is investigated. The design aim is to synthesize a state feedback control law such that for prescribed eigenvalues of the closed-loop control system corresponding eigenvectors are as close to decoupled ones as possible. The set of parametric vectors and the set of closed-loop eigenvalues represent the degrees of freedom existing in the control design, and can be further properly chosen to meet some desired specification requirement, such as mode decoupling and robustness. An illustrative example and the simulation results show that the proposed parametric method is effective and simple.

Poster: 13

Application of Mathematical Morphology on Nanostructure Image Processing

Petrová, J., Mudrová, M., Procházka, A., Fojt, J.

Institute of Chemical Technology, Prague

Mathematical morphology is a very effective tool on image segmentation. This paper presents selected methods of mathematical morphology that are applied to the microscopic images of nanomaterials. The first part briefly describes the mathematical background of the fundamental morphological methods, including their application on the test image. The second part contains an application both of binary and grayscale morphological methods on the nanostructure images. The influence of various structure elements is investigated, as well.

Poster: 14

Safety Verification of Rule-Based Controllers

Paulovič, M., Kvasnica, M., Szucs, A., Fikar, M.

Slovak University of Technology in Bratislava

This paper proposes how to transform a control algorithm, written in MATLAB, into a hybrid system in order to verify its stability properties. The procedure first converts the code into a corresponding HYSDEL equivalent, which is then used to generate a suitable mathematical model. Safety verification is then formulated as a mixed integer linear program with feasibility objective.

Poster: 15

The Empirical Mode Decomposition in Real-Time

Trnka, P., Hofreiter, M.

Czech Technical University in Prague

The paper devotes analysis of environmental time series by using the on-line empirical mode decomposition (OEMD). The environmental data were measured by meteorological stations which are deployed in the southern part of Czech Republic. The EMD algorithm was modified for the possibility of the on-line analysis of environmental time series.

Poster: 16

Control of the Laboratory Helicopter Simulator

Macháček, J., Havlíček, L.

University of Pardubice

The laboratory helicopter simulator is a nonlinear two inputs – two outputs system with significant cross-coupling. The papers deals with control of vertical angle, where the controlled variables was the position angle and the manipulated variable was main motor voltage. The control with PID controller, IMC controller and self-tuning adaptive controller was designed and

tested. The control algorithms were used for tracking of the reference values and rejection of disturbances (moving of the tail rotor).

Poster: 17

Piecewise-Linear Neural Models for Process Control

Doležel, P., Taufer, I., Mareš, J.

University of Pardubice

There is introduced an algorithm which provides piecewise-linear model of nonlinear plant using artificial neural networks, in this paper. That piecewise-linear model is precise and each linear submodel is valid in some neighbourhood of actual plant state. This model can be used for plant control design. There is presented an example at the end of this paper, where defined nonlinear plant is controlled via Pole Assignment technique using piecewise-linear neural model and control response is compared to data obtained by common PI controller.

Poster: 18

PI/PID Controller Design for FOPDT Plants Based on the Modulus Optimum Criterion

Cvejn, J.

University of Pardubice

We present the PI/PID controller settings for the first order systems with dead time, based on the modulus optimum criterion. The settings provide fast closed-loop response to changes of the reference input. Unlike most other tuning methods, the parameters are obtained without approximation of the delay term, so they remain valid for long dead time. Besides the performance indices, quality of the settings is also evaluated by the stability margin. Although optimal values of the parameters are valid for the reference tracking problem, a compensation of the disturbance lag that preserves the stability margin is proposed for the disturbance rejection problem.

Poster: 19

Signal Shapers for BWB Aircraft Control

Kucera, V., Hromčík, M.

Czech Technical University in Prague

This article shows results related to application of impulse signal shapers (ZV, ZVD, EI), applied on reference signal as a feed-forward vibration compensator for pilot commands incorporated with feedback control system (FCS) design for blended-wing-body aircraft (ACFA 2020). The results are nicely indicating ability of connection feed-forward approach for reducing vibration cooperation with active damping. Other goals are study signal shapers design for hard nonlinearities in elevator and ailerons like saturation and rate limiters, induce by finite rates and deflection of servomechanism of control surface. Standard design can't be directly used for higher deflection of elevator and ailerons, because nonlinearities deform shaped command. Two efficient modifications used as alternatives to standard shapers configuration, suggested in the

article, permit application of the feed-forward compensation in respect of this setup.

Poster: 20

Time Sub-Optimal Control of Triple Integrator

Bisták, P.

Slovak University of Technology in Bratislava

The time sub-optimal control is studied in this paper. The nonlinear controller that respects input saturations is derived for the simple linear system represented by the triple integrator. In comparison with the pure time optimal controller the designed sub-optimal controller changes its limit values smoothly with exponential behaviour. Similarly to the time optimal control the design is based on switching surfaces but these are shifted and modified according to the original ones in the time optimal control. This can assure the decrease of high sensitivity of time optimal control. New parameters introduced during the design correspond in linear cases to the poles of the closed loop system. They enable to tune the control changes. The time sub-optimal control is compared with model predictive control. The resulting formulas for the control value are complicated but they have an explicit form so they can be evaluated fast enough to be used in real time systems.

Poster: 21

Robust Decentralized Controller Design for Performance

Kozáková, A., Veselý, V., Osuský, J.

Slovak University of Technology in Bratislava

Abstract: The paper presents an innovation of the robust decentralized controller design for multivariable uncertain systems within the setting of the Equivalent Subsystems Method (ESM). The aim of the proposed design procedure is to guarantee robust stability and plant-wide nominal performance in terms of maximum overshoot achieved through phase margins specified for equivalent subsystems. The developed design procedure is illustrated by an example.

Poster: 22

Solution of a Robust Stabilization Problem Using YALMIP and Robust Control Toolboxes

Bakošová, M., Oravec, J., Kačur, M.

Slovak University of Technology in Bratislava

The aim of this paper is to compare two toolboxes used for solving the robust stabilization problem. Robust static output feedback controller was designed for a continuous stirred tank reactor (CSTR) in which two parallel exothermic reactions take place. The reactor is a system with parametric uncertainty and multiple steady states. The problem of robust controller design was converted to a problem of solution of linear matrix inequalities (LMIs) and computationally simple non-iterative and iterative algorithms have been used for controller tuning. The MATLAB-Simulink environment enables to compare the results of the YALMIP and the Robust Control toolboxes.

Poster: 23

Lateral Flight Dynamic Controller for Flexible BWB Aircraft

Haniš, T., Hromčík, M.

Czech Technical University in Prague

Two different approaches for design of lateral control augmentation system for large blended-wing-body aircraft (BWB) with flexible structure are presented and assessed in this paper. The most challenging issue is handling of rigid-body dynamics and flexible modes coupling. First, a more classical approach is employed giving rise to separate flight dynamics controller (H_2 optimal, with sufficient roll-off) and an active damper for most prominent lateral flexible modes on top of that (mixed-sensitivity H_∞ design). This approach proves successful and has obvious advantages related to the design process complexity, or implementation and testing issues. On the other hand, there is always a risk of potentially significant performance loss compared to a fully integrated design. For this reason, fully integrated design is also presented in the form of a fixed-order MIMO H_∞ optimal FCS controller, obtained by means of direct non-convex non-smooth optimization package HIFOO. Performance of both approaches is assessed.

Poster: 24

Control of a Tubular Heat Exchanger

Bakošová, M., Kačur, M., Oravec, J.

Slovak University of Technology in Bratislava

Using of a modified Smith predictor for compensation of measurable disturbances affecting a time-delay system is studied in this paper. The controlled system is a tubular heat exchanger, in which the kerosene is heated by hot water. The heat exchanger is a nonlinear system with time delay. The Smith predictor and the modified Smith predictor are used for control of the heat exchanger without and with disturbances. Obtained simulation results confirm that the modified Smith predictor with feed-forward compensation of measurable disturbances can improve the closed-loop control responses of the time delay systems with disturbances.

Poster: 25

Robust Control of a Hydraulic System with Unstructured Uncertainties

Karšaiová, M., Bakošová, M., Vasičkaninová, A.

Slovak University of Technology in Bratislava

The paper presents simulation results obtained by robust control of a system of three serially connected tanks. The method used for robust controller design is based on the small gain theorem. The robust PID controller is designed that assures the stability of the closed-loop control system for a certain range of unstructured uncertainties.

Poster: 26

Virtual Laboratory of Process Control

Kalúz, M., Čirka, L., Fikar, M.

Slovak University of Technology in Bratislava

This paper describes new PID control features, which have been implemented in our virtual Flash laboratory that was originally designed for simulations of technological plants. We discuss methods of discrete PID implementation and show new functions of the virtual laboratory.

Poster: 27

Bode Plots in Maxima Computer Algebra System

Gajdošík, D., Žáková, K.

Slovak University of Technology in Bratislava

The aim of the paper is to demonstrate possibilities of open software environment Maxima in educational process at technical universities whereby our attention is dedicated to the teaching of Bode plot. The developed procedure for drawing its asymptotic approximation can be used both for checking results on the base of the entered system transfer function and also for self testing purposes. In addition, the results were used for the building of web application that will be used in frame of the subject Control Theory.

Poster: 28

Neuro-Fuzzy Control of the Three Tank System

Blahová, L., Dvoran, J.

Slovak University of Technology in Bratislava

This paper presents the control design via the combination of the neural predictive controller and the neuro-fuzzy controller type of ANFIS. The neuro-fuzzy controller works in parallel with the predictive controller. This controller adjusts the output of the predictive controller, in order to enhance the predicted inputs. The performance of our proposal is demonstrated on the three tank system control problem with disturbance. Simulation results demonstrate the effectiveness and robustness of the proposed approach.

Poster: 29

Neuro-fuzzy Control of a Chemical Reactor with Uncertainties

Vasičkaninová, A., Bakošová, M., Karšaiová, M.

Slovak University of Technology in Bratislava

This work deals with the design and application of a neuro-fuzzy control of a chemical reactor. The reactor is exothermic one. There are two parameters with only approximately known values in the reactor. These parameters are the reaction enthalpies. Because of the presence of uncertainty in the continuous stirred tank reactor, the robust output feedback is designed.

Simulations confirmed that robust neuro-fuzzy controllers can be successfully used for control of CSTRs with uncertainties and disturbances.

Poster: 30

Transplant Evolution for Optimization of General Controllers

Ošmera, P.

Brno University of Technology

This paper describes a new method of evolution that is named Transplant Evolution (TE). None of the individuals of the transplant evolution contains genotype. Each individual of the transplant evolution contains only phenotype. Reproduction methods as crossover and mutation work and store only the phenotype. The hierarchical structure of grammar-differential evolution that is used for finding optimal structures and parameters of general controllers is described.

Poster: 31

Tests of Various Types of Residuals in Regression Diagnostics

Javiřek, M., Taufer, I.

University of Pardubice

Approximation of experimental data by means of an analytical or general mathematical dependence is performed most frequently by the regression method using the least squares approach. The quality of curve fitting is evaluated on the basis of analysis of resulting set of residuals which, however, can be defined in various ways. This paper deals with suitability tests of the individual types from the standpoint of curve fitting quality of the regression dependence.

Poster: 32

Predictive Control Using Neural Network Applied on Semi-batch Reactor

Macků, L., Sámek, D.

Tomas Bata University in Zlin

The article deals with the control of the semi-batch reactor that is used in chromium sludge processing. To simulate the real process a mathematical model including reaction kinetics was used. The parameters of the achieved model were obtained and verified by experiments. The control of the semi-batch reactor is difficult by common control methods because of the strongly exothermic chemical reaction. A model predictive control using artificial neural network is applied to the temperature control problem. The system control is generally complicated because of its nonlinearities.

Poster: 33

Pole Placement Controller with Compensator Adapted to Semi-Batch Reactor Process

Novosad, D., Macků, L.

Tomas Bata University in Zlin

This paper deals with the modelling and control of semi-batch reactor used for chromium sludge regeneration process. A comparison of three process control approaches is presented. Usual PID controller without online identification (OI) and adaptive PID controller were adapted to semi-batch reactor process in our previous studies. In this study the two-degrees-of-freedom (2DOF) controller is developed for the same reactor control.

Poster: 34

Real-Time Model Predictive Control of a Fan Heater via PLC

Rauová, I., Valo, R., Kvasnica, M., Fikar, M.

Slovak University of Technology in Bratislava

This paper deals with real-time implementation of Model Predictive Control (MPC) of a fan heater system using Programmable Logic Controller (PLC) platform. The MPC problem is solved using parametric programming techniques, which encode the optimal control moves as a lookup table. The challenge then becomes how to implement such a table on a memory-restricted device. The proposed design procedure is illustrated on real-time control of a laboratory heat exchange plant.

Poster: 35

H_∞ Controller Design for Active Suspension System

Zuščíková, M., Belavý, C.

Slovak University of Technology in Bratislava

This paper presents the H_∞ synthesis of control for an active suspension design based on an extended quarter-car model. The usage of automobile active suspension has two main reasons, to increase ride comfort and to improve handling performance. Both these requirements are contradictory. To obtain the model performances and solve the H_∞ synthesis the Matlab software with the Robust Control Toolbox has been used. The benefits of controlled active suspensions compared to passive ones are here emphasized.

Pl-Th-1 Plenary Lecture

Chairman: *Šebek, M.*

Time: 08:45

Decoupling Optimal Controllers

Kučera, V.

Czech Technical University in Prague

Decoupling is a way to decompose a complex system into non-interacting subsystems. In fact, certain applications necessitate controlling independently different parts of the system. Even if this is not required, the absence of interaction can significantly simplify the synthesis of the desired control laws.

The basic form of decoupling into single-input single-output subsystems, often referred to as the diagonal decoupling, was posed by Voznesenskij in terms of transfer function matrices. A more general form of decoupling into multi-input multi-output subsystems is known as the block decoupling and was introduced by Wonham and Morse. Using the state space approach, they solved the problem by static as well as dynamic state feedback.

A comeback of the transfer function methods in the study of block decoupling is due to Hautus and Heymann, Kučera, Desoer and Gündes, and Lee and Bongiorno. A dynamic state feedback was shown to be equivalent with combined dynamic output feedback and feedforward reference compensation, often referred to as a two-degree-of-freedom controller. To address stability issues, the Youla-Kučera parameterization of all stabilizing controllers was invoked.

The two-degree-of-freedom controller structure is ideally suited to decoupling since stability and non-interaction can be treated as two independent constraints. This is not true for a pure feedback, or a one-degree-of-freedom controller.

This paper adopts the two-degree-of-freedom controller structure. The class of all such controllers that decouple and stabilize the system is determined in parametric form and the parameter is used to obtain the H₂-optimal controller. The solution is simple and direct.

Le-Th-2 Lectures: Model Predictive Control

Chairman: *Ogonowski, Z.*

Time: 09:30

Two-State Bilinear Predictive Control for Hot-Water Storage Tank

Ogonowski, Z.

Silesian University of Technology

The paper presents original predictive algorithm for use in two-state (or binary) input control of nonlinear systems which are described with state-constrained bilinear models. It is shown in the paper, that instead of non-linear continuous-time model, non-stationary linear discrete-time model can be used to predict the system response. On the other hand, state constrains can be attached to the criterion index to be minimized in the predictive control law. This inclusion

assures the closed-loop stability of the control system and simplifies minimization problem. The proposed algorithm is particularly valuable for applications in heating systems where bilinearity follows from the heat exchange due to flow of liquid medium and constrains concern temperature regime. Application of the algorithm to control a hot water tank is presented in the paper. The tank is modeled by stratified model. Necessity of state observation is pointed out and the observer is derived. Speed of observer convergence is discussed. Performance of the proposed algorithm has been compared with standard relay controller. Experiments have been carried out in real-life environment. Simulations have been used to tune the resulting predictive controller.

Time: 09:50

NMPC for Stiff, Distributed Parameter System: Semi-Automatic Code Generation and Optimality Condition Evaluation

Noga, R.¹, Ohtsuka, T.²

¹ European Organization for Nuclear Research

² Osaka University

AutoGenU is a Mathematica program to automatically generate simulation programs for Nonlinear Model Predictive Control (NMPC). It analytically evaluates the Jacobians necessary to calculate the optimality condition in the NMPC realized using Continuation/Generalized Minimum Residual (C/GMRES) method.

However, in the case of the LHC Superfluid Helium Cryogenic System, which is distributed parameter system, these Jacobians, expressed directly in terms of inputs, states and co-states become complex expressions due to cascading relations between internal variables of the circuit's model.

A semi-automatic code generation procedure based on AutoGenU is presented, where intermediate variables are introduced and the chain rule is applied to evaluate the Jacobians, thereby avoiding complex expressions. In addition, the ODE set describing the system state dynamics is stiff, thus the dynamics time integration step is small. The intermediate variables are available at each step and are used to evaluate the optimality condition more precisely at low additional computing cost. The observed computational cost of the semi-automatically generated code is slightly lower than that of automatically generated and the controller performance is similar in both cases. However, the generation of semi-automatic code requires significantly less memory, and is much faster, widening the applicability of code generation for complex systems.

Time: 10:10

Improvement of the Decoupling Effect of the Predictive Controllers GPC and PFC by Parameter Adaptation

Zabet, K.¹, Haber, R.¹, Schmitz, U.², Bars, R.³

¹ Cologne University of Applied Science, Köln

² Shell Deutschland Oil GmbH

³ Budapest University of Technology and Economics

Two simple techniques are presented and compared for predictive control of TITO (Two-Input, Two-Output) processes to improve the decoupling effect. These techniques are applied for GPC (Generalized Predictive Control) and PFC (Predictive Functional Control). According to the first technique the controller parameters are tuned in synchronization to a reference signal change. According to the second one the controller parameters are set dependent on the actual control error. The second method makes the synchronization to a reference signal change superfluous and its realization is therefore very easy.

Time: 10:30

Separating Functions for Complexity Reduction of Explicit Model Predictive Control

Rauová, I., Kvasnica, M., Fikar, M.

Slovak University of Technology in Bratislava

In this work we propose to reduce memory footprint of explicit MPC controllers by eliminating a significant portion of controller's regions in which the value of the optimal control action attains saturated values. Such regions are then separated by a suitable function, which serves to recover the original control behavior. As a consequence, complexity of explicit MPC feedback laws is reduced considerably without sacrificing optimality.

Le-Th-3

Lectures: Modelling, Simulation, and Identification of Processes

Chairman: *Huba, M.*

Time: 09:30

Lifetime Estimation of Heat Exchangers with Consideration of On-line Cleaning

Friebel, T.¹, Haber, R.¹, Schmitz, U.²

¹ Cologne University of Applied Science, Köln

² Shell Deutschland Oil GmbH

In the presented paper two quality parameters are used to represent the state of a heat exchanger. The remaining lifetime can be estimated by trend regression. Also of interest is the uncertainty of the predicted lifetime which is determined by the confidence interval of the parameter estimation. These algorithms developed are used in this paper in an off-line evaluation of the measurements on a heat exchanger in a refinery. It is shown that the time point of the

heat exchanger cleaning can be predicted. So the presented method can be used for planning the cleaning time point in advance and saving money in maintenance.

Time: 09:50

New Mathematical Tools for Analysis and Control of Platoons of Cars in Future Automated Highway Systems

Šebek, M., Hurák, Z.

Czech Technical University in Prague

This paper introduces new mathematical tools for stabilization and asymptotic following in infinite platoons of vehicles in future automated highway systems. The platoon description, behavior analysis and control is approached in 2-D polynomial framework, that is, the dynamics of the problem are described using a fraction of two bivariate polynomials. In contrast to some previous works, the platoon here assumes a leader (and an infinite number of followers), therefore the often used bilateral z -transform should not be used here since it was developed for doubly infinite vehicular strings. The unilateral z -transform seems better suited. However, it brings about the need to take the boundary conditions into consideration; among other, the leader vehicle comes into the scene. The necessary formalism is introduced in the paper and used to provide elegant alternative proofs of some well-known facts about the platooning problem.

Time: 10:10

Use of Cross Wavelet Transform for Diagnosis of Oscillations Due to Multiple Sources

Sivalingam, S., Hovd, M.

NTNU Trondheim

Oscillations are the most prominent indications of deteriorated controller performance. Control loop oscillations are a common type of plant-wide disturbance and the root-causes can be one or more among poorly tuned controllers, process or actuator non-linearities, presence of model plant mismatch and oscillatory disturbances. This article addresses detection and diagnosis of oscillations in measurements due to multiple sources under a framework of internal model control. A pattern recognition based approach using cross wavelet transforms is proposed to pinpoint the source(s) of oscillation in the control loops. The phase information in wavelet domain between input and output signals is exploited to diagnose the source(s) of oscillations.

Time: 10:30

Relay Identification Analyzing Non-symmetrical Oscillations for Optical Plant

Huba, M.¹, Ľapák, P.²

¹ STU in Bratislava, FernUniversität in Hagen

² Slovak University of Technology in Bratislava

The paper deals with approximation of systems with the dominant first order dynamics by the Integrator Plus Dead Time (IPDT) model based on the analysis of the nonsymmetrical

oscillations with possible offset arising typically under relay control. The analytical derivation is illustrated by results achieved by identification of optical plant. The results are experimentally verified by PI controller tuned using the identification results. Process parameters in various operating points are analyzed and the robust controller tuning based on performance portrait analysis is employed.

Le-Th-4 Lectures: Model Predictive Control

Chairman: *Haber, R.*

Time: 11:10

Real-time Air/Fuel Ratio Model Predictive Control of a Spark Ignition Engine

Kopačka, M., Šimončič, P., Csambal, J., Honek, M., Wojnar, S., Polóni, T., Rohal'-Ilkiv, B.

Slovak University of Technology in Bratislava

The following paper describes the control of air/fuel ratio (AFR) of a spark ignition engine utilizing the analytical model predictive controller based on the multi-model approach. The multi-model approach employs the autoregressive model (ARX) network, using the weighting of local models, coming from the sugeno-type fuzzy logic. The weighted ARX models are identified in the particular working points and are creating a global engine model, covering its nonlinearity. Awaited improvement of a proper air/fuel mixture combusted in a cylinder is mostly gained in the transient working regimes of an engine. In these regimes, the traditional control approach loses its quality, compared to steady state working regimes of an engine. This leads to higher fuel consumption and level of emissions from an engine. Presented results of the air/fuel ratio control are acquired from the real-time control of the VW Polo 1390 ccm engine, at which the original electronic control unit (ECU) has been replaced by a dSpace system executing the model predictive controller. It has been proven, that the proposed controller is suitable for the air/fuel ratio control giving sufficiently good and steady system output.

Time: 11:30

Wind Turbine Power Control for Coordinated Control of Wind Farms

Spudic, V.¹, Jelavić, M.², Baotic, M.¹

¹ University of Zagreb

² KONČAR - Electrical Engineering Institute, Inc.

The new grid regulations require that a grid-connected wind farm acts as a single controllable power producer. To meet this requirement a traditional wind farm control structure, which allowed individual wind turbines to internally define their power production, has to be modified. In this paper the opportunity for wind turbine load reduction that arises from dynamic power control of wind turbines is studied. The wind farm controller design is proposed that utilizes coordinated power control of all wind turbines to achieve the wind farm regulation requirements and to minimize the wind turbine loads.

Time: 11:50

Advanced Process Control of the BGHT7 Desulphurization Unit

Čížniar, M.¹, Puna, D.²

¹ Honeywell Slovakia

² Honeywell Czech Republic

The contribution deals with the design and practical implementation of an advanced process control (APC) on the BGHT7 Desulphurization Unit at Slovnaft, Bratislava Refinery. First, the process and operation of the BGHT7 Desulfurization Unit is briefly described, then the control objectives are introduced, and finally, design and implementation of multivariable predictive control solution is presented.

Le-Th-5

Lectures: Modelling, Simulation, and Identification of Processes

Time: 11:10

Laboratory for Renewable Energy Sources and Identification of the Laboratory Wind Turbine Model

Bobanac, V., Brekalo, M., Vašak, M., Perić, N.

University of Zagreb

This paper presents Laboratory for Renewable Energy Sources (LARES) at the Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia. Laboratory consists of experimental setups for wind energy, solar energy and hydrogen fuel. The aim of LARES is development and experimental research of the advanced control strategies, in order to improve the energy conversion efficiency and thus increase the cost effectiveness of renewable energy sources. Focus of this paper is placed on the wind part of LARES and especially on mathematical model identification of the laboratory wind turbine. Obtained model is a basis for subsequent development of the wind turbine control algorithms.

Time: 11:30

Mathematical Modeling and Implementation of the Airship Navigation

Jelenčiak, F.

FernUniversität in Hagen

The main source of errors for airship navigation is that the airship body is not solid. For this reason a standard fixed calibration for a navigation system is not the best solution. This article provides an overview of the proposed navigation system for airships with compensation of errors due to resilience.

Time: 11:50

Robust Decentralized PID Controller Design for the 3D Crane Process

Nguyen, Q.T., Veselý, V.

Slovak University of Technology in Bratislava

Abstract: The subject of this paper is to design robust decentralized PID controllers for the 3Dcrane to stabilize motion of the cart along axes-x, axes-y using the Small Gain Theorem, and Parameter Dependent Lyapunov Functional (PDLF) in time domain. The obtained results were evaluated and verified in the Matlab simulink and on the real model of the 3DCrane.

Time: 12:10

Comparison of Two Methods for Determining the Optical Flow

Seibold, P.

FernUniversität in Hagen

An unmanned Arial Vehicle (UAV) outfitted with autonomous control devices shall navigate to predefined positions. By means of cameras and optical flow the position, height above ground, orientation and velocity is determined. Two flow methods, differential technique by Bruce D. Lucas and Takeo Kanade and normalized cross correlation are presented and compared.

Workshop

Polynomial Optimisation, LMI and Dynamical Systems

Time: 14:00–18:00

Henrion, D.

LAAS CNRS Toulouse / Czech Technical University in Prague

The first part of the tutorial surveys achievements of the last decade on polynomial optimisation and semidefinite programming (linear matrix inequalities, LMI) with a focus on the generalised problem of moments and existing software tools. The second part of the tutorial deals with a recent extension of these techniques to stability analysis and stabilising controller design for polynomial dynamical systems, exploring connections with classical LMI techniques from the 1990s arising from mainstream robust control.

Pl-Fr-1 **Plenary Lecture**

Chairman: *Kvasnica, M.*

Time: 08:45

Model Predictive Control for Industrial Applications

Papafotiou, G.

ABB Switzerland

Model Predictive Control represents an exciting academic research field and at the same time a well established and mature technology in many industrial applications, where physical processes need to be controlled in an efficient and reliable way. Until recently, however, its appeal has been mainly restricted to processes with rather slow dynamics with sampling times ranging from a few minutes to many hours, such as the ones encountered in the areas of (petro)chemicals, minerals and metals. The main reason for this restriction can be traced to the computational demand that optimization-based algorithms can pose to the control hardware platforms, since in its most common version MPC requires the online solution of a constrained optimization problem at each time step. Nowadays, however, the increased computational capacity that is becoming available in the commonly employed controllers, coupled with recent algorithmic advances, has encouraged the emergence of MPC applications in the automotive, and more recently the power electronics industry, where the time scales are in the range of milli- or even micro-seconds. This talk tries to emphasize this visible trend in industrial reality and present recent developments in the application of MPC for the efficient control of Medium Voltage induction motor drives.

Le-Fr-2 **Lectures: Robust and Adaptive Control**

Chairman: *Vesely, V.*

Time: 09:30

Application of Quantitative Feedback Theory for Wind Turbine Controller Design

Bencic, G.¹, Jelavić, M.², Perić, N.¹

¹ University of Zagreb

² KONČAR – Electrical Engineering Institute, Inc.

To enable wind turbines to produce power under great variety of wind conditions a sophisticated control system is needed. Wind turbine system is highly nonlinear system and its dynamic changes rapidly with the change of wind speed. Many classical control methods fail to properly address this uncertainty of wind turbine dynamics. For that reason the Quantitative Feedback Theory is presented and its application to synthesis of rotor speed controller explained.

Time: 09:50

Robust PID Controller Design for Coupled-Tank Process

Holič, I., Veselý, V.

Slovak University of Technology in Bratislava

The paper deals with the design of the robust PID controller for real uncertain Coupled-Tank process in the frequency domain. Only the first independent tank is considered (single-input single-output system). Robust controller is designed in two ways. The first approach is performed with the Edge Theorem and the Neimark's D-partition method for the affine model and the second one is performed with the modification of the Neimark's D-partition which ensures desired phase margin.

Time: 10:10

Robust Tuning of PI Controller for IPDT Plant

Huba, M.

STU in Bratislava, FernUniversität in Hagen

By considering robust tuning of the PI controller for uncertain Integral Plus Dead Time plant (IPDT) this paper demonstrates possibilities of the new Matlab/Simulink tool based on the performance portrait method enabling for plants with parameters defined over uncertainty intervals to guarantee transient responses with specified deviations from ideal shapes at the plant output and input and fulfilling additional optimality specification, defined e.g. in terms of the minimal IAE values for the setpoint and disturbance steps, in terms of the maximal integral gain, etc. In difference to the robust tuning methods of the 1st generation considering typically controller parameters calculated from plant parameters specified by a single entry, in this new method uncertain plant parameters are specified by two entries characterizing their extreme values. As the ideal step responses at the plant output monotonic transients are considered, whereas at the plant input one-pulse step responses consisting of two monotonic intervals are supposed.

Time: 10:30

Robust Decentralized Controller Design with Specified Phase Margin

Osuský, J., Veselý, V.

Slovak University of Technology in Bratislava

This paper presents the robust decentralized controller design in the frequency domain for stable plants. Robust condition based on M-delta structure is included in controller design. In controller design for MIMO systems equivalent subsystem method is used. For subsystems of equivalent model, frequency method ensuring desired phase margin is applied. Design procedure is illustrated on two tanks process.

Le-Fr-3 **Lectures: Process Optimisation**

Chairman: *Fikar, M.*

Time: 09:30

Sensitivity Analysis of Hyperbolic Optimal Control Systems with Boundary Conditions Involving Time Delays

Kowalewski, A.¹, Sokolowski, J.²

¹ AGH University of Science and Technology

² Polish Academy of Sciences

In the paper the first order sensitivity analysis is performed for a class of optimal control problems for hyperbolic equations with the Neumann boundary conditions involving constant time delays. A singular perturbation of geometrical domain of integration is introduced in the form of a circular hole. The Steklov-Poincare operator on a circle is defined in order to reduce the problem to regular perturbations in the truncated domain. The optimality system is differentiated with respect to the small parameter and the directional derivative of the optimal control is obtained as a solution to an auxiliary optimal control problem.

Time: 09:50

Tighter Convex Relaxations for Global Optimization Using alphaBB Based Approach

Paulen, R., Fikar, M.

Slovak University of Technology in Bratislava

This paper is devoted to investigation of certain issues that appear in solving of deterministic global optimization problems (GOPs). Basically, we focus ourselves on introducing a procedure which may serve to establish tighter convex relaxations for a certain class of non-convex optimization problems. Tightness of these convex relaxations plays important role in speeding of the convergence of branch-and-bound algorithm which is used as a basic framework of solving GOPs in this study. Two case studies are solved where it is shown how significant improvement can be achieved by considering proposed framework.

Time: 10:10

Real-time Dynamic Optimisation by Integrated Two-Time-Scale Scheme

Podmajerský, M., Fikar, M.

Slovak University of Technology in Bratislava

This paper deals with the problem of uncertainties in optimal control of real process. The measurement-based optimisation is used to treat variations in terminal constraints, model mismatch and process disturbances. It is assumed that this process will be carried out several times in a row and so that run-to-run optimisation can be performed. The paper presents an integrated two-time-scale control where constraints in optimisation problem are adopted between runs and the pre-computed optimal inputs are corrected according to the on-line output

measurements during the run. Moreover, the proposed control approach has been implemented to control level transition in two connected tanks with liquid interaction. The results uncover better convergence properties with the resulting control scheme than individual schemes dealing either with run-to-run adaptation or with neighbouring extremal corrections inside the run.

Time: 10:30

Optimal Control via Initial State of an Infinite Order Time Delay Hyperbolic System

Kowalewski, A.

AGH University of Science and Technology

In this paper, we consider an optimal control problem for a linear infinite order hyperbolic system. One from the initial conditions is given by control function. Sufficient conditions for the existence of a unique solution of such hyperbolic equations with the Dirichlet boundary conditions are presented. The performance functional has the quadratic form. The time horizon T is fixed. Finally, we impose some constraints on the control. Making use of the Lions scheme, necessary and sufficient conditions of optimality for the Dirichlet problem with the quadratic performance functional and constrained control are derived.

Le-Fr-4 Lectures: Robust and Adaptive Control

Chairman: *Bobál, V.*

Time: 11:10

Digital Self-tuning Smith Predictor Based on Pole Assignment Approach

Bobál, V., Chalupa, P., Dostál, P., Brázdil, M.

Tomas Bata University in Zlin

Time-delays (dead times) are found in many processes in industry. Time-delays are mainly caused by the time required to transport mass, energy or information, but they can also be caused by processing time or accumulation. The contribution is focused on a design of algorithms for self-tuning digital control for processes with time-delay. The algorithms are based on the some modifications of the Smith Predictor (SP). One modification of the SP based on the digital PID controller was applied and it was compared with new designed modification based on polynomial (pole assignment) approach. The program system MATLAB/SIMULINK was used for simulation verification of these algorithms.

Time: 11:30

Robust PSD Controller Design

Veselý, V., Rosinová, D.

Slovak University of Technology in Bratislava

A state space approach to a design of PSD robust controllers is studied for linear uncer-

tain system with affine (polytopic) uncertainty. The discrete time PSD controller design is based on stability condition derived using parameter dependent Lyapunov-Krasovskii function in the form for time-delay system. The resulting design employs solution of BMI, the results are illustrated on the example.

Time: 11:50

The Robust Motion Control of a Robot Manipulator

Kardoš, J.

Slovak University of Technology in Bratislava

Any feasible control of the multi-DOF mechatronic system has to face the problem of an extreme variability of the plant parameters as well as a strong influence of the variable external forces. The classical control methods are not able to manage such a complex and difficult task. One of the promising control approaches is the contemporary variable structure control (VSC) theory with its specific attribute – the sliding mode. In sliding mode, the system's phase trajectory is robust and independent of the parametric and external disturbances due to reserve in power. Based on the VSC, the equivalent time sub-optimal control (ETSC) algorithm has been formulated for a single-DOF motion control system. The main benefits of this control are a simple control structure, the fastest possible and overshoot-free response and the insensitivity to any (parametric, signal) type of disturbances. One of the problems of VSC, the chattering elimination, has been solved via the reaching law approach. The aim of this contribution is the implementation of the prospective ETSC algorithm in the control structure of a multi-DOF robot manipulator. The robustness and accuracy of the control algorithm is verified and illustrated by the numerical simulation of a control system. Both the dynamic and the steady-state accuracy have been achieved despite the enormous influence of the mechanical coupling among the DOF's of the robot manipulator. The simple implementation of the control algorithm, given by the linear combination of the mechatronic system's directly accessible phase variables, represents an additional benefit of the presented method.

Time: 12:10

Robust Elimination Lemma: Sufficient Condition for Robust Output Feedback Controller Design

Veselý, V., Rosinová, D.

Slovak University of Technology in Bratislava

A linear algebra result known as Elimination lemma is frequently used in lot of filtering and control problems to transform products of unknown matrices to LMI form, however, the robust counterpart to elimination lemma is not known. In this paper, sufficient robust stability condition inspired by elimination lemma is developed and the respective robust static output feedback controller design procedure based on LMI formulation and solution is proposed. The proposed robust controller design procedure is computationally not demanding and is illustrated on example.

Le-Fr-5 Lectures: Control Education

Chairman: *Žáková, K.*

Time: 11:10

Online design of SciLab/Xcos block schemes

Janík, Z., Žáková, K.

Slovak University of Technology in Bratislava

The paper presents a tool that supports building of simulations for online laboratories accomplished in SciLab/Xcos environment. For running such simulations it is necessary to build a block scheme corresponding to a control of virtual or remote device. The presented tool offers a comfortable way of such solution. It's programmed in widely used technologies to ensure wide compatibility and platform independence. This application can be used as a supporting tool in virtual and remote laboratories.

Time: 11:30

Remote Control Software for Thermo-Optical Plant

Kalúz, M., Čirka, L., Fikar, M.

Slovak University of Technology in Bratislava

This paper describes development of a remote control laboratory. The main aim of this work is to create computer software for remote access and control of thermo-optical device uDAQ28/LT. We describe solutions that have been chosen for meeting the requirements for a fully user-friendly and an easy to use application. We choose the software programming platform Adobe Flash for client side application development and we develop a solution based on technologies PHP, MySQL, and MATLAB for server side.

Time: 11:50

Comparison of Supervisory and Networked Control in Remote Laboratories

Folvarčik, P.

Slovak University of Technology in Bratislava

This paper presents some problems of remote control of real systems. Firstly, it compares the quality of local control (controller are located on the server PC) and remote control (controller are located on client PC) for systems with short time constant. Consequently it deals with solving the problems in the remote control. Solution is realized by modification of communication between client and server and reduction of the quantity of transferred and processed data. After that, communication will be faster and the application will be usable for systems with a shorter time constant.

Time: 12:10

ABS/TCS Simulator

Juhás, M.¹, Seman, P.¹, Bodi, S.²

¹ Slovak University of Technology in Bratislava

² ATEC automatizačná technika s.r.o

Paper gives information about development of laboratory device – simulator for automotive applications. The design of simulator allows the use of different setups for simulating braking of vehicle's front and rear wheel as well as acceleration of front and rear wheel driven vehicle. Main use of simulator is development and evaluation of control strategies for anti-lock braking system and traction control system, but device can also be used as general mechatronic system with non-linear behaviour for testing of control system designs.

Author Index

A

Al-Rashedi, N., 28
Alexeev, A., 30

B

Bahník, P., 28
Bakošová, M., 22, 25, 36–38
Balda, P., 33
Baotic, M., 23, 45
Bars, R., 43
Behrendt, S., 21
Belavý, C., 40
Belikov, J., 26
Bencic, G., 49
Bisták, P., 36
Blahová, L., 38
Bobál, V., 20, 52
Bobanac, V., 46
Bobko, Y., 21
Bodi, S., 54
Bonvin, D., 19
Brázdil, M., 52
Brekalo, M., 46

C

Čech, M., 33
Černý, F., 30
Chalupa, P., 52
Čirka, L., 37, 54
Čižniar, M., 45
Csambal, J., 45
Cvejn, J., 35

D

Dünow, P., 21
Doležel, P., 32, 35

Dostál, P., 20, 52
Duchoň, F., 27
Dušek, F., 30, 32
Dvoran, J., 38

F

Fikar, M., 24, 34, 37, 40, 43, 51, 54
Filasová, A., 20, 24
Fojt, J., 34
Folvarčík, P., 54
Fonod, R., 33
Fribert, M., 25
Friebel, T., 43

G

Gajdošík, D., 38
Gerke, M., 28

H

Haber, R., 43
Halás, M., 27, 28
Haniš, T., 37
Havlena, V., 32
Havlíček, L., 34
Henrion, D., 47
Hippe, P., 19
Hofreiter, M., 34
Holič, I., 50
Honc, D., 30
Honek, M., 45
Hovd, M., 44
Hrnčířík, P., 30
Hromčík, M., 35, 37
Huba, M., 23, 29, 44, 50
Hurák, Z., 44

I

Iles, S., 23

J

Janík, Z., 54
Javůrek, M., 39
Jelavić, M., 45, 49
Jelenčiak, F., 46
Jirkovský, J., 17
Jones, C.N., 25
Juhás, M., 54
Jurišica, L., 27

K

Kačur, M., 36, 37
Kaldmäe, A., 26
Kalúz, M., 37, 54
Kardoš, J., 53
Karšaiová, M., 37, 38
Kocánek, M., 33
Kocsis, P., 33
Kolonis, F., 23
Kopačka, M., 45
Kotta, Ü., 26, 27
Kowalewski, A., 51, 52
Kozák, Š., 21, 22, 24
Kozáková, A., 36
Krokavec, D., 20, 24
Kucera, V., 35
Kučera, V., 41
Kurčík, P., 28
Kvasnica, M., 24, 34, 40, 43

L

Lampe, B.P., 21
Leibak, A., 26
Lovecká, P., 30

M

Macháček, J., 34
Macků, L., 39, 40
Makýš, M., 21
Mareš, J., 30, 32, 35
Masar, I., 29
Mateljak, P., 23

Matusko, J., 23

Michalcová, A., 33
Mudrová, M., 33, 34
Mullari, T., 27

N

Náhlík, J., 30
Nguyen, Q.T., 46
Noga, R., 42
Novosad, D., 40

O

Ogonowski, Z., 41
Ohtsuka, T., 42
Oravec, J., 25, 36, 37
Ošmera, P., 39
Osuský, J., 36, 50

P

Papafotiou, G., 49
Paulen, R., 51
Paulovič, M., 34
Perić, N., 46, 49
Pestun, I., 28, 29
Petrík, M., 22
Petrová, J., 34
Petrović, V., 23
Pilka, J., 28, 29
Podmajerský, M., 51
Polóni, T., 45
Procházka, A., 32–34
Puna, D., 45
Pushkarev, M., 30

R

Rathouský, J., 32
Rauová, I., 40, 43
Rohal' -Ilkiv, B., 45
Rosinová, D., 52, 53
Rozsival, P., 30

S

Sámek, D., 39
Schmitz, U., 43
Schochmann, R., 29

Šebek, M., 44
Sedlák, M., 31
Seibold, P., 47
Seman, P., 54
Severa, O., 33
Shumsky, A., 21, 27
Šimončíč, P., 45
Sivalingam, S., 44
Slavíková, P., 33
Sobota, J., 33
Sokolowski, J., 51
Spudic, V., 45
Števek, J., 24
Stöhr, E., 29
Suchý, M., 29
Szucs, A., 24, 34

T

Ťapák, P., 44
Taufel, I., 35, 39
Tönso, M., 26
Trnka, P., 34

V

Vachálek, J., 31
Valo, R., 40
Vašak, M., 46
Vasičkaninová, A., 37, 38
Veselý, V., 36, 46, 50, 52, 53
Vojtěšek, J., 20
Vörös, J., 30
Vovsík, J., 30
Vrancic, D., 23

W

Wojnar, S., 45

Z

Zabet, K., 43
Žáková, K., 38, 54
Zamyatin, S., 30
Závacká, J., 22
Zeilinger, M., 25
Zhirabok, A., 21, 27
Zuščíková, M., 40

List of Participants

Belgium

Krommer, Gabor, Brussels, Poslanecký klub EL'S v Európskom parlamente

Croatia

Bencic, Goran, Zagreb, Koncar – Power Plant and Electric Traction Engineering / Faculty of Electrical Engineering and Computing, University of Zagreb

Bobanac, Vedran, Zagreb, Faculty of Electrical Engineering and Computing, University of Zagreb

Iles, Sandor, Zagreb, University of Zagreb, Faculty of Electrical Engineering and Computing (FER)

Petrović, Vlaho, Zagreb, Faculty of Electrical Engineering and Computing, University of Zagreb

Spudić, Vedrana, Zagreb, University of Zagreb Faculty of Electrical Engineering and Computing Department of Control and Computer Engineering

Czech Republic

Bobál, Vladimír, Zlín, Department of Process Control, Faculty of Applied Informatics, Tomas Bata University in Zlín

Cvejn, Jan, Pardubice, Univerzita Pardubice, Fakulta elektrotechniky a informatiky

Doležel, Petr, Pardubice, University of Pardubice, Faculty of Electrical Engineering and Informatics, Department of Process Control

Dostál, Petr, Zlín, Department of Process Control, Faculty of Applied Informatics, Tomas Bata University in Zlín

Dušek, František, Pardubice, University of Pardubice Faculty of Electrical Engineering and Informatics Department of Process Control

Fribert, Miroslav, Pardubice, Univerzita Pardubice, katedra elektrotechniky

Haniš, Tomáš, Prague, Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Control Engineering

Havlíček, Libor, Pardubice, University of Pardubice, Department of Process Control and Computer Techniques

Honc, Daniel, Pardubice, Department of Process Control Faculty of Electrical Engineering and Informatics University of Pardubice
Javůrek, Milan, Pardubice, University of Pardubice, Faculty of Electronics and Informatics, Department of Control Systems
Jirkovský, Jaroslav, Praha 8, HUMUSOFT s.r.o.
Krynský, David, Praha, Nuclear Research Institute Řež plc, division Energoprojekt Praha
Kubina, Adam, Praha, Nuclear Research Institute Řež plc, division Energoprojekt Praha
Kucera, Vladimír, Praha 6, Czech Technical University in Prague, FEE, Department of control engineering
Kučera, Vladimír, Praha 6, Faculty of Electrical Engineering Czech Technical University in Prague
Macků, Lubomír, Zlín, Faculty of Applied Informatics, Tomas Bata University in Zlín
Macháček, Jiří, Pardubice, Univerzita Pardubice
Mareš, Jan, Prague 6, Institute of Chemical Technology Prague Faculty of Chemical Engineering Department of Computing and Control Engineering
Petrová, Jana, Praha 6, Department of Computing and Control Engineering Institute of Chemical Technology in Prague
Rathouský, Jan, Praha 6, Department of Control Engineering, Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic
Severa, Ondřej, Plzeň 1, University of West Bohemia in Pilsen, Czech Republic
Slavíková, Petra, Prague 6, Institute of Chemical Technology Prague Department of Computing and Control Engineering
Sobota, Jaroslav, Plzeň 1, University of West Bohemia in Pilsen, Czech Republic
Šebek, Michael, Praha 6, Czech Technical University in Prague, Faculty of Electrical Eng.
Trnka, Pavel, Prague, Czech Technical University in Prague Faculty of Mechanical Engineering Department of Instrumentation and Control Engineering

Estonia

Belikov, Juri, Tallinn, Control Systems Department, Institute of Cybernetics at TUT
Kaldmäe, Arvo, Tallinn, Department of Control Systems, Institute of Cybernetics at Tallinn University of Technology
Kotta, Ülle, Tallinn, Dept. of Control Systems Institute of Cybernetics at TUT
Mullari, Tanel, Tallinn, Institute of Cybernetics at Tallinn University of Technology
Tõnso, Maris, Tallinn, Dept. of Control Systems Institute of Cybernetics at TUT

France

Henrion, Didier, Toulouse, LAAS-CNRS Toulouse

Germany

Al-Rashedi, Naef, Hagen, Fern-University in Hagen, Faculty of Informatic and Mathematic, Process Control Research Group.

Bahník, Pavol, Hagen, FernUniversität in Hagen

Behrendt, Stefan, Wismar, Hochschule Wismar, University of Applied Sciences, Faculty of Engineering

Gerke, Michael, Hagen, FernUniversität in Hagen Department of Electrical Engineering Control Systems Engineering group

Haber, Robert, Köln, University of Applied Science Cologne, Institute Process Engineering

Hippe, Peter, Erlangen, Lehrstuhl für Regelungstechnik Universität Erlangen-Nürnberg

Jelenčiak, František, Hagen, FernUniversität in Hagen

Masar, Ivan, Hagen, FernUniversität in Hagen MI/PRT

Seibold, Peter, Hagen, FernUniversität in Hagen

Norway

Sivalingam, Selvanathan, Trondheim, Post doctoral researcher, Department of Engineering Cybernetics, NTNU, Norway

Poland

Kowalewski, Adam, Kraków, Institute of Automatics, AGH University of Science and Technology

Ogonowski, Zbigniew, Gliwice, Institute of Automatic Control, Silesian University of Technology

Russia

Alexeev, Alexander, Tomsk, Department of Integrated Computer Control Systems, Tomsk Polytechnic University

Bobko, Yevgeny, Vladivostok, Far Eastern Federal University

Slovak Republic

Bisták, Pavol, Bratislava, Slovak University of Technology (Organization unit: Fac. of El. Eng. and Inf. Technology)

Blahová, Lenka, Bratislava, Slovak University of Technology, Faculty of Chemical and Food Technology. Institute of Information Engineering, Automation, and Mathematics. Department of Information Engineering and Process Control

Csambal, Jozef, Bratislava, Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering Institute of Automation, Measuring and Applied Informatics Námestie slobody 17 812 31 Bratislava

Čirka, Ľuboš, Bratislava, Department of Information Engineering and Process Control FCFT STU

Čizniar, Michal, Bratislava, Honeywell Process Solutions, Honeywell s.r.o.

Duchoň, František, Bratislava, FEI STU

- Dvoran**, Ján, Bratislava, Department of Information Engineering and Process Control FCHPT STU
- Fikar**, Miroslav, Bratislava, Department of Information Engineering and Process Control FCFT STU
- Filasová**, Anna, Kosice, Technical University of Kosice, Dept. of Cybernetics and AI
- Folvarčík**, Pavol, Bratislava, Slovenská technická univerzita, Fakulta informatiky a informačných technológií, Ústav riadenia a priemyselnej informatiky.
- Fonod**, Robert, Kosice, Technical University of Kosice, Department of Cybernetics and AI
- Halás**, Miroslav, Bratislava, Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and IT, Slovak University of Technology
- Holič**, Ivan, Bratislava, Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and IT, Slovak University of Technology, Slovak Republic
- Huba**, Mikuláš, Bratislava, STU FEI Bratislava
- Janík**, Zoltán, Bratislava, Faculty of Electrical Engineering and Information Technology Slovak University of Technology
- Jendroľ**, Vladimír, Giraltovce, Slovenská technická univerzita v Bratislave Fakulta elektrotechniky a informatiky
- Juhás**, Martin, Bratislava, Department of Automation, Measurement and Applied Informatics; Faculty of Mechanical Engineering; Slovak University of Technology in Bratislava
- Kalmárová**, Andrea, Bratislava, Department of Information Engineering and Process Control
- Kalúz**, Martin, Bratislava, Department of Information Engineering and Process Control FCFT STU, Slovak Republic
- Kardoš**, Ján, Bratislava, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava
- Karovič**, Jaroslav, Bratislava, Country Manager, Invensys Systems sro, Division Foxboro
- Karšaiová**, Mária, Bratislava, Department of Information Engineering and Process Control, Faculty of Chemical and Food Technology, Slovak University of Technology
- Keseli**, Roland, Sala, ProCS Ltd. Sala
- Kopačka**, Matúš, Bratislava, Slovak University of Technology in Bratislava Faculty of Mechanical Engineering Institute of Automation, Measuring and Applied Informatics
- Kozáková**, Alena, Bratislava, URPI FEI STU
- Krokavec**, Dušan, Kosice, Department of Cybernetics and AI Technical University of Kosice Faculty of Electrical Engineering and Informatics
- Kvasnica**, Michal, Bratislava, Department of Information Engineering and Process Control FCFT STU
- Makýš**, Miroslav, Bratislava, Slovenská technická univerzita Fakulta informatiky a informačných technológií
- Mészáros**, Alojz, Bratislava, KIRP STU
- Nguyen**, Quang Thuan, Bratislava, Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava
- Oravec**, Juraj, Bratislava, FCHPT STU
- Osuský**, Jakub, Bratislava, FEI STU

Paulen, Radoslav, Bratislava, Institute of Information Engineering, Automation and Mathematics STU in Bratislava

Pestun, Ivan, Bratislava, Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and IT, Slovak University of Technology

Petrík, Matej, Bratislava, Institute of Applied Informatics at FIIT SUT

Podmajerský, Marian, Bratislava, Department of Information Engineering and Process Control FCHPT STU

Rauová, Ivana, Bratislava, Institute of Information Engineering, Automation, and Mathematics; Faculty of Chemical and Food Technology; Slovak University of Technology in Bratislava

Rosinová, Danica, Bratislava, Department of Automatic Control Systems, STU, Faculty of Electrical Engg. and IT Bratislava Slovakia

Sedlák, Michal, Bratislava, Faculty of Electrical Engineering and Information Technology Slovak University of Technology

Szucs, Alexander, Bratislava, Department of Information Engineering and Process Control FCFT STU, Slovak Republic

Števek, Juraj, Bratislava, Phd student

Ťapák, Peter, Bratislava 1, FEI STU

Vagač, Stanislav, Bratislava, Department of Information Engineering and Process Control

Vachálek, Ján, Bratislava, Ústav automatizácie, merania a aplikovanej informatiky, Strojnícka fakulta, Slovenská technická univerzita v Bratislave

Valo, Richard, Bratislava, Institute of Information Engineering, Automation, and Mathematics FCFT STU in Bratislava

Vasičkaninová, Anna, Bratislava, KIRP, FCHPT

Veselý, Vojtech, Bratislava, Institute of Control and II, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology

Vörös, Jozef, Bratislava, Slovak Technical University Faculty of Electrical Engineering and Information Technology Department of Automation and Control

Závacká, Jana, Bratislava, Department of Information Engineering and Process Control, Faculty of Chemical and Food Technology, STU, Slovakia

Zuščíková, Monika, Bratislava, Slovenská technická univerzita, Strojníka fakulta, Ústav automatizácie, merania a aplikovanej informatiky, Bratislava

Žáková, Katarína, Bratislava, ÚRPI FEI STU

Slovenia

Vrancic, Damir, Ljubljana, J. Stefan Institute

South Africa

Asante, Kwaku Effa, Kyalami, None

Switzerland

Bonvin, Dominique, Lausanne, EPFL Lausanne

Jones, Colin, Lausanne, EPFL Lausanne

Noga, Rafal, Geneva, European Organization for Nuclear Research

Papafotiou, George, Baden-Dättwil, ABB Switzerland

Zeilinger, Melanie, Lausanne, EPFL Lausanne

Thailand

Sraman, Liton, Khon Kaen, Mahamakut Buddhist University, Thailand