Slovak University of Technology in Bratislava

Summaries Volume

Štrbské Pleso, High Tatras, Slovak Republic

June 9 – 12, 2009

Slovak University of Technology in Bratislava
Institute of Information Engineering, Automation, and Mathematics

Summaries Volume

17TH INTERNATONAL CONFERENCE ON PROCESS CONTROL '09

June 9 – 12, 2009, Štrbské Pleso, High Tatras, Slovakia

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ISBN 978-80-227-3081-5

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.*

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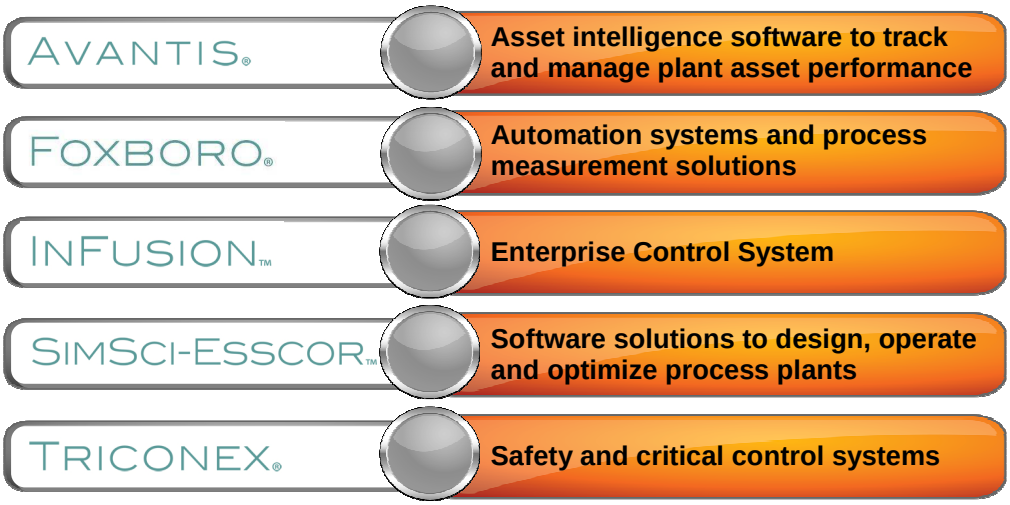

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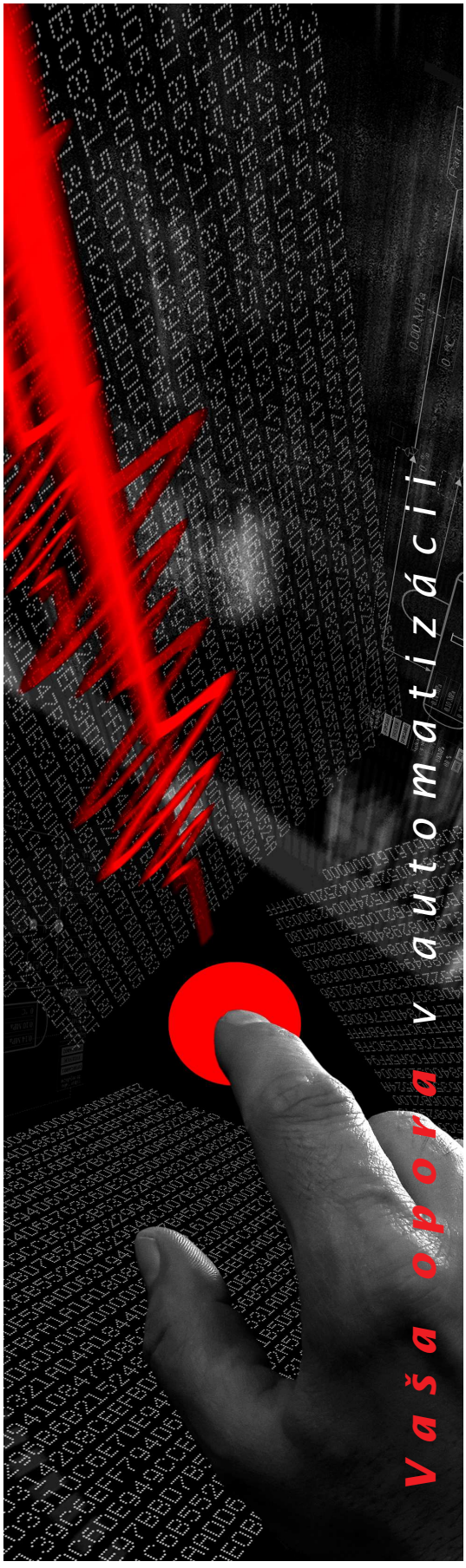

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Program

Tuesday

15:00–18:00 **Matlab Simulink Workshop**

18:00–19:00 **Dinner**

Wednesday

08:30–08:45 **Opening**

08:45–09:25 **Pl-We-1 – Hall A – Plenary lecture**
Mikleš, J.

08:45 Pole-by-Pole Shifting via a Linear-Quadratic Regulation
Cigler, J., Kučera, V. 15

09:30–12:30 **Le-We-2 – Hall A – Lectures: Linear and Non-linear Control System Design**
Tchaikovsky, M., Krokavec, D.

09:30 Model Matching for Nonlinear Systems Not Having the State-Space Realization
Halás, M., Kotta, Ü. 15

09:50 Anisotropic Balanced Truncation - Application to Reduced-Order Controller Design
Tchaikovsky, M. 15

10:10 Some Observations About the RMS Ring for Delayed Systems
Pekař, L., Prokop, R. 16

10:30 Probabilistically Tuned LQ Control for Mechatronic Systems
Belda, K. 16

10:50 **Coffee break**

11:10 Some Aspects of Exponential Stability for Networked Control Systems with Random Delays
Krokavec, D., Filasová, A. 17

11:30 Optimal Control of Chain of Integrators with Constraints
Bláha, L., Schlegel, M., Mošna, J. 17

11:50 Numerical Issues in Designing PI Controller for IPDT Plant
Huba, M., Marko, L'., Bahnik, P., Oravec, I. 17

12:10 An often Missed Detail: Formula Relating Peek Sensitivity with Gain Margin Less Than One
Šebek, M., Hurák, Z. 18

09:30–12:30 Le-We-3 – Hall B – Lectures: Process Optimisation
Kowalewski, A., Latifi, M.A.

10:50 Coffee break

12:30–14:00 Lunch

14:00–18:00 MPC Workshop

17:40–18:30 Po-We-4 – Posters: Linear and Non-linear Control System Design

Thursday

Friday

Pl-We-1
Plenary lecture
Mikleš, J.

Time: 08:45
Pole-by-Pole Shifting via a Linear-Quadratic Regulation
Cigler, J., Kučera, V.
Czech Technical University in Prague

The linear-quadratic regulator and pole placement techniques are considered for designing continuous-time multivariable control systems. The proposed method combines the two approaches in a particular manner. The weighting matrices for the linear-quadratic optimization are constructed corresponding to a set of prescribed eigenvalues. In fact, a single eigenvalue (or a pair of complex conjugate eigenvalues) can be shifted at a time, leaving the remaining eigenvalues at their original positions. The simultaneous knowledge of the weights and the associated closed-loop eigenvalues provides the designer with the opportunity of interaction in both directions. Thereby eigenvalues located in undesired positions can be shifted to more suitable ones. The area into which each eigenvalue can be shifted is described in detail. The allowable shifts result in a faster and dampening feedback.

Le-We-2
Lectures: Linear and Non-linear Control System Design
Tchaikovsky, M., Krokavec, D.

Time: 09:30
Model Matching for Nonlinear Systems Not Having the State-Space Realization
Halás, M.[1] *, Kotta, Ü.*[2]
[1] Slovak University of Technology in Bratislava
[2] Tallinn University of Technology

In this technical note the model matching problem for nonlinear systems not having the state space realization is discussed. It is shown that even in such a case it is still possible to find a realizable compensator. To advantage, a transfer function formalism of nonlinear systems is employed.

Time: 09:50
Anisotropic Balanced Truncation - Application to Reduced-Order Controller Design
Tchaikovsky, M.
Russian Academy of Sciences

This paper addresses the problem of reduced-order normalized anisotropic optimal controller design by anisotropic balanced truncation. This controller is the solution to the normalized anisotropy-based stochastic H-infinity problem. Anisotropic balanced truncation is aimed at

reducing the order of closed-loop system. Two respective Riccati equations involved are used to define a set of closed-loop input-output invariants of closed-loop system called anisotropic characteristic values. The part of controller corresponding to smaller anisotropic characteristic values is truncated to give a reduced-order one. Truncation is carried out for the closed-loop state-space realization in anisotropic balanced coordinates, when the product of two respective Riccati equation solutions is a diagonal matrix with the squares of anisotropic characteristic values situated in descending order on its main diagonal. In anisotropic balanced coordinates, small characteristic values correspond to states which are easy to filter and control in a sense of anisotropic norm. It is shown that the reduced-order anisotropic controller is the full-order one for the reduced-order plant.

Time: 10:10
Some Observations About the RMS Ring for Delayed Systems
Pekař, L., Prokop, R.
Tomas Bata University in Zlin

This paper questions the validity of the definition and some properties of the RMS ring traditionally utilized for the description of time-delay systems. The original description of the ring is faced with findings obtained while dealing with this ring. In the light of these observations, it seems that a revisited definition of the ring ought to be formulated, and thus a new possible conception is presented in the contribution. It is also shown in the paper that the RMS ring proposed in the paper is not a unique factorization domain and thus it is not a principal ideal domain. The extended Euclidean algorithm is attempted to be performed for the ring to prove that it is a Bézout domain, which induces the question of existence of the coprime factorization for each pair of elements of the ring. These two problems are discussed; however, they remain partially unsolved.

Time: 10:30
Probabilistically Tuned LQ Control for Mechatronic Systems
Belda, K.
Czech Academy of Sciences

Mechatronic systems comprise elemental part of production machines and industrial robots. The key task is a design of their suitable control, which should ensure safe control actions in spite of sudden changes of working conditions. The paper presents specific probabilistic interpretation of well-known Linear Quadratic control. This interpretation employs complex information on system behavior and gives physical meaning for fine-tuning of control parameters. The principles of fully probabilistic design with emphasis on on-line tuning are demonstrated on physical model of gearbox mechatronic system representing flexible mechanism occurring in rolling mill machines.

Time: 11:10
Some Aspects of Exponential Stability for Networked Control Systems with Random Delays
Krokavec, D., Filasová, A.
Technical University of Kosice

In this paper, the problem of stability for the standard form of state control, realized in a networked control system structure, is studied. To deal with the problem of stability analysis of event–time–driven modes in networked control systems the delayed–dependent exponential stability condition are proven and actualized. Based on the delay-time dependent Lyapunov-Krasovskii functional the linear matrix inequalities for stability conditions are new formulated. Since presented method can use bilinear matrix inequality techniques it is computationally enough efficient.

Time: 11:30
Optimal Control of Chain of Integrators with Constraints
Bláha, L., Schlegel, M., Mošna, J.
University of West Bohemia in Pilsen

Limitations on control signals and magnitudes of state variables as velocity and acceleration are common requirement in motion control applications. It is well known that time optimal control problem for a chain of integrators with bounded input leads to "bang-bang" control strategy and can be converted to finding real solutions of a system of polynomial equations. The similar result is missing for the problem when magnitude constraints on the state of all integrators in the chain except the last one are added. The paper introduces a new solution of this problem which is based on the theory of Gröbner bases.

Time: 11:50
Numerical Issues in Designing PI Controller for IPDT Plant
Huba, M.[1] *, Marko, L'.*[2] *, Bahnik, P.*[2] *, Oravec, I.*[2]
[1] STU in Bratislava, FernUniversität in Hagen
[2] Slovak University of Technology in Bratislava

This paper deals with numerical issues arising in robust design of the PI controller for the Integral Plus Dead Time plant (IPDT) under robust tuning based on experimentally achieved regions of parameters corresponding to non-overshooting, monotonic, or monotonic and one-pulse control.

Time: 12:10
An often Missed Detail: Formula Relating Peek Sensitivity with Gain Margin Less Than One
Šebek, M., Hurák, Z.
Czech Technical University in Prague

An inequality relating gain margin with sensitivity peek value is presented in numerous basic control textbooks. In fact, this inequality fails to hold as soon as the open loop Nyquist plot crosses the negative real axis on the left from the critical point. This opposite case is usually ignored by the textbook authors. A simple alternative inequality is derived in the paper to cover the not so popular opposite case. This fills a small gap one often encounters in basic control courses.
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Le-We-3
Lectures: Process Optimisation
Kowalewski, A., Latifi, M.A.

Time: 09:30
Boundary Control of an Infinite Order Time Delay Parabolic System with Non-Differentiable Performance Functional
Kowalewski, A.
AGH University of Science and Technology

In this paper, we consider an optimal boundary control problem for an infinite order parabolic system with time delay given in the integral form. Sufficient conditions for the existence of a unique solution of the infinite order parabolic delay equation with the Neumann boundary condition involving a time delay in the integral form are proved. The performance functional constitutes the sum of a differentiable and non-differentiable function. 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 Neumann problem are derived.

Time: 09:50
Multiobjective Optimization of an Emulsion Copolymerization Process
Benyahia, B., Latifi, M.A., Fonteix, C., Pla, F.
LSGC - ENSIC Nancy

A multiobjective optimization procedure based on evolutionary algorithm has been devel-

oped to determine the optimal control policies for a fed-batch emulsion copolymerization reactor, particularly for styrene and butyl acrylate in the presence of n-C12 mercaptan as chain transfer agent (CTA). The process model was elaborated and validated experimentally in order to predict the global monomer conversion, the number and weight average molecular weights, the particle size distribution and the residual monomers. The process objectives are to produce core-shell particles with specific end-use properties and high productivity. This has been achieved by the maximization of the conversion at the end of the process and the minimization of the error between the glass transition temperature and a designed profile subject to a set of operational constraints. The nondominated Pareto solutions obtained were ranked according to the decision maker preferences using multiple attribute utility theory (MAUT). The selected solution gives the best set of the decision variables to be implemented to the real system.

Time: 10:10
Global Optimization for Parameter Estimation of Dynamic Systems
Paulen, R.[1] *, Fikar, M.*[1] *, Čižniar, M.*[1] *, Latifi, M.A.*[2]
[1] Slovak University of Technology in Bratislava
[2] LSGC - ENSIC Nancy

This work deals with the problem of finding a global solution for parameter estimation problem of a dynamic system described by a set of ordinary differential equations (ODE). Deterministic spatial branch and bound optimization algorithm is used to find the solution of problem. Upper bound is generated by sequential approach to dynamic optimization problem. Lower bound is provided by a solution of convex relaxation of the original problem. Selected examples from chemical engineering are solved and the resulting solution is discussed.

Time: 10:30
Hybrid Dynamic Optimisation: Case Study of a Pressure Swing Adsorption Process
Ayoub, S., Latifi, M.A.
LSGC - ENSIC Nancy

In this paper, a hybrid dynamic optimisation approach is developed for simulation of a pressure swing adsorption (PSA) process. The simulation problem which consists in the determination of the cyclic steady-state (CSS) is formulated as an optimisation problem where the performance index is the CSS condition, the decision variables are the state variables at the start of the cycle and the process model along with associated initial and boundary conditions gives the constraints. The necessary conditions of optimality for the hybrid dynamic system using the adjoint system method are derived and the gradients are computed for the non linear programming (NLP) solver used. The optimisation results are compared to those obtained with gradients computed by means of finite differences method.

Time: 11:10
Sensitivity Analysis of Parabolic 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 parabolic equations with the Neumann boundary conditions involving 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: 11:30
On-Line Neighbouring-Extremal Controller Design for Setpoint-Transition in Presence of Uncertainty
Podmajerský, M., Fikar, M.
Slovak University of Technology in Bratislava

In this paper we present an approach suitable for optimal constrained control of processes subject to uncertainties. The controller follows from a nominal solution of dynamic optimisation of a theoretical model which needs not to be very accurate. The nominal optimal control trajectory is identified as a sequence of arcs and boundaries. Real output measurements are used to cancel model mismatch and to augment nominal inputs on-line using state-feedback law. Neighbouringextremal controller is designed to follow the nominal output trajectory in interior arcs using necessary conditions for optimality (NCO). Methodology will be implemented for setpoint-transition of van de Vusse reactor type. Finally, the performance of neighbouring-extremal controller will be benchmarked using several perturbation scenarios.

Time: 11:50
Practical Aspects of Boiler Performance Optimization
Georgiev, B.
Invensys Systems

This paper discuss some practical aspects of implementing Model Predictive Control project in real plant. First part presents in brief the background of application of model predictive control and linear programming optimizer of multiple boilers load in boiler house with general description of requirements and expectations. This introduction to real plant problems is followed by model predictive control project life cycle description. Next chapter contains selected topics which are not directly related to the control algorithms but are crucial factors of project success. Overview of possibilities of Connoisseur follows as an example of the commercial tool which

supports main part of the project life cycle and is able to perform model predictive control and linear programming optimization tasks in real process environment. Last chapter describes possibilities of external tool integration with basic process control system.

Time: 12:10
Increasing Benefits of APC Implementation in Conjuction with Unit Licensor
Niedoba, P.
Honeywell Process Solutions

Advanced process control systems based on multidimensional predictive controllers utilizing process models (Advanced Process Control, APC) are becoming standard tools for optimizing production processes. A frequent problem of APC implementation is the limited access to process information, which are subject to protection of intellectual properties of the licensor. Therefore it is not possible to fully utilize potential benefits of such a control approach. This contribution described an efficient cooperation between the APC implementator and the unit licensor and shows incremental benefits of such an approach.

Po-We-4
Posters: Linear and Non-linear Control System Design

Poster: 1
PSD Controller Tuning Using Artificial Intelligence Techniques
Doležel, P., Taufer, I.
University of Pardubice

There is described new method of PSD controller tuning in this paper. This method tunes PSD controller parameters online through the use of genetic algorithm and neural model of controlled system in order to control successfully even highly nonlinear systems. After method description and some discussion, there is performed comparison to one chosen conventional control technique.

Poster: 2
Decentralized Controller Design with Interaction Rejection
Osuský, J., Veselý, V.
Slovak University of Technology in Bratislava

The paper presents independent decentralized controller design approach with interaction rejection for MIMO systems. Presented method can be used for decentralized control design or for tuning of multivariable systems. Controller gains are as small as possible what decrease noise sensitivity of the system. The approach is demonstrated on example

Poster: 3
Control of Systems with Time-Varying Delay: An Algebraic Approach vs. Modified Smith Predictors
Matušů, R., Prokop, R., Vojtěšek, J.
Tomas Bata University in Zlin

The main aim of this paper is to compare three different control design methods which are applied to a continuous-time single-input single-output (SISO) system with harmonically time-varying delay. The first technique uses a modified PI-PD Smith predictor in combination with standard forms for minimum of integral squared time error (ISTE). The second methodology is also based on modified Smith predictor and on design by Coefficient Diagram Method (CDM). And finally, the third approach to synthesis is grounded in general solutions of Diophantine equations in the ring of proper and Hurwitz-stable rational functions (RPS) for 1DOF or 2DOF control system. The comparison of methods is performed and illustrated on a simulation example.

Poster: 4
Second Order Sliding Mode Control of the DC Motor
Huspeka, J.
University of West Bohemia in Pilsen

This paper deals with the second order sliding mode control algorithm known as terminal sliding mode control. The main advantage of this control method lies in the finite-time convergence of the switching variable and its first derivation to zero. Firstly, the paper introduces the principle of sliding mode control method. The main result of the paper is the analysis the terminal sliding mode control. Then, the comparison between first and second sliding mode control is made on the real model of the DC motor. At last, simulation results are presented.

Poster: 5
Improved Procedure for Robustness Regions Design
Vyskočil, M., Schlegel, M.
University of West Bohemia in Pilsen

The design problem of robustness controllers for LTI systems is a fundamental problem in control theory. Some robustness region methods for PID controllers based on frequency design specifications (e.g. conditions on the maximum of sensitivity and complementary sensitivity functions) were published recently. However, these methods find all roots of a high order polynomial equation in each step and consequently are very demanding with respect to computation time. The paper introduces more effective procedure for determination of robustness regions based on the classical Laguerre's root finding algorithm.

Poster: 6
Evolution of Continuous-Time Controllers with Various Criterion Functions
Sekaj, I.
Slovak University of Technology in Bratislava

A genetic algorithm based controller design approach is described. The genetic algorithm represents an optimisation procedure, where the cost function to be minimized comprises the closed-loop simulation and a performance index evaluation. Depending on performance index various control aims can be considered. In the paper, several performance indices are analysed in a single-criterial and multi-criterion case. All design methods are experimentally compared.

Poster: 7
Application of Auto-Tuning to a Laboratory Model
Korbel, J., Dostálek, P., Prokop, R.
Tomas Bata University in Zlin

The paper is focused on application of relay based auto-tuning combined with algebraic controller design to a laboratory heat exchange model. The principle used in this paper consists of two steps. First phase is an identification of the controlled system parameters. It is performed by the relay experiment with biased relay in the feedback loop and consecutive approximation by the first order transfer function with time delay. Second phase is a computation of the controller parameters through parameterized solution of Diophantine equations in the ring of proper and stable rational functions. Controller parameters are tuned through a pole placement problem as a desired multiple root of the characteristic closed loop equation. This approach enables tuning of the controller parameters by introducing a scalar parameter m>0 which can be adjusted by several principles.

Poster: 8
Realization of Servomechanism with Linear Motor in MATLAB - Simulink Environment
Tejklová, E.
Technical University of Liberec

This paper describes a realization of a servomechanism with a linear motor. The paper is focused on identification of the parameters of a linear motor for the construction of its simulation model. Parameters for regulation loop of the servomechanism in the Real-Time Toolbox in Matlab/Simulink environment were calculated using the Modulus Optimum (MO) Method from those constants.

Po-We-5
Posters: Process Optimisation

Poster: 9
Confidence Intervals of Operational Optimum
Javůrek, M., Taufer, I.
University of Pardubice

The article presents a method of simulated determination of the optimum regime in a reactor in which a competitive consecutive reaction A - B - C takes place. The algorithm of optimization method of reverse step is described, and results of experimental determination of the optimum are given. Also described are the methods of determination of limit values of reliability intervals, and the reliability intervals - uncertainty of "measured" values are evaluated from experimental data. Good accordance between the experimental results and theoretical presumptions is stated.

Poster: 10
Modal Sensors Placement Optimization
Haniš, T., Hromčík, M.
Czech Technical University in Prague

A new approach to optimal placement of sensors in modal sensor sense is presented. In contrast to existing methods, the optimal sensor set selection is based on suppressing of the observation of unwanted modes (typically higher order modes), while simultaneously the observability of low frequency modes should be as high as possible. An efficient numerical algorithm is presented, developed from an existing routine based on the Fischer information matrix analysis. Performance of our approach is demonstrated be means of two simple textbook examples.

Po-We-6
Posters: Modelling, Simulation, and Identification of Processes

Poster: 11
Approximate Mathematical Model of a Steam Overheater
Cvejn, J.
University of Pardubice

We describe a construction of a mathematical model of a controlled powerplant steam overheater. The overheater consists of two subsystems that can be identified separately - cooling steam by water injection and the heating steam part. The model is subsequently to be used in design of a cascade-type control system for regulation of outlet temperature of overheated steam. The second subsystem has distributed parameters and for the purposes of control design it has to be simplified. One way of such an approximation is proposed in the paper. The procedure

of estimation of the model parameters from measured service data is described in a stand-alone paper in the same proceedings.

Poster: 12
Estimation of Parameters of a Model of a Steam Overheater from Service Data
Cvejn, J.
University of Pardubice

The paper describes a procedure of obtaining estimated values of parameters of a model of a controlled powerplant steam overheater from measured service data. A construction of a mathematical model of the overheater is described in a stand-alone paper in the same proceedings. The overheater consists of two subsystems that can be identified separately - cooling steam by water injection and heating steam part. Statistical estimation of parameters from measured data is complicated by the fact that the disturbances influencing the outlet temperature are not pure random. Moreover, since the plant is under feedback, correlation between the disturbances and the system input has to be considered.

Poster: 13
Simulation of One of Possible Method of Control of Heat Output of Hot-Water Piping for Heat Supply to District Heating System: Basic Method of Control
Navrátil, P., Balátě, J., Chramcov, B., Sysala, T.
Tomas Bata University in Zlin

The paper deals with the simulation verification of one of possible approaches to heat output control of hot-water piping for heat supply to wide district heating system. It is described algorithm of the so called qualitative-quantitative control method of heat output control with utilization of prediction of daily diagram of heat supply in hot-water piping systems of district heating. Designed algorithm enables elimination of the influence of transport delay between the source of heat and heat consumption of relatively concentrated consumers. Distance between the source of heat and consumers is in the rank of kilometres. Transport delay depends on flow speed of heat-carrying medium (hot water) and on the length of feeder piping. This method of hot-water piping output control consists in simultaneous and continuous acting of two variables influencing the transferred heat output and in using the prediction of required heat output in a specific locality.

Poster: 14
Compact Identification of Process Static Gain and One Point of Frequency Response
Mertl, J., Schlegel, M.
University of West Bohemia in Pilsen

The aim of this paper is to present a new process identification method suitable for automatic tuning of PID controllers. The method combines two experiments together. The first experiment is a process static gain identification and the second is a relay experiment which

identifies one point of the process frequency response. Moreover a constant-phase filter is used in the relay feedback loop to get a frequency response sample with phase shift different from -180 degrees. The constant-phase filter parameters are tuned during the first experiment part.

Poster: 15
The First Results of Systems Identification Methods for fMRI Data
Tauchmanová, J., Hromčík, M.
Czech Technical University in Prague

The main goal of this paper is using identification methods as a certain alternative to DCM analysis which detects the so-called intrinsic connections among selected brain areas. In recent years it has been shown that the similar problems, as there appear in fMRI area, are formulated in dynamic system identification and estimation tasks. The subspace identification methods were chosen for this identification procedure because they prove good results for MIMO (Multiple Input Multiple Output) systems identification. These methods produce state space description of identified system. The main part of this paper deals with the quality of identification results depending on some important data parameters. Consequently the processing of final state space description into more suitable form follows.

Poster: 16
Modelling of Evapotranspiration Field of Ecosystem
Hofreiter, M., Novák, M.
Czech Technical University in Prague

This paper deals with the modelling of evapotranspiration of ecosystems. It uses the Penman-Monteith method to estimate evapotranspiration and method based on the use of the Bowen ratio. The aim of the present article is to demonstrate the possibility of more precise methodology for modelling evapotranspiration and to display the evapotranspiration field when the measured data from meteorological stations are sup-plemented with the information in the form of infrared images of a monitored locality. This approach is demonstrated by the data observed in the selected ecosystem in the southern part of Bohemia. The infrared images of this locality were captured by infrared camera from a plane. The data processing and modelling of the evapotranspiration of the selected ecosystem was done using the Matlab programming environment. This article discusses the method of extraction information from infrared images and contains several images documenting the achieved results.

Poster: 17
On Stability Tests of Spatially Distributed Systems
Augusta, P.[1] *, Hurák, Z.*[2]
[1] Czech Academy of Sciences
[2] Czech Technical University in Prague

The paper describes tests of stability of spatially distributed shift-invariant systems discrete in both time and space. The systems are considered to be described by multivariate polynomial fractions, so, the tests based on manipulation with polynomials are taken into account. Methods of root maps and Schur-Cohn criterion are depicted and shown by means of examples. These methods originally formulated for systems with lumped parameters are used for multidimensional systems with support on a symmetric half-plane. At the end of the paper the problem of stability of multivariate polynomial is formulated as a problem of stability of interval polynomial. The problem is then solved using of Kharitonov's theorem.

Poster: 18
A Comparision of Different EKF Approaches for Parameters Estimation
Vörös, J., Mikleš, J., Čirka, Ľ.
Slovak University of Technology in Bratislava

In many chemical engineering applications the extended Kalman filter (EKF) is often used to deal with certain classes of nonlinear systems. This paper compares basic and polynomial approach of EKF for parameters estimation of nonlinear continuous-time stochastic systems. The proposed approaches are used to estimate constants k11 and k22 for interacting tank-in-series process and frequency factor k0 and temperature of reaction mixture theta for continuous stirred-tank reactor (CSTR).

Poster: 19
Mathematical Modelling and Identification of Thermal Plant
Jelenčiak, F.[1] *, Ťapák, P.*[2] *, Huba, M.*[3]
[1] FernUniversität in Hagen
[2] Slovak University of Technology in Bratislava
[3] STU in Bratislava, FernUniversität in Hagen

The paper discusses identification of the laboratory model of thermal-plant. Due to the presence of several non-linearities the non-linear model is used to describe the plant's dynamics. For the identification, recursive method of consecutive integral (RMOCI) is employed.

Poster: 20
Semi-Batch Reactor from the Control Theory View
Macků, L., Gazdoš, F.
Tomas Bata University in Zlin

The tannery is an essential industry process today. Its product is a natural hide. Some of the leather properties (such as softness, plasticity, stability, absorption) cannot be replaced by any artificial material. Currently, majority of a solid waste from the chromium tanning is land filled. This paper deals with an analysis of a semi-batch chemical reactor for chromium sludge (chromium filter cake) recovery. The reactor is used for the chromium filter cake (i.e. product of an enzymatic hydrolysis obtained from the chromium waste) processing and the analysis is performed from the control theory point of view by simulation means mainly to obtain useful information for sub-sequent optimal control design. A mathematical model of the system is derived and all variables are defined together with their physical values and limits. Further, steady-state and dynamical behaviour is studied by simulation means. Possible control strategies are discussed at the end of the contribution together with areas for possible future research.

Poster: 21
On Modeling and Identification of Systems with General Backlash
Vörös, J.
Slovak University of Technology in Bratislava

The notion of general backlash is introduced where instead of straight lines determining the upward and downward parts of backlash characteristic general curves are considered. An analytic form of general backlash characteristic description is proposed, which is based on appropriate switching and internal functions. Hence the multi-valued mapping is represented by one equation. All the parameters in the model equation describing this hard nonlinearity are separated; consequently their estimation can be solved as a quasi-linear problem using an iterative parameter estimation method with internal variable estimation.

Po-We-7
Posters: Industrial Automation

Poster: 22
New Implementation of the Mobile Ordering System
Matýsek, M.
Tomas Bata University in Zlin

The work goal was to create an effective tool for supplying companies sales representatives to make their activities easier and more effective. It represents the com-munication improvement and acceleration between the branch and the salesman, the lim-iting of human factor influence on the order processing regarding errors, the acceleration of order processing, live offer related to the stock inventory, and last but not least, the quicker information feed for the

customers and for salesmen.

Poster: 23
Generator of Actuating Signal for Linear Pneumatic Drives
Moučka, M.
Technical University of Liberec

The presented paper deals with application Visual Signal Generator /2, which is focused to generation of actuating signals for control of pneumatic linear unitist. There is insinuate way of operations with generator inclusive of way of using generated data in environment labVIEW from National Instruments. There are described equations of implemented actuating signals.

Poster: 24
Renovation of Control System of the Contour Cutter for EPS Cutting
Kopček, M., Strémy, M., Bezák, T., Eliáš, A.
Slovak University of Technology in Bratislava

Abstract: We are working on many projects within the cooperation with praxis. One such cooperation was the project of changing the contour cutter control system for cutting of expanded polystyrene (EPS) in PLASTIKA a.s. Nitra. The OEM was composed of hardware from different manufacturers; it was old and served out. For all that we decided to use CNC system Siemens SINUMERIK 802D sl as a new control system. The change was made in six weeks and consists of the delivery and assembly of the new servo - drives and control system. We have also made some custom solutions to fulfill the requirements of the customer e. g. 12 bit AD converter for speed control and 8 bit DA converter for temperature control. The cutter has three axes, where two of them are coupled. We solved this problem through a custom postscript, which postprocesses the cutting program. The working - out of the documentation and induction course for the staff was of course certainty. Since we have done our job the contour cutter has bigger memory (for storing the cutting programs), it has higher precision and more user friendly GUI. Using a simple CAM system we achieve full visual control during a cutting program creation, which makes the work for designers more comfortable. Furthermore we minimized the price as much as possible to achieve satisfaction on both sides - ours and customers.

Poster: 25
Simulation Based Performance Analysis of the Multi-product Manufacturing System
Švančara, J., Králová, Z.
Slovak University of Technology in Bratislava

The paper presents a case study on simulation modelling and analysis of the power supply production line in the factory Power-One Ltd. in Dubnica nad Váhom. Simulation technique is applied to evaluate the performance of the existing manufacturing system and to find the factors with significant impact on the overall performance of the system. The average total processing

time for the given set of production orders is used as criterion for comparison of possible variants. Then, a new system design is proposed to enhance the overall performance and is verified using a simulation model. The simulation system WITNESS is used for this study.

Po-We-8
Posters: Process Measurements and Devices

Poster: 26

On-Line Monitoring of Biopolymer Content in Bacterial Cells Using Radio-Frequency Impedance

Hrnčiřík, P., Vovsík, J., Jurníček, V., Náhlík, J.
Institute of Chemical Technology, Prague

This paper describes the implementation of a radio-frequency (RF) impedance-based sensor for on-line monitoring of a biopolymer - medium chain length poly(3-hydroxyalkanoates) (mcl-PHAs, shortly PHA) production process by the Pseudomonas putida KT2442 strain with emphasis on on-line in-situ monitoring of PHA content in bacterial cells. First, motivation for the application of the commercially available RF impedance-based sensor technology is presented. Subsequently, experimental results obtained from fed-batch cultivations of the Pseudomonas putida KT2442 strain are presented and discussed, and a novel scheme for on-line estimation of the PHA content in bacterial cells under the conditions of aerated cultivations combining the capacitance and offgas composition measurements is proposed.

Poster: 27

New Aspects of Small Electric Input Power Measurement

Skočík, P., Hruška, F.
Tomas Bata University in Zlin

The paper is focused on the small electric input power measurement for research and study of material machining. The requirement is to have the measurement with high accuracy and sensitivity. The commercial devices for measuring the electric input/output power are available only for wide ranges. Therefore, an analog device for electric input power measurement was developed. The new demand is to redesign the circuit for enhancing the sensitivity. Measurement of high electric input power values is changed to the measurement of their differences with reference value. The device consists of analog operational amplifiers and analog multiplier unit of effective electric current and voltage.

Poster: 28
Modelling and Design of Microflow Sensors Based on Measuring of Temperature
Adámek, M., Matýsek, M., Kodriková, K.
Tomas Bata University in Zlin

This article describes modelling and measurement of tiny liquid flows of the order of microlitres through mililitres per minute. The measurement of mentioned flow range is becoming more and more important for a lot of applications in the life science, analysis, biotechnologies, synthesis (of e.g. pharmaceuticals) and nanotechnology markets. Accompanying demands to flow sensors suited for this low flow range are an extremely small internal volume, the use of for instance PEEK and fused silica as wetted material for the flow sensor tube (instead of stainless steel), and a modular set-up of the instruments, so they can be easily exchanged and adapted to a new need.

Po-We-9
Posters: Intelligent Control Systems

Poster: 29
Neural-Fuzzy Control of Chemical Technological Processes
Blahová, L., Dvoran, J.
Slovak University of Technology in Bratislava

By continuous improvement of the intelligent control systems achieves more accurate values of the controlled parameters which lead to the more effective control, entirely. This paper presents the intelligent control system design via the combination of the predictive and the neural-fuzzy controller type of ANFIS. The neural-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 chemical reactor control problem. Experimental results confirmed control quality improvement in the combined controller over the original predictive and PID controller.

Poster: 30
Design of the Neural Model Structure Based on Genetic Algorithms
Sekaj, I.
Slovak University of Technology in Bratislava

Genetic algorithm based neural model structure design of a non-linear dynamic system is described. The genetic algorithm represents an optimisation procedure, where the cost function, which is minimized consists of the non-linear dynamic process neural model simulation and a selected performance index evaluation. Using this approach the neural model of the process has been optimised from point of view its internal architecture. A multilayer perceptron (MLP) artificial neural network has been used, where the training was realized by the Levenberg-Marquardt method.

Poster: 31

The Use of Matlab Parallel Computing Toolbox for Genetic Algorithm-Based MIMO Controller Design

Sekaj, I.
Slovak University of Technology in Bratislava

The paper describes the use of Matlab's Parallel Computing Toolbox for parallel genetic algorithm-based design of a MIMO controller. Parallel genetic algorithms (PGA) represents a stochastic optimization approach which is computed in more co-operating and interconnected computation nodes in a parallel mode. Each node of the PGA can be located on the same processor, on more processors or on more computers respectively. This approach is able to solve very complex search/optimization/design tasks, but on the other hand, it requires a high computation power. From that reason the distribution of computation complexity to more processors under Matlab environment is presented.

Le-Th-1
Lectures: Model Predictive Control

Ogonowski, Z., Veselý, V.

Time: 09:30

Output Feedback Model Predictive Control Design with Input Constraints

Veselý, V.
Slovak University of Technology in Bratislava

Abstract: The paper addresses the problem to design a quadratic stable output/state feedback model predictive control for linear systems with input constraints. In the proposed design technique the model predictive control is designed for N2 step ahead prediction using Lyapunov function approach with cost function guaranteing input constraints. Output gain matrix calculation is realized offline and through dynamic behavior with respect to quadratic stability of closed-loop system only modification of output gain matrix is realized to guarantee input constraints. Two examples are given to demonstrate the effectiveness of the proposed methods.

Time: 09:50

Constrained NMPC Using Polynomial Chaos Theory

Aliyev, T., Gatzke, E.
University of South Carolina

Establishing an accurate model of a multivariable nonlinear process with uncertain parameters can be difficult. Application of control methods based on nonlinear optimization may result in sub-optimal performance due to changes in the parameters. This paper presents a new control method to handle parametric uncertainty through incorporation of a Polynomial Chaos Theory (PCT) model used in a constrained Nonlinear Model Predictive Control (NMPC) formulation. Uncertain parameters are treated as random variables with a uniform distribution. PCT expresses the entire uncertain process by a complete and orthogonal Legendre polynomial basis in terms of random variables where expanded process outputs are determined by applying Galerkin projection onto the polynomial basis. NMPC formulation has the ability to apply hard input and soft output constraints to maintain the process within specified bounds. It is shown that the proposed formulation can be applied with an adequate tuning to minimize the effect of parametric uncertainty on the process outputs.

Time: 10:10

Real-Time Model Predictive Control of a Laboratory Liquid Tanks System

Rauová, I., Kvasnica, M., Čirka, Ľ., Fikar, M.
Slovak University of Technology in Bratislava

This paper deals with real-time implementation of Model Predictive Control (MPC) of a laboratory liquid tanks system using the dSPACE platform. The MPC problem is solved using parametric programming techniques, which allow closed-form solution to the underlying

optimization problem to be obtained off-line in a form of a look-up table. Once such a table is calculated, the subsequent implementation reduces to a simple set-membership test, which can be performed very efficiently on-line. In the paper we present a step-by-step description of all steps leading towards the derivation and implementation of such a controller for a laboratory device.

Time: 10:30
System Identification and Explicit Predictive Control of Cantilever Lateral Vibrations
Polóni, T., Takács, G., Kvasnica, M., Rohal'-Ilkiv, B.
Slovak University of Technology in Bratislava

The aim of this study is to investigate the efficiency of a explicit predictive control technique in the numerical simulation and experimental study of system identification of piezoelectric smart structure. A complete active vibration control system comprising the cantilever plate, the piezoelectric actuators, the laser sensor and the digital signal processor board is set up to conduct the experimental system identification. Based on the structure responses determined by measurement, an explicit first mode state space model of the equivalent linear system is developed by employing subspace identification approach. The multiparametric programming algorithm is employed for controller design. The control law is incorporated into the finite state space partitions to perform as closed loop controller. The control law performance is further evaluated in the context of a simulation.

Time: 11:10
Fast Linearization Algorithm for Predictive Control
Ogonowski, Z.
Silesian University of Technology

The applicability of nonlinear predictive control algorithms is limited by the necessity of on-line solving an optimization problem. Complexity follows from nonlinearity of the model and from the extension of the prediction horizon, which result in constrained non-convex optimization problem. The common heuristic simplification bases on linear approximation, well-known as successive linearization or linearization along prediction trajectory. However still, the control algorithm can be numerically to complex, especially in fast sampling cases, mainly because of linearization procedure.
The paper proposes a new and fast linearization algorithm using identification procedure. The non-linear noise-free model is assumed to be given. Impulse response of nonlinear model creates identification data and allows for flexible linearization where the vicinity of the operating point is discussed rather then point-sensitive linearization as in the standard procedures. There are two key-simplifications that makes the algorithm fast. The generic nonlinear model is usually given as time-continuous. The lack of the nonlinear discrete counterpart causes that the linearization has to be done first and discretization afterwards. The method proposed in the paper coupled these two operations. The second simplification comes from the Toeplitz-type of the matrix being inverted in the identification Least-Mean-Square algorithm. It is shown in the paper that

the number of matrix elements is reduced usually 4-5 times. Then fast algorithms can be used to invert the final general-Toeplitz matrix (e.g. Martinsson-Rokhlin-Tygert, 2005). The efficiency of the resulting algorithm is illustrated in the paper by comparison of the computation-time with standard linearization procedure, which bases on perturbation algorithm and discretizes obtained continuous-time linear model using modified scaling and squaring method.

Time: 11:30
Predictive Control of Pressure Swing Adsorption
Mulholland, M.[1] *, Latifi, M.A.*[2]
[1] University of KwaZulu-Natal
[2] LSGC - ENSIC Nancy

Pressure swing adsorption requires a repeated cycle of four steps. The periods of these steps, or other defined terminal conditions, determine the rate and quality of the product, and its cost. In transient situations such as upsets or grade changes, it is not intuitively obvious how the steps should be progressively altered to bring the plant to the desired operating point in an optimal fashion. The present work considers the problem of real-time maximisation of the production of a single adsorber, and maintaining a setpoint concentration in its product receiving vessel. In a modelling exercise, these objectives have been met using predictive control based on completion of the present step, plus two full future cycles to reduce the end-effect. The approach sought to be fast and robust by suitable linearisation of the system. This allowed MILP solution in the mixed logical dynamical (MLD) framework as a mixed integer dynamic optimisation (MIDO). However, this problem was ultimately solved faster and more reliably by testing all combinations for constraint violations and the objective value.

Time: 11:50
Real-Time Control of a Thermo-Optical Device Using Polynomial Approximation of MPC Scheme
Herceg, M., Kvasnica, M., Fikar, M., Čirka, Ľ.
Slovak University of Technology in Bratislava

This paper deals with real-time control of a thermo-optical device. A polynomial approximation of the optimal Model Predictive Control (MPC) feedback law is employed as a controller. Such an approximate controller enjoys the key benefits of MPC schemes, namely it provides all-time constraint satisfaction and closed-loop stability guarantees. The main advantage of the proposed approximation scheme is that it can be implemented in real time using very limited computational resources.

Le-Th-2
Lectures: Robust and Adaptive Control

Huba, M., Kozák, Š.

Time: 09:30

Robust Control Design for Thermo-Optical Plant UDAQ28/LT

Osuský, J., Hypiusová, M.
Slovak University of Technology in Bratislava

In this paper design of robust control for thermo-optical plant uDAQ28/LT is presented. Decentralized approach for controller design is used. For modeling real and complex perturbation input multiplicative uncertainty was applied and robust stability condition was derived in terms of the M-delta structure.

Time: 09:50

Adaptive Sliding-Mode Control of Nonlinear Systems Using Neural Network Approach

Schmid, C.
Ruhr-Universität Bochum

This paper is concerned with the adaptive sliding-mode control of nonlinear dynamic systems with model uncertainties. The proposed control method combines the advantages of sliding-mode control and backstepping methodology, such that the requirement of the restrictive matching condition is removed, which seriously clams the application of sliding-mode control. In the control scheme, networks of Gaussian radial basis functions with variable weights are used to compensate the model uncertainties. The adaptive law developed using the Lyapunov synthesis approach guarantees the stability of the control scheme. The performance is illustrated by experimental studies with a flexible-joint manipulator.

Time: 10:10

Robust Design of Integrating Controllers for IPDT Plant

Huba, M.
STU in Bratislava, FernUniversität in Hagen

This paper deals with robust tuning of the Integral Plus Dead Time plant (IPDT), whereby it compares results achieved by the analytical tuning of the PI controller guaranteeing triple real dominant pole with those achieved with P controller extended by disturbance observer (DOB) under robust tuning based on experimentally achieved regions of parameters corresponding to the one-pulse control.

Time: 10:30
Asymptotically Stable Control Design for Time-Delay Systems
Filasová, A., Krokavec, D.
Technical University of Kosice

The purpose of this paper is to present an improved version of time-delay system state feedback control methods and any extension over the one concerning the output and input variables constraint. Based on the standard Lyapunov-Krasovskii functional and norm-bounded constraints, delayed–independent stability condition is derived using linear matrix inequalities. The results obtained with a numerical example are presented to compare limitation in system structure for defined constraints. Since presented method is based on convex optimization techniques it is computationally very efficient.

Time: 11:10
Control of a Laboratory Chemical Reactor Using Robust PI Controller
Závacká, J., Bakošová, M., Vaneková, K.
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 (kp, ki)-plane. Then parameters of stabilizing PI controllers are determined. The designed robust PI controller is used for control of a laboratory chemical continuous stirred tank reactor Armfield PCT40. 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: 11:30
Tuning Decentralized Controllers for Robustness and Performance
Kozáková, A., Osuský, J., Veselý, V.
Slovak University of Technology in Bratislava

The paper presents a modification of the decentralized controller design technique for continuous-time systems (named "Equivalent Subsystems Method", ESM) proposed in (Kozáková and Veselý, 2003; 2007) and further developed towards securing robust stability and nominal performance (Kozáková and Veselý, 2005; 2006). The proposed design procedure combines the ESM with a subsequent detuning to fulfil the M-ïĄĎ structure robust stability conditions adapted for the decentralized control. Robust decentralized controllers designed for two real plants show practical applicability of the proposed design philosophy.

Time: 11:50
An Effective Robust Controller Algorithm Design
Kozák, Š., Cigánek, J.
Slovak University of Technology in Bratislava

The paper deals with the design of robust digital controller using advanced approach based on the reflection vectors techniques. Proposed robust algorithms were successfully verified on the case study examples for different dynamical processes. In this paper we demonstrate an application of theoretical principles to a robotic benchmark problem. Simulations were realized in MATLAB-Simulink systems. Obtained numerical and simulation results confirm applicability of the theoretical principles for robust control of processes subject to parametric model uncertainty.

Time: 12:10
Robust Control Design for LTI Systems with Reduced Conservatism
Rosinova, D., Veselý, V.
Slovak University of Technology in Bratislava

The novel robust stability condition is proposed, appropriate for the structured uncertain system matrix with constant part. This is the case when dynamic robust controller is designed (e.g. PID) and the augmented system includes both uncertain controlled system and fixed part respective to controller dynamics. The developed condition is generally less conservative than the ones from literature. The structured auxiliary matrices are used with parameter dependent part respective to fixed part of augmented system matrix, which reduces conservatism of the robust stability condition. The resulting robust control design method apply BMI solver on the proposed stability condition. The qualities of the method are illustrated on randomly generated examples.

Po-Th-3
Posters: Model Predictive Control

Poster: 1
Predictive Functional Control of Thermal Process with Dead Time
Mareš, J., Honc, D.
University of Pardubice

Paper deals with mathematical model of thermal process and its control by two different controllers. Firstly, the real system and mathematical model is briefly described. Two different controllers are designed afterwards. First of them is PID controller designed in empirical way by using Çžström-Hägglund method. The second one is simple predictive controller Predictive Functional Controller based on Richalet's principal.

Poster: 2
Hybrid Predictive Controller Based on Fuzzy-Neuro Model
Paulusová, J., Dúbravská, M.
Slovak University of Technology in Bratislava

Predictive control is a control strategy that is based on the prediction of the plant output over the extended horizon in the future, which enables the controller to predict future changes of the measurement signal and to base control actions on the prediction. In this paper a hybrid fuzzy-neuro model based predictive control is addressed, proposed and tested. The proposed hybrid fuzzy-neuro convolution model consists of a steady-state fuzzy-neuro model and a gain independent impulse response model. The proposed hybrid fuzzy-neuro convolution model can be considered as a gain-scheduled convolution model. This paper shows advantages of a combination of static nonlinearity and gain-independent dynamic part. The proposed model is tested in a model based predictive control scheme of the concentration control in the chemical reactor, manipulating its flow rate. The paper deals with theoretical and practical methodology, offering approach for intelligent fuzzy-neuro robust control design and its successful application.

Poster: 3
Fuzzy Logic Autotuning Methods for Predictive Controller
Paulusová, J., Dúbravská, M.
Slovak University of Technology in Bratislava

In this paper a new method for predictive auto-tuning PID fuzzy logic controller is proposed, analyzed and tested. The paper contains theoretical as well as practical part and offers a new approach to control design and its successful application. Firstly, identification of a process model and design of a conventional PID is necessary to be done as a starting point. After that, the fuzzy engine is designed. The gain and phase margins are considered to be linguistic variables whose values are defined with respect to the same universe of discourse specified by human expertise about the operational knowledge of the process. It is assumed that the feedback system gain and phase margins are in prescribed ranges. To achieve the objective of predictive control, the fuzzy model has been used as the process behaviour predictor. The proposed predictive controller is used to control nonlinear process. The results show that the proposed algorithm is capable of an effective control.

Poster: 4
Pulse-Step Model Predictive Controller for TITO system
Sobota, J., Schlegel, M.
University of West Bohemia in Pilsen

This paper describes a novel model based predictive controller with manipulated value constraints for TITO systems. Both amplitude and rate constraints are considered. It is assumed that the controlled system is stable, linear and t-invariant FIR system. Four discrete step response

sequences are used as the process model. Alternatively it is possible to use three-parameter models. To make the open-loop optimization easier the set of admissible control sequences is restricted to stepwise "pulse-step" sequences. The optimization procedure is then executable in reasonable time.

Poster: 5
Terminal State in a Predictive Controller Cost Function
Dušek, F., Honc, D.
University of Pardubice

In the paper, an impact of a terminal state in a cost function on predictive controller behaviour is discussed for case of a set point tracking task. Attention is paid to the form of the terminal state added to the cost function and its effect to stability and quality of a feedback control. A complete design procedure of the predictive controller based on the state space description of controlled system is shown. The controller design includes the terminal state in a form of deviation from a desired terminal state. The concept of the desired terminal state opens the way to involve additional demands into the controller design. The stabilization effect of the terminal state in case of short control horizon is demonstrated on simulated control examples of a non-minimum phase system (system with unstable zero). The effect of the terminal state on the control quality is discussed, too.

Poster: 6
Flight Recovery System
Hospodář, P., Hromčík, M.
Czech Technical University in Prague

Primary task of an automatic recovery system is to solve a situation when a pilot loses orientation. This space disorientation happens when there is a variance of angle position between what pilot thinks and real physical angle position of the airplane. This situation occurs firstly in case when the pilot cannot see the horizon (by low or zero visibility, during a night flight over monotonous terrain without distinct segmentation, when wrongly reading/failure of position indicators, with disturbance of the pilot and losing concentration under high pressure e.g.).

Poster: 7
Predictive Control Using Self-Tuning Model Predictive Controllers Library
Chalupa, P.
Tomas Bata University in Zlin

The paper is focused on a library of adaptive controllers which use model predictive control design. The Self-Tuning Model Predictive Controllers Library (STuMPCoL) has been designed in the MATLAB / Simulink environment and contains a framework for design and testing of Model predictive control approach combined with on-line identification of

controlled process (self-tuning control). The paper presents techniques incorporated into the STuMPCoL and describes structure of self-tunig model predictive controllers. Moreover, the contribution includes some results obtained by simulation and real-time verification of the library.

Poster: 8
Neural Network Predictive Control of a Chemical Reactor
Vasičkaninová, A., Bakošová, M.
Slovak University of Technology in Bratislava

Model Predictive Control (MPC) refers to a class of algorithms that compute a sequence of manipulated variable adjustments in order to optimize the future behaviour of a plant. MPC technology can now be found in a wide variety of application areas. The neural network predictive controller that is discussed in this paper uses a neural network model of a nonlinear plant to predict future plant performance. The controller calculates the control input that will optimize plant performance over a specified future time horizon. In the paper the neural network based predictive control for the continuous stirred tank reactor is presented.

Po-Th-4
Posters: Robust and Adaptive Control

Poster: 9
Decentralized Robust Control of Two Inputs - Two Outputs System
Macháček, J.
University of Pardubice

This paper deals with methods of decentralized control, for systems with two inputs and two outputs. Robust control methods were used for tuning of the decentralized controllers. The method considers diagonal transfer function as a nominal model and the coupling part as a model uncertainty. The set of possible controller parameters creates family of models, for which a robust controller was designed. Range of the possible controller parameters was derived on the basis of Palmor's method of decentralized control. The ultimate gain of the diagonal transfer functions may be taken as maximum values for all possible controllers and difference between ultimate frequencies gives the range all possible ultimate frequencies used for controllers design. Approximation models are obtained experimentally by two relay autotuning experiments. Controllers are designed on the basis of common condition for robust stability and robust performance. The method was tested in MATLAB/Simulink first for accurate model and then for approximate model. The parameters of controllers as well as the time responses of approximate models did not too differ from accurate model. Advantage this method is in shorter experimental work in comparison with the classic Palmor's method, as only two relay experiment is claimed instead of several iterations. The results of simulation show, that responses are slower with smaller overshoots. The work has been supported by the grant agency MSM 002 162 7505. This support is very gratefully acknowledged.

Poster: 10
Reinforcement Learning Parameterization: Softmax Between Exploration and Exploation
Macek, K.
Czech Technical University in Prague

Control in dynamic systems stands for a complex task with respect to changing conditions, nonlinear dependencies and time delays. One of tools of online optimization of control parameters is reinforcement learning. Present paper deals with its application in PID parameters optimization and examines the most appropriate parameterization of softmax selection mechanism.

Poster: 11
Robust PI and PID Stabilization of a Chemical Reactor
Bakošová, M., Puna, D., Vasičkaninová, A., Karšaiová, M.
Slovak University of Technology in Bratislava

Possibility to stabilize open-loop unstable processes using robust static output feedback controllers was studied. The non-iterative algorithm based on solving of linear matrix inequalities was used for design of robust PID like controllers. The design procedure guarantees with sufficient conditions the closed-loop robust quadratic stability and the guaranteed cost of control. Possibility to use robust PI and PID controllers for stabilization of a continuous stirred tank reactor was verified by simulations. Considered reactor with one first order exothermic reaction had two uncertain parameters: reaction rate constant and the reaction enthalpy. Furthermore, the reactor had multiple steady states and it was stabilized in the surroundings of its open-loop unstable steady state.
The results confirmed that the presented simple non-iterative algorithm based on solving of two sets of LMIs is an effective tool for the design of robust stabilizing controllers. Its advantage is that it can be used for P, PI and PID controller design. Robust static output feedback PI or PID controllers can be successfully used for control of CSTRs with multiple steady states, uncertainties and disturbances, even though CSTRs are very complicated systems from the control viewpoint. Both, PI and PID controllers are able to stabilize the open-loop unstable processes and their advantage in comparison with the robust P controller is that they do not retain offsets. The disadvantage of PID controllers is their more complicated implementation and they are not suitable for using in the presence of noise.

Poster: 12
One-Step Active Controller with Dual Properties
Rathouský, J., Havlena, V., Štecha, J.
Czech Technical University in Prague

In stochastic adaptive control, the controller that achieves required control performance and keeps gathering information about the system at the same time, is referred to as a controller

with dual properties. As the optimal dual controller is computationally intractable, approximations of the optimal problem are searched. In this paper we propose a control strategy for ARX systems with dual properties. This active control strategy is based on the well known cautious strategy, but takes the quality of identification in one step ahead into consideration. This strategy shows how to improve control performance mainly in cases when the initial uncertainty in system parameters is large.

Po-Th-5
Posters: Applications and Case Studies

Poster: 13
Control of TISO Process - Thermostatic Bath Case Study
Králová, J., Honc, D.
University of Pardubice

The paper is aimed on problematic of multivariable control. Multivariable system can be controlled by multivariable controller or we can use distributed control scheme. Control of thermal system with two inputs and one output is shown in the paper. The system is controlled by two on-off controllers, two PID controllers, split range and PID controller and by static compensator and PID controller. Control strategies are compared in the view of control quality and costs, information and knowledge required by control design and application.

Poster: 14
Application of Output Tracking for DC Motor with Flexible Shaft
Švejda, M.
University of West Bohemia in Pilsen

The paper deals with the application of the output tracking method for the controlled system pepresented by the DC motor with a flexible shaft. The proposed output tracking method uses the known results of the state coordinate transformation and tracking convergence for an integrator chain. The control law is designed in such a way that ensures the tracking error to converge to zero exponentially. The robustness of the proposed method is discussed. At last, the simulation results are presented for the controlled system without uncertainties and for the perturbed controlled system with one unknown parameter of the flexible shaft.

Poster: 15
Conception of Hydraulic Tandem Control for Artificial Dumper Chamber
Kolaja, J.
Technical University of Liberec

The subject of this article is to show conception of hydraulic tandem drive when two different linear fluid engines work together. This cooperation is necessary to provide accurate

forces for one of the project scoping liquid's behaviour in fluid damper by artificial dumper chamber where damper's valve is flown by liquid which is moved by model of hydraulic drive. First experiments have been done on system with one linear hydraulic drive but one piston has appeared not to be strong enough to act on the system by proper power.

Po-Th-6
Posters: Control Education

Poster: 16

Modelling and PID Control Design of Nonlinear Educational Model Ball & Plate

Jadlovská, A., Jajčišin, Š., Lonščák, R.
Technical University of Kosice

This paper is focused on modelling and control of nonlinear dynamical system Ball & Plate in language Matlab/Simulink. PID/PSD controller is used in closed loop feedback control structure for the purpose of control. The verification of designed PID control algorithms, the same as nonlinear model of dynamical system, is performed with functional blocks of Simulink environment. This paper includes testing of designed PID control algorithms on real model Ball & Plate using multifunction I/O card MF 614, which communicates with PC by the functions of Real Time Toolbox. Visualization of the simulation results is realized by internet applications, which use Matlab Web Server.

Poster: 17

An Embedded Multifunction Board for Automatic Control Applications

Ježek, O., Balda, P.
University of West Bohemia in Pilsen

This paper describes basic features of an universal embedded board developed in our university. After a brief summarization of the board hardware design, the paper focuses on presented software architecture solution. The modular firmware structure based on input/output driver model and a real time operating system (FreeRTOS in our case) is explained and the usage of the software development kit (SDK) plugged-in the Eclipse development platform is shown. Moreover, a recently developed technique for automatic generation of advanced control algoritms has been ported to this platform. This technique called MicroREX is based on the Micro RexLib function block library. Software generation is demonstrated on two examples.

Poster: 18
A New Technique for Automatic Generation of Java Applets for Web-based Control Education
Čech, M., Balda, P.
University of West Bohemia in Pilsen

The paper presents a new technique for automatic generation of Java source code for complex control algorithms simulation. The algorithms can be designed in graphical form either in Simulink model editor or in RexDraw, the graphical editor of the REX control system.The designed models are used for generation of Java source code files, which can be easily accomplished by graphical user interfaces and further used in both standalone Java applications and Java applets embedded into web pages. The proposed methodology can speed up the development of interactive control education tools because it interconnects Java with simulation and real-time domain. It is demonstrated on a closed loop simulation example using Pulse-step predictive controller and compared to earlier manual procedure.

Poster: 19
The Use of Virtualization in the IT Courses
Vojtěšek, J., Matušů, R., Bližňák, M.
Tomas Bata University in Zlin

This article presents virtualization as one of the effective teaching and training tool in the university courses connected to IT problems. However, applications of the virtualization can be found in many other areas, not only in IT. The case study is based on the idea of virtualization of the physical computer for lower costs and security reasons. The VMware products are used nowadays in our university and the article want to show other, especially free, alternatives to this commercial product like VirtualBox, Microsoft Virtual PC, XEN etc. Presented results provides conclusions focused mainly on the performance of the virtual computers.

Poster: 20
Virtual and Remote Laboratories Based on Matlab, Java and EJS
Bisták, P.
Slovak University of Technology in Bratislava

Online learning becomes more active and virtual and remote laboratories have significant contribution to this process. They are growing with expansion of Internet. The paper will describe basic characteristics of virtual and remote laboratories suited for education of control engineers and will give recommendations how to build such laboratories. Their design is based on a Java client server application and the Matlab/Simulink software package. Also the special case when the control algorithm is computed at the client side is considered. The Easy Java Simulations (Ejs) free software package is briefly mentioned in order to create the client interface rapidly and comfortably.

Poster: 21
Remote Control of Real Equipment Models Through Programmable Controller
Sysala, T., Navrátil, P., Sobolík, M.
Tomas Bata University in Zlin

The paper is focused on description of remote control of laboratory models that are used in the process of education at our faculty. The models are connected to programmable logical controller (PLC) and through this equipment the models are controlled. There is explained process of building one of the models. As the first step the students have to connect the model to a PLC. The PLC Saia is used, the product Saia Burgess Company. With that they have to make a program to the model control and they must verify its functionality. The last step is the visualization of the process control in some commercial SCADA/HMI systems. There are also described possibilities of remote control in the paper. It is possible to control the model through serial interface RS232, RS485, Internet or Intranet interface or through GSM mobile net. Examples of all these cases are presented in this contribution.

Po-Th-7
Posters: MATLAB Computing and Toolboxes

Poster: 22
Recursive Identification Algorithms Library
Navrátil, P., Bobál, V.
Tomas Bata University in Zlin

This paper presents simple SIMULINK library for recursive parameter estimation of linear dynamic models ARX, ARMAX and OE. Several recursive identification methods were implemented in this library: Least Square Method (RLS), Recursive Leaky Incremental Estimation (RLIE), Damped Least Squares (DLS), Adaptive Control with Selective Memory (ACSM), Instrumental Variable Method (RIV), Extended Least Square Method (RELS), Prediction Error Method (RPEM) and Extended Instrumental Variable Method (ERIV). To cope with tracking the time-variant parameters several forgetting factor and modification of basic algorithm are taken into consideration.

Poster: 23
Software for PID Controller Tuning
Bakošová, M., Oravec, J.
Slovak University of Technology in Bratislava

Software for PID controller tuning PIDTOOL 1.0 was developed in the MATLAB - Simulink programming environment using its graphic user interface. The main aim of the PIDTOOL design was creating user friendly tool for simple and fast identification from data measured on

the controlled process as well as for simple and fast PID controller tuning. The controlled system is identified from its step response in the form of the 1st order transfer function or in the form of the transfer function of the higher order. PID controllers are tuned using various experimental methods. The PIDTOOL properties determine its using especially for teaching purposes. The software is nowadays used for teaching at the IIEAM FCFT STU in courses oriented on process control.

Po-Th-8
Posters: Algorithms and Computing for Control

Poster: 24
Program for Analysis of Residua
Javůrek, M.
University of Pardubice

At present, the evaluation of experimental data by means of regression methods represents one of most frequently adopted procedures thanks to large expansion of computer technology. There exist a number of professional algorithms that perform regression calculations of various functions with application of many known methods. However, the calculation results need to be additionally verified, i.e. it must be stated whether or not the solution found is sufficiently correct and accurate. For this purpose a significant tool is the analysis of residua, but this analysis is often omitted even in commercial algorithms. Therefore, a subroutine REZID was assembled: it tests the obtained set of residua by numerical and some graphical methods. The subroutine was designed mainly for use with the program set SPONA [LUKŠAN, 1982 and 1987], which is why it was written in FORTRAN 77 language.

Poster: 25
Application of Designed Program Modules in C# Language for Simulation of Models of Dynamic Systems
Jadlovská, A., Dolinský, K., Lonščák, R.
Technical University of Kosice

The purpose of this paper is to give a brief illustration of possibilities of programing language C# in field of modeling and classical control theory. We describe implementation of algorithms that perform transformation of continuous linear dynamic systems into their discrete equvivalents, continuous PID control into its discrete form and employ these algorithms in discrete closed loop control. We also show how implemented numerical methods can be used to solve systems of differential equations which are used in modeling of nonlinear dynamic systems. All required related functions are implemented and integrated into program modules which are used together in two similar applications designed to simulate control of linear and nonlinear dynamic system Ball & Plate thus verifying robustness of the PID controllers.

Poster: 26

Robots Control by Means of Object Oriented Technology

Šťastný, J., Motyčka, A.
Mendel University of Brno

The paper deals with problems of the industrial robots control on a trajectory given with a view to the 6-axial anthropomorphic robots. The control program which has been created by means of modern object oriented technology applied to the design and implementation of the program data structure and to the chosen vector method in the calculation of an inverse kinematics problem. The principles and algorithms given below have been used in an application that was developed at Brno University of Technology and Mendel University in Brno.

Pl-Fr-1
Plenary lecture
Fikar, M.

Time: 08:45
Online Optimizing Control: the Link Between Plant Economics and Process Control
Engell, S.
Technische Universität Dortmund

In chemical process operation, the purpose of control is to achieve optimal process operation despite the presence of significant uncertainty about the plant behavior and distur-bances. Tracking of set-points is often required for lower level control loops, but on the process level in most cases this is not the primary concern and may even be counterproductive. In this survey, different approaches how to realize optimal process operation by feedback control are reviewed. The emphasis is on direct online optimizing control by optimizing an economic cost criterion online over a finite horizon where the usual control specifications in terms of e.g. product purities enter as constraints and not as set-points. The potential of this approach is demonstrated by its application to a complex process which combines a chemical reaction with chromatographic separation. Issues for further research are outlined in the final part.

Le-Fr-2
Lectures: Control Education
Schmid, C

Time: 09:30
About Grid Supported Learning Environments and Collaborative Virtual Control Laboratories
Schmid, C.
Ruhr-Universität Bochum

In this paper, grid technologies are introduced to build e-learning environments for virtual laboratories to be used in control education. Service-oriented grids open new fields of applications, the Learning Grids. The learning services concept and their deployment through grid technologies are excellent means to integrate virtual laboratories into collaborative e-learning environments for control engineering education. An introduction into this area, a review of the grid techniques and example applications from a virtual laboratory demonstrate grid based solutions.

Time: 09:50
Some Experience in Teaching of Computer Aided Process Simulation at PICT
Požívil, J., Hanta, V.
Institute of Chemical Technology, Prague

Analysis and design of chemical technological processes is faster and more effective when using simulations. That is why knowledge of chemical process simulation is an important part of study at Prague Institute of Chemical Technology. The Computer Assisted Process Simulation course is relatively popular among students. But it does not mean that its teaching is without problems. In this contribution some experience in teaching of Computer Aided Process Simulation is introduced. Some difficulties associated with the bidirectional flow of information, with the simulation of recycle systems and with the use of subflowsheets are described and illustrated with examples.

Time: 10:10
A Contribution to Remote Control of Thermo-optical Plant
Kohút, M., Žáková, K.
Slovak University of Technology in Bratislava

The paper is focused on a thermo-optical plant that is used for experimental work at Faculty of Electrical Engineering and Information Technology STU in Bratislava. Our attention was dedicated to one approach of its remote control. Java client-server application was created that enables to connect the graphical user interface with the Matlab engine running on the server.

Le-Fr-3
Lectures: Modelling, Simulation, and Identification of Processes
Kvasnica, M.

Time: 09:30
Modeling and Control of Thermal Plant
Ťapák, P.[1] *, Huba, M.*[2]
[1] Slovak University of Technology in Bratislava
[2] STU in Bratislava, FernUniversität in Hagen

The aim of this paper is to analyze the efficiency of rising the order of the linear model in modeling thermal plant. Results achieved both in identification and control are compared by considering 1st, 2nd and 3rd order plant models. For each model the most appropriate controller is evaluated by simulation and real time control. The simulations and the real experiment results are compared to determine which one is more appropriate to describe the plants dynamics.

Time: 09:50
Qualitative Modeling and Data Mining In the Monitoring of the Selected Ecosystem
Bíla, J., Jura, J.
Czech Technical University in Prague

The Trebon region in the South Bohemia is known with its picturesque landscape and with its ponds. However the Trebon ecosystem is violated by continuous parasitic dehumidifying and dehydrating which attacks the Small Water Cycle (SWC). In our mentioned ecosystem is evaporated water quickly brought up in the zone in which does not condense yet and in this height zone is transported outside the ecosystem to distanced mountains where spontaneously condenses in rising air streams. As a basic reason of these facts are usually introduced two phenomena:

- The overheating of the air above landscape surface as a result of the solar radiation phenomena on the extensive reflex areas (corn fields, roofs of towns, etc.).
- The increased transport velocity in non condensation zone.

Seemed to be, that the extension of vegetation fields (that makes evaporation slower) and the decrease of reflex areas surface (that will be rather difficult in towns), could be sufficient for improvement the situation. The proposed paper that belongs to the project (Pokorný et al. 2008), deals with another possible ways yet. (The goals of the project (Pokorný et al. 2008) are concentrated on the description of the energy flows and on the development of biodiversity in the ecosystem.)
The paper proposes two data mining methods used for modeling and monitoring of the selected ecosystems. The first method works with qualitative state diagram and leads to the detection of unexpected situations (Bíla and Jura 2007). The second method extracts the matroid structure on the set of states and works with implications from matroid bases. The methodology is developed with data support of a real ecosystem. The frame structure of the measurement centers network and the associated structure of the system database is introduced.
Key references:
[1] Pokorný, J., Jirka, V., Pechar, L., Bíla, J., Jura, J., Hofreiter, M., Petrová, R., Zicha, J., Kobrzek F. and Mareček, J. (2008). Partial Report to project 2B 06023, MSMT, Czech Republic.
[2] Bila J. and Jura, J. (2007). Fuzzy Concepts in the Detection of Unexpected Situations. Acta Polytechnica. Vol. 47, No.1. pp. 5-8.

Time: 10:10
Input Shaping Filters for the Control of Electrical Drive with Flexible Load
Goubej, M., Škarda, R., Schlegel, M.
University of West Bohemia in Pilsen

This paper deals with control of flexible mechanical systems. The goal is to modify the input signal in order to minimize the residual vibrations excited during a motion of a system with flexible parts. The filter is designed in the time domain via impulse function analysis. Possible application of the proposed solution is demonstrated on two examples of flexible system - control

of a crane with hanging load and an electrical servo drive with attached flexible shaft. The effect of nonlinearities in the signal path caused by saturation of the servo loop controllers is studied. Various possibilities for the placement of the filter are discussed.

Time: 10:30
UniSim Design and Refinery Unit Modeling
Longauerová, M.[1] *, Niedoba, P.*[2]
[1] Honeywell
[2] Honeywell Process Solutions

The UniSim Design Suite is part of Honeywell simulation software rigorous modeling of the processes. The oil and gas production, gas processing, petroleum refining and chemicals industries must optimize their process designs to achieve more reliable and stable operations. Optimum designs must be quickly identified with minimum risk of rework so that companies remain competitive and maximize their business performance. Process engineers are challenged with making timely business decisions while meeting the business objectives of designing and operating efficient, safe and profitable plants. Process modeling is a powerful technology that enables decision makers and engineers to link critical business objectives to process design, thus enabling true plant lifecycle modeling.

Le-Fr-4
Lectures: Applications and Case Studies
Belov, A.

Time: 11:00
Longitudinal H_∞ Reduced Order Flight Control
Belov, A.
Russian Academy of Sciences

This paper presents the solution for longitudinal flight control problem in a windshear by means of H_infinity-suboptimal controller of given order. The control aims at minimizing transfer function H_infinity norm between wind disturbance and aircraft airspeed and altitude. Comparison of H_infinity-suboptimal reduced order controllers of closed-loop system simulation results is carried out.

Time: 11:20
Aspects of Signal Condition from DC Bridge Circuits
Hruška, F., Lkhagvatseren, T.
Tomas Bata University in Zlin

Sensors based on the variation of the electric resistance are very common. There are many mechanisms that can modify the electric resistance of a material and also many signal conditions

for resistive sensors. However, Wheatstone bridge measurement method is often used to measure unknown electrical resistance. This paper examined with the application of signal condition for very small change of resistance. The tests were performed by a model with deformation unit which consists of two semiconductor strain gauges situated in two axes . The outputs of bridges are connected into new special circuits which are distinguishable from operational and instrumental amplifier. The results according to the accuracy and uncertainty are played very positive quality for instrumentation amplifier. There is advantage to use only one am-plifier and only one resistor as extern element for amplifying in the range from 1 to 10000 with minimum offset and temperature drift. The survey confirmed that high accuracy, stability and minimal uncertainty of bridge circuit measurement is with instrumental amplifier and the circuit is very suitable as an intermediate stage between sensors and analogue inputs for microcontrollers

Time: 11:40
Robust Control of a Laboratory Process
Vaneková, K.[1] *, Bakošová, M.*[1] *, Matušů, R.*[2] *, Závacká, J.*[1]
[1] Slovak University of Technology in Bratislava
[2] Tomas Bata University in Zlin

The paper presents robust control of a laboratory transport delay process using the industrial control system SIMATIC. Due to varying transport delay the laboratory process is modeled as a system with interval parametric uncertainty. The process is identified in the form of a transfer function. The Taylor expansion of the transport delay term leads to interval polynomials. Robust PI controllers are designed for the laboratory process. The robust synthesis method is based on plotting the stability boundary locus in the (kp, ki) - plane and the subsequent choice of a stabilizing PI controller using the pole-placement method so that the prescribed quality of control is achieved.

Time: 12:00
Design of an Experimental Workbench for Testing of Control Approaches on a Spark Ignition Combustion Engine
Honek, M., Csambal, J., Kopačka, M., Rohal'-Ilkiv, B.
Slovak University of Technology in Bratislava

The following document describes a design and a build-up of a workbench dedicated for implementation of different control approaches on a four-stroke spark ignition engine. It consists of a host PC, target hardware with high computational power able to execute real-time applications for control of a combustion engine and an engine itself. Aim of this activity is to have a fully programmable control system, which offers to a user implementation of different control approaches and algorithms. This allows to unstick from the standard look-up table control of todays' engines and implement into the control advanced predictive or robust algorithms. Result of this effort should be better control of engines with increased power and decreased fuel consumption and emissions of CO, CHx and NOx in exhaust gasses.

Le-Fr-5
Lectures: Algorithms and Computing for Control
Kotta, Ü.

Time: 11:00
WebMathematica Based Tools for Continuous-Time Nonlinear Control Systems
Tőnso, M., Rennik, H., Belikov, J., Kotta, Ü.
Tallinn University of Technology

The package NLControl, developed in the Institute of Cybernetics at Tallinn University of Technology within Mathematica environment, has been made partially available over the internet using webMathematica tools. The package consists of functions that assist the solution of different modeling, analysis and synthesis problems for nonlinear control systems, described either by state or by input-output equations. This paper focuses on describing the webMathematica-based tools for continuous-time nonlinear control systems.

Time: 11:20
TCP/IP Output from the Simulink
Sysel, M.
Tomas Bata University in Zlin

This paper describes an option for TCP/IP output from the program MATLAB/Simulink. The new developed Simulink block and instructions for building this one are described here. This client block enables Simulink models to communicate with remote applications and devices over TCP/IP communications. A very similar functionality (more complex) is provided by the TCP/IP block in the Instrument Con-trol Toolbox offered by MathWorks.

Time: 11:40
Target-Oriented Fuzzy-Collision-Avoidance for Vehicles
Warias, R., Gerke, M.
FernUniversität in Hagen

Autonomous mobile systems (AMS) mostly navigate on paths created by global path planners. But due to often appearing unforeseen objects the AMS needs a local collision avoidance (LCA) which takes over control functions and guides the AMS around obstacles. Mostly this maneuver results in leaving the preplanned path. Unfortunately it is possible that the AMS cannot find back to the precomputed path because the obstacles' arrangement is too complex. Therefore it is useful to equip the LCA with a target-oriented component during collision avoidance in order to guide the AMS back to the precomputed path. Our approach realizes a fuzzy-based LCA using direct sensor information to generate a steering angle. The results of our examinations show, that the AMS successfully reaches the target-point in most of the cases; with-

out any global path planning, only with the means of fuzzy logic and a target-oriented component.

Time: 12:00
A Neuro-Fuzzy Controller for a Trajectory Following Mobile Robot
Masar, I., Gerke, M.
FernUniversität in Hagen

The design of a motion controller for a mobile robot can be a very difficult and tedious task, especially for robots with a complex kinematic structure. Even though several types of motion controllers have been proposed in literature, they are not always applicable on car-like mobile robots equipped with conventional steering wheels. The reason is, that it is generally not possible to derive an inverse kinematic model for such robots. In this paper, a self-tuning intelligent controller for a quasi-omnidirectional mobile robot is presented. The controller is used to control the robot following a desired trajectory. It is implemented as a neuro-fuzzy controller, which can adapt its parameters by a self-learning process in such manner, that the mobile robot can follow a desired trajectory with required accuracy and speed. The process of tuning controller parameters tuning is demonstrated on experiments with a quasi-omnidirectional mobile robot F.A.A.K.

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