SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

INSTITUTE OF INFORMATION ENGINEERING, AUTOMATION AND MATHEMATICS

DEPARTMENT OF INFORMATION ENGINEERING AND PROCESS CONTROL

ANNUAL REPORT

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CONTENTS

I PREFACE

Department of Information Engineering and Process Control has at the Faculty of Chemical and Food Technology of the Slovak University of Technology in Bratislava more than forty-year tradition. In the frame of the bachelor study program Information Engineering, Automation and Management in Chemical and Food Industry and the master study program Information Engineering and Automation in Chemical and Food Industry, it educates high-qualified specialists in the field of process control for design, implementation and processing of control systems.

Nowadays, information technologies and process control with using microprocessor based control technique represent important and acknowledged scientific branches. These branches more and more influence the economic and social growth in the whole world and successively also in Slovakia. The chemical, food and pharmaceutical industries with their technologies are no exceptions. No technology is able to be successful in the competition without optimisation and advanced control systems or without using information technologies. In the connection with these facts, all our graduates have found their jobs without problems during the whole history of the department. It confirms also, that the education of the specialists in the information engineering and process control has been very attractive and its significance is even growing. The graduates of the department do well not only in the companies and institutions oriented on design and supplying of control systems for various technologies but also in the bank sector and they found their own firms respectively.

Teaching and research activities of the department are oriented on process control, identification and modelling of systems, adaptive control, construction and testing of measuring devices and equipment, and on development of software packages for intelligent control systems. Second branch is devoted to information technologies, data management, and Internet programming.

Prof. Dr. Ing. Miroslav Fikar

II INTRODUCTION

This report summarizes the teaching and research activities at the Department of Information Engineering and Process Control at the Faculty of Chemical and Food Technology at the Slovak University of Technology in Bratislava during the period 1 January – 31 December 2008.

Department of Information Engineering and Process Control of the FCFT STU in Bratislava was constituted from the Department of Measuring and Control Technique of the Faculty of Electrical Engineering of the Slovak University of Technology in Bratislava in 1962. Because of the specific control problems of the processes and systems in the chemical and biochemical technologies, the specialization Process Control in the frame of the study branch Chemical Engineering and Process Control has been established. Students and postgraduate students have been educated since 1964. So far, more than four hundreds specialists and almost thirty PhD students have been graduated here and three professors and nine associated professors have been appointed. Since 2005, Department of Information Engineering and Process Control and Department of Mathematics have formed Institute of Information Engineering, Automation, and Mathematics.

The first head of the department was Prof. Daniel Chmúrny, PhD, DSc in 1962 – 1986. Prof. Ján Mikleš, PhD, DSc headed the department in 1986 – 1994 and in 1998 – 2003. The head in 1995 – 1997 was Assoc. Prof. Alojz Mészáros, PhD and Prof. Dr. Ing. Miroslav Fikar has headed the department since 2003.

Department of Information Engineering and Process Control is one of the 22 departments at the FCFT STU, where students obtain specialization in various branches of chemical technology or chemical engineering. Approximately 1000 students are currently enrolled in the three-year bachelor programs leading to the Bc. degree and two-year master programs leading to the Ing. degree, which is equivalent to the MS degree. The best of them continue in the four-year doctor programs leading to the PhD degree. Three study programs are guaranteed by the Department of Information Engineering and Process Control: bachelor study program Information Engineering, Automation and Management in Chemical and Food Industry, master study program Information Engineering and Automation in Chemical and Food Industry and PhD study program Process Control.

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IV TEACHING AND RESEARCH LABORATORIES

IV.1 Teaching Laboratories

Laboratory of Process Control
Laboratory of Control Systems
Computer Laboratory (PC - Windows, Linux)
Computer Laboratory (Solaris)

IV.2 Research Laboratories

Laboratory of Control Theory
Laboratory of Modelling and Simulation
Laboratory of Identification
Laboratory of Optimisation
Laboratory of Neural Networks
Laboratory of Fuzzy Control and Expert Systems
Laboratory of Chemical Reactor Analysis and Control
Laboratory of Biochemical Process Analysis and Control
Laboratory of Distillation Column Analysis and Control
Laboratory of Computer Aided Design (Siemens-SIMATIC S-7 300, FOXBORO, Yokogawa, dSPACE, MATLAB/Simulink)

V. EDUCATIONAL ACTIVITIES

V.1 Bachelor Study

2nd semester (spring)

Computer Based Data Processing	0/0/2	Karšaiová, Vaneková
Optimisation	3/3/0	Dvoran, Blahová

4th semester (spring)

Modelling	2/3/0	Bakošová, Karšaiová, Vasičkaninová, Závacká
Operating Systems	1/2/0	Fikar, Podmajerský

5th semester (autumn)

Process Control	2/0/0	Fikar
Laboratory Exercises of Process Control	0/0/2	Karšaiová, Vasičkaninová, Závacká
Design of Information and Control Systems	2/3/0	Kvasnica, Vöröš

6th semester (spring)

Automatic Control Fundamentals	2/0/0	Bakošová
Laboratory Exercises of Automatic Control Fundamentals	0/0/2	Bakošová, Karšaiová
Bachelor projects	0/0/9	Bakošová, Čirka, Fikar, Hirmajer, Kvasnica, Mikleš, Vaneková, Vasičkaninová, Vöröš, Závacká
Process Control	2/0/0	Bakošová
Laboratory Exercises of Process Control	0/0/2	Bakošová, Karšaiová, Vasičkaninová, Závacká
Computer Based Data Processing	0/0/2	Čirka

Integrated Control in Process Engineering	2/0/3	Mikleš, Kvasnica, Vöröš
Information Engineering and Systems	1/2/0	Čirka
Laboratory Exercises of Information Engineering and Systems	0/0/2	Čirka

V.2 Master Study

1st semester (autumn)

Automatic Control Theory I	3/0/2	Mészáros, Herceg, Podmajerský
Process Dynamics and Control	2/1/0	Bakošová, Karšaiová
Modelling in Process Industries	2/0/2	Bakošová, Karšaiová
Technical Means of Automation	2/0/2	Juhás
Programming of Network Application	1/0/2	Čirka
Semestral project	0/0/3	Bakošová, Čirka, Fikar, Kvasnica, Vaneková, Vasičkaninová, Závacká

2nd semester (spring)

Optimisation	2/0/1	Dvoran
Control Theory I	2/0/2	Čirka, Mikleš
Laboratory Exercises of Control Theory I	0/0/2	Mikleš
Experimental Identification	2/0/0	Fikar
Laboratory Project II	0/0/6	Čirka, Dvoran, Vaneková
Modelling and Control of Polymerization Processes	2/0/2	Dvoran

3rd semester (autumn)

Control Theory II	2/0/0	Mészáros
Laboratory Exercises of Control Theory II	0/0/2	Mészáros
Intelligent Control Systems	2/0/0	Dvoran
CAD Systems	2/0/0	Karšaiová
Semestral Project	0/0/8	Čirka, Dvoran, Karšaiová, Vaneková
Industrial Applications of Process Control	2/0/0	Vaneková
Control of Technological Processes	1/0/2	Bakošová, Vasičkaninová

4th semester (spring)

Diploma Thesis	0/0/27	Čirka, Fikar, Vaneková, Kvasnica

V.3 PhD Study

1st semester (autumn)

Control Theory (Selected topics)	4/0/0	Mészáros

2nd semester (spring)

Control Theory II (Selected topics)	2/0/0	Mikleš

3rd semester (autumn)

Modelling and Control of Chemical Processes	2/0/0	Bakošová
Identification of Dynamic Systems	2/0/0	Fikar
Intelligent Control Systems	2/0/0	Dvoran

V.4 Course contents

V.4.1 Lectures in Bachelor study

Optimisation (3h/week, 2nd semester)

Static optimisation, classification of problems, goal functions, boundaries. Extremum without boundaries – analytical methods. Single-dimensional case, multi-dimensional case, Hess matrix. Conditions for extremum. Extremum with boundaries – linear boundaries, direct method, method of Lagrange multipliers. Extremum with boundaries – nonlinear boundaries, Kuhn – Tucker theorem. Non-gradient methods – Box-Wilson method, flexible simplex method, method of cyclic exchange of parameters. Gradient methods – Regula falsi method, Newton method, Broyde method, DFP method, PARTAN method. Convergence of gradient methods.

Modelling (2h/week, 4th semester)

Fundamentals of chemical process modelling and simulation. Linear and nonlinear state-space models. Mathematical models of selected chemical processes with lumped parameters. Nonlinear and linearized models of a tank and serially connected tanks. Linear and nonlinear models of mixing processes. Mathematical models of processes with heat transfer: recuperative heat exchanger, shell heat exchanger, flow heater. Nonliner and linearized mathematical models of continuous stirred tank reactors. Dynamic and static behaviour of processes.

Operating Systems (1h/week, 4th semester)

Introduction to operating systems of computers. Multitasking, types of multitasking and their comparison. Linux – operation system of UNIX-type, its installation. Free and Open Source Software, GNU Foundation. Introduction to Solaris operating system. Basic file and directory operations, editing, searching, regular expressions, makefiles. Introduction to computer typesetting. Remote computers, communication tools: telnet, ssh, ftp, http, smtp.

Process Control (2h/week, 5th and 6th semester)

Introduction to process control. Modelling of special types of processes of chemical technology. Static and dynamic behaviour of controlled systems. Closed loop for control of technological processes. Controllers. Dynamic behaviour of closed loops. Stability of systems. Synthesis of controllers. Control of special types of processes of chemical technology. Basic principles of devices and methods for measurement of technological quantities.

Design of Information and Control Systems (2h/week, 5th semester)

Basic principles and methods for control systems design concerning control aims requirements. Systematic design approach. Utilization of modern software and technical tools for control design. Information control supply.

Automatic Control Fundamentals (2h/week, 6th semester)

Introduction to automatic control fundamentals. Modelling of special types of processes of chemical technology. Static and dynamic behaviour of controlled systems. Closed loop for control of technological processes. Controllers. Dynamic behaviour of closed loops. Stability of systems. Synthesis of controllers. Control of special types of processes of chemical technology. Basic principles of devices and methods for measurement of technological quantities.

Integrated Control in Process Engineering (2h/week, 6th semester)

Process control and automation. Economic criteria of process control. Process unit optimisation. Optimal control of continuous and batch processes. Feedback control and production quality. Supervising control. Logistic process control. Process and production design. Bounds between process automation and operation. Processes, fabrications and information systems.

Information Engineering and Systems (1h/week, 6th semester)

Information system, systems for data processing. Database system structure. Logic data organization methods, database architecture. Means of data defining and manipulation. SQL language. Visualisation level of technological and production process control. SCADA/HMI (Supervising Control and Data Acquisition / Human Machine Interface) application design. Professional software packages and components (WinCC, dSPACE/Control Desk, MATLAB/MWS pre Windows XP/2000/NT). Creating HTML application and dynamic web pages bounded to control system databases, SCADA/HMI systems etc.

V.4.2 Lectures in Master study

Automatic Control Theory I (3h/week, 1st semester)

Continuous-time systems, discrete systems. Pole-placement method. State-space approach. Deterministic state estimate. Dynamic output feedback. Connections between state and input-output approach to control design. Pseudo-state. Asymptotic observer. Control law based on an observer for deterministic problem. Fractional approach, set of all stabilizing controllers. BIBO stability. Parameterisation of stabilizing controllers. Bezaut equation. Dynamic

optimisation. Principle of minimum. Fundamental theorem of the variation calculus. Necessary conditions for the optimal control. LQC problem. Kalman linear (L), quadratic (Q) controller. Euler-Lagrange equations. Optimal control. Matrix Riccati equation. Output control. LQ controller with integral properties. LQ control. Connections between the state-space and input-output approaches. Spectral factorisation. LQ control and deterministic state estimation. Polynomial solution of the problem. PI controllers and LQ controller design. Optimal LQ tracking of SISO systems, input-output approach. State and parameter identification. LQ state controller, LQG input-output controller. H_2 feedback control. Solution by using of two generalized algebraic Riccati equations. Connection between LQG and H_2 control.

Process Dynamics and Control (2h/week, 1st semester)

Introduction to control of technological processes. Principles of control of technological processes: feedback and feedforward control. Simple feedback control loop. Methods for PID controller tuning. Complex control loops: time-delay compensation (Smith predictor), cascade control, feedforward compensation of disturbances, flow-ratio control. Control of tanks, control and controlled variables. Control of heat exchangers, controlled and control variables, control loops. Control of distillation and absorption columns, controlled and control variables, control loops. Control of chemical reactors, controlled and control variables, control loops. Basic principles of devices and methods for measurement of technological quantities: liquid level, temperature, pressure, flow rate, concentration.

Modelling in Process Industries (2h/week, 1st semester)

Introduction to modelling in process engineering, modelling importance, static and dynamic mathematical models of liquid storages, shell and tube heat exchangers, packed and deck rectification columns, adsorption columns, extraction columns, continuous and batch chemical and biochemical reactors, tube chemical reactors with or without catalyst.

Technical Means of Automation (2h/week, 1st semester)

Continuous-time controllers, types and their static and dynamic behaviour. Discrete controllers, their dynamic behaviour and using in control loops. PC in the role of a controller. Servo-drives for electric and pneumatic control system. Control valves. Digital devices. Logic functions, electric devices for realization of logic functions. Sequence loops. Hardware for control of technological processes. Analogue input modules, A/D, D/A converters. Digital input modules. Sources of inaccuracies in control loops.

Programming of Network Application (1h/week, 1st semester)

PHP language a SQL database systems basics. Internet programming. Process or other database sources data and measurement processing.

Control Theory I (3h/week, 1st semester)

Continuous-time systems, discrete systems. Pole-placement method. State-space approach. Deterministic state estimate. Dynamic output feedback. Connections between state and input-output approach to control design. Pseudo-state. Asymptotic observer. Control law based on an observer for deterministic problem. Fractional approach, set of all stabilizing controllers. BIBO stability. Parameterisation of stabilizing controllers. Bezaut equation. Dynamic optimisation. Principle of minimum. Fundamental theorem of the variation calculus. Necessary conditions for the optimal control. LQC problem. Kalman linear (L), quadratic (Q) controller. Euler-Lagrange equations. Optimal control. Matrix Riccati equation. Output control. LQ controller with integral properties. LQ control. Connections between the state-space and input-output approaches. Spectral factorisation. LQ control and deterministic state estimation. Polynomial solution of the problem. PI controllers and LQ controller design. Optimal LQ tracking of SISO systems, input-output approach. State and parameter identification. LQ state controller, LQG input-output controller. H_2 feedback control. Solution by using of two generalized algebraic Riccati equations. Connection between LQG and H_2 control.

Optimisation (2h/week, 2nd semester)

Static optimisation, classification of problems, goal functions, boundaries. Extremum without boundaries – analytical methods. Single-dimensional case, multi-dimensional case, Hess matrix. Conditions for extremum. Extremum with boundaries – linear boundaries, direct method, method of Lagrange multipliers. Extremum with boundaries – nonlinear boundaries, Kuhn – Tucker theorem. Non-gradient methods – Box-Wilson method, flexible simplex method, method of cyclic exchange of parameters. Gradient methods – Regula falsi method, Newton method, Broyde method, DFP method, PARTAN method. Convergence of gradient methods. Heuristic and learning methods, genetic algorithms. Linear, dynamic, nonlinear programming. Optimal and strategic decision-making. Large-scale optimisation tasks and their decomposition.

Experimental Identification (2h/week, 2nd semester)

The identification of dynamic systems from their step responses of the 1st and 2nd order, Strejc, Šalamon, Hudzovič, Söderström methods. Statistical identification methods. Classification of models for experimental identification. Least-square method, recursive least- square method, lemma about the matrix inversion, REFIL, LDFIL, LDDIF algorithms. Prediction error method and auxiliary variable method. Using of recursive identification methods for

identification of multivariable and continuous-time systems. Aspects of the least square method and identification of static models, passive and active experiment. Correlation methods of identification, stochastic signals, correlation functions. Wiener-Hopf equation and its using for identification. Filtration and prediction of signals. State estimation and observability – Lueneberg observer, Kalman filtration. Using of identification for modelling and control of technological processes.

Modelling and Control of Polymerization Processes (2h/week, 2nd semester)

Principles of modelling of processes of chemical technology. Analytical and experimental approaches to modelling. Identification of static models based on the least square method. Recursive identification of discrete dynamic models. Analysis of synthesis, modification and production of polymers from the measurement and control point of view. Analysis of fibre production from the measurement and control point of view. Analysis of tire production from the measurement and control point of view. Analysis of processes of polygraphic technology from the control point of view. Analysis of processes of pulp and paper technology from the control point of view.

Control Theory II (2h/week, 3rd semester)

Algebraic theory of linear control, mathematical basement. Using of algebraic theory for continuous-time and discrete controller design, pole-placement, dead beat. Adaptive control. Self-tuning adaptive systems, recursive identification. Continuous-time and discrete adaptive control. Model reference adaptive control systems (MRAS), principles, MRAS according to MIT, MRAS in the sense of Ljapunov theory of stability. Predictive control. Robust control, H_2 and H_∞ control.

Intelligent Control Systems (2h/week, 3rd semester)

Expert systems – knowledge based systems. Knowledge representation. Basic features of expert systems, structure and processing. Diagnostic expert systems. Planning expert systems. Expert systems based on rules, frames and logical programming. Programming tools for expert systems – programming languages LISP and PROLOG. Fuzzy systems. Basic principles of fuzzy sets and fuzzy logic. Fuzzy decision processes, fuzzy modelling and identification. Design procedures for fuzzy logic controllers. Rule based fuzzy controllers, model based fuzzy controllers. Neural nets. Basic principles of artificial neural nets (ANS). Representation of dynamic systems using feed-forward and feedback neural nets. System identification based on using of neural nets. Parameter estimation and neural net training. Controllers based on using of neural nets. Adaptive control based on using of neural nets, direct and non-direct. Genetic control algorithms. Control of textile production.

CAD Systems (2h/week, 3rd semester)

Classification of automatic control systems, types of control algorithms. Automatic control system design. Feedback control loops – simple, composed. Control loops for flow rate, pressure, level control. Control loops for heat exchangers, distillation, absorption, extraction columns, batch and continuous-time chemical reactors. MIMO control of distillation columns. Large-scale systems – analysis, modelling and control.

Industrial Application of Process Control (2h/week, 3rd semester)

Introduction to industrial application of process control. Problems connected with control system design and control system application in practice. Hardware and software of industrial control systems, programming of industrial automata, data processing and visualization. Control of a binary plate distillation column. Solving of control problems for chemical industry.

Control of Technological Processes (1h/week, 3rd semester)

The course is given for students of specialization Organic Technology and Petrochemistry. Course content is following. Introduction to control of technological processes. Principles of control of technological processes: feedback and feedforward control. Simple feedback control loop. Methods for PID controller synthesis. Complex control loops: time-delay compensation (Smith predictor), cascade control, feedforward compensation of disturbances, flow-ratio control. Control of tanks, control and controlled variables. Control of heat exchangers, controlled and control variables, control loops. Control of distillation and absorption columns, controlled and control variables, control loops. Control of chemical reactors, controlled and control variables, control loops. Basic principles of devices and methods for measurement of technological quantities: liquid level, temperature, pressure, flow rate, concentration.

V.4.3 Laboratory exercises in Bachelor study

Computer Based Data Processing (2h/week, 2nd semester)

MATLAB/Simulink as a tool for system simulation, MATLAB – Control toolbox. Filtration of signals, analogue and digital filters, MATLAB – Signal processing toolbox. MS Excel as a tool for data processing. Data processing by tables, data visualization by graphs, analytical tools in MS Excel, statistics in MS Excel. Origin as a tool for data visualization and processing.

Optimisation (3h/week, 2nd semester)

Extremum without boundaries – analytical methods. Single-dimensional case, multi-dimensional case. Extremum with boundaries – linear boundaries, direct

method, method of Lagrange multipliers. Extremum with boundaries – nonlinear boundaries. Non-gradient methods – Box-Wilson method, flexible simplex method, method of cyclic exchange of parameters. Gradient methods – Regula falsi method, Newton method, Broyde method, DFP method, PARTAN method.

Laboratory Exercises of Automatic Control Fundamentals (2h/week, 6th semester)

MATLAB/Simulink as a simulation tool for LEPC. Laplace transform as a mathematical tool for LEPC. Input-output description of dynamic systems, transfer functions, poles and zeros. Step responses and impulse responses of dynamic systems. Mathematical models and dynamic behaviour of processes of chemical technology. Feedback control. PID controllers and their properties in feedback control. Controller synthesis and control of processes of chemical technology.

Laboratory Exercises of Information Engineering and Systems (1h/week, 6th semester)

Introduction to information systems and technologies. Electronic computers, computer software and computer networks. Internet. Language XHTML a CSS. Installation and setting of the software for programming (Apache, PHP, MySQL). Principles of programming language PHP. Work with databases.

Laboratory Exercises of Process Control (2h/week, 5th and 6th semester)

MATLAB/Simulink as a simulation tool for LEACF. Laplace transform as a mathematical tool for LEACF. Input-output description of dynamic systems, transfer functions, poles and zeros. Step responses and impulse responses of dynamic systems. Mathematical models and dynamic behaviour of processes of chemical technology. Feedback control. PID controllers and their properties in feedback control. Controller synthesis and control of processes of chemical technology.

V.4.4 Laboratory exercises in Master study

Laboratory Exercises of Control Theory I (2h/week, 2nd semester)

Simulation of pole-placement method. State-space approach. State observer design for simple systems. Simulation of state feedback. Simulation of feedback control with a state observer. Design of a set of stabilizing controllers for simple systems. Simulation of MIMO feedback systems by using of stabilizing controllers. Simulation of feedback control by using of a LQ controller for simple serially connected tanks and for a chemical reactor. Synthesis of a PI

controller, PI controller design by LQ method. Simulation comparison of a classic and a LQ PI controllers. Simulation of LQ control with deterministic state estimation. LQG state controller. Simulation of feedback control by a state-space LQG controller. LQG input-output controller. Adaptive control. Closed-loop identification. Closed-loop recursive identification. Simulation of adaptive control with recursive identification and with LQ/LQG controller. Adaptive control of serially connected tanks, adaptive control of a chemical reactor.

Laboratory Exercises of Process Dynamics (1h/week, 2nd semester)

Simulation of dynamic behaviour of systems in MATLAB/Simulink. Analysis and simulation of static and dynamic behaviour of a system of serially connected tanks with/without interactions. Analysis and simulation of static and dynamic behaviour of a tube heat exchanger as a continuously distributed parameter system. Transformation of a system of partial differential equations to a system of ordinary differential equations by discretization. Calculation of a steady-state of a plate distillation column, analysis and simulation of static and dynamic behaviour of a plate distillation column as a discretely distributed parameter system. Analysis and simulation of static and dynamic properties of an exothermic continuous-time stirred tank reactor. Calculation of steady state of a chemical reactor, steady-state analysis of a chemical reactor, linearization of nonlinear models.

Laboratory Exercises of Control Theory II (2h/week, 3rd semester)

Algebraic theory of linear control. Control of the 2nd order continuous-time system by discrete controller. Self-tuning adaptive control system for the 2nd order linear system, discrete and hybrid approach. Model reference adaptive control (MRAC). Adaptation of static gain. MRAC for the 1st and 2nd order systems. MRAC in the sense of the Ljapunov theory of stability, application on the 1st order system. Predictive control.

VI. CURRENT RESEARCH ACTIVITIES

Research at the Department of Process Control is oriented to advanced control theory as so as to practical applications in control of processes of chemical technology.

VI.1 Main Research Areas

Modelling and Simulation (M. Bakošová, M. Karšaiová, A. Mészáros, J. Mikleš)

Modelling and simulation play an important role in the investigation of static and dynamic properties of chemical processes, units and systems. Most chemical systems are strongly non-linear and their simulation is necessary for the control design as well as for the investigation of the overall control systems. The main aim of the research is to develop program packages for modelling and simulation of various kinds of models. During the last year a package for PC in Simulink and C-language was created.

System Identification (Ľ. Čirka, M. Fikar, J. Mikleš)

System identification deals with problem of the parameter estimation of static or dynamic systems from observed input-output data. Among many topics of system identification, the following areas have been investigated in this project:

- nonparameteric methods, correlation and spectral analysis
- recursive identification of transfer functions of continuous-time systems, Z-transform discrete-time models and delta-transform discrete-time models
- identification in closed-loop

A program package IDTOOL has been developed for Simulink. This toolbox implements recursive LS algorithm LDDIF and provides blocks for continuous and discrete time parameter estimation.

Optimal Control Design (M. Fikar, J. Mikleš)

The main aim of this area is to develop a package of algorithms and program implementation of various known control design for a given plant. The research interests include single input-single output systems as well as multivariable dynamic systems. Control design covers strategies in discrete-time and

continuous-time formulation. A program package is created in MATLAB and Simulink environment.

Adaptive Control (M. Bakošová, Ľ. Čirka, M. Fikar, A. Mészáros, J. Mikleš)

Most of technological plants exhibit non-linear behaviour. To apply a successful control design to practical problems is a substantial effort. The processes are known to be modelled and controlled with serious difficulties caused by their non-linear behaviour, high order dynamics, and tendency to instability. Many of industrial processes must be considered as multivariable systems. In a great deal of available control design techniques it is often necessary to carry out the steps of modelling, identification and control design. Theory and implementation of adaptive control in technological systems have been the long-time research topics. The activities in the adaptive control have been concentrated to three main areas as follows:

- self-tuning control - characterised by repeating parameter estimation and control design
- model reference adaptive control based on the Lyapunov method
- decentralised adaptive control

Neural Networks and Fuzzy Control (A. Mészáros, J. Dvoran, A. Vasičkaninová)

The aim of this research is to investigate fuzzy controllers based on genetic algorithms, two-layer hierarchical control structures for biochemical systems, integrated optimising algorithms for higher layers of hierarchical control structures, artificial neural-network models obtained by back-propagation for specified biochemical systems, design of a robust long-range constrained predictive control algorithms on the basis of ANN involving a stochastic approximation training algorithm, and development of a control system for our laboratory fermenter.

Model Predictive Control (M. Fikar, M. Kvasnica)

Model Predictive control (MPC) has been successful not only in academia but in industrial process applications as well. Its main drawbacks are the stability problems. The aim of this research is to enhance the basic input-output predictive methods. The problem is solved by means of the Youla-Kučera parameterisation of all stabilising controllers. Both finite and infinite horizon formulations are handled. Another approach is to assume that the loop is already controlled by a linear controller and to find the minimum number of control, or tracking error steps that leads to stable closed-loop behaviour. In all

cases, it can be shown that the minimum number of steps is closely related to the number of unstable poles/zeros of the plant. Another area of research is development of new methods for explicit model predictive control. In this approach, the optimal solution to the given MPC problem is obtained for all admissible initial conditions by employing parametric programming methods. The resulting optimal feedback law is then represented by a look-up table, which allows for real-time implementation of MPC to processes with rapid sampling.

Dynamic Optimisation (M. Fikar)

Increased quality requirements in chemical and petrochemical industries call for more complicated and sophisticated control strategies. Moreover, there is a need to know the achievable limits of performance and speed of transient behaviour of processes. Optimal control theory is able to provide responses to these questions. In this research, changeover problems in multicomponent distillation, waste-water treatment are studied.

Robust Control (M. Bakošová)

Chemical processes are usually very complicated systems from the control point of view because of their strong nonlinearity, varying operating points, not exactly known dynamics, varying or not exactly known parameters. All these problems can be included into mathematical models of chemical processes either in the form of parametric or dynamic uncertainty and robust control is a suitable tool for such processes. The research in this field is focused especially on robust static output feedback stabilization of chemical processes.

Modelling and control of chemical reactors, biochemical reactors, distillation columns and heat exchangers (M. Bakošová, J. Dvoran, Ľ. Čirka, M. Fikar, M. Karšaiová, A. Mészáros, J. Mikleš, A. Vasičkaninová)

The research of all research groups is focused on modelling and control of various types of chemical and biochemical processes.

Control Engineering Education (M. Fikar, Ľ. Čirka, M. Bakošová, T. Hirmajer)

Research in this domain focuses on application of information technologies in control education. This covers interactive on-line blocks and automatic generation of testing problems. The current research involves personification of students problems.

Information technologies (M. Fikar, Ľ. Čirka, T. Hirmajer, M. Kvasnica)

Research in this domain is oriented to:

- application of information technologies for data treatment and visualisation
- development of static and dynamic web pages not only for purposes of measurement and control but for general information treatment
- automatic data acquisition from various internet sources

Open Source solutions are applied:: web, mail, smb servers, databases (MySQL), programming tools (PHP, JavaScript) on operating systems GNU/Linux, FreeBSD, Solaris.

VI.2 Research Projects in Slovak Republic

1. VEGA 1/4055/07: Advanced Approaches to Control of Chemical and Biochemical Processes with Uncertainties (M. Bakošová)

The project deals with development of advanced approaches to control of systems with uncertainties and focuses on processes typical for chemical and food technologies, as e.g. chemical reactors, biochemical reactors, distillation columns, and others. Development of methods of robust analysis, robust stabilization and robust control of systems with uncertainties constitutes the core of the project. Processes with recycle can be also included to the systems with uncertainties. Designed algorithms, controllers, and control structures will be tested by simulations and in laboratory conditions. Obtained results will be transferred to the industrial praxis.

2. VEGA 1/3081/06: Optimisation and Control of Chemical and Biochemical Processes (M. Fikar)

The project deals with development of modern control and optimisation methods and focuses into processes typical in chemical and food industries: chemical reactors, distillation columns, waste-water treatment plants, and others. Involves static and dynamic, and global optimisation methods, predictive control as well as supervisory control. Developed algorithms, controllers, and control structures will be tested by simulations and in laboratory conditions.

Scientific goals

Connection of laboratory processes to the control systems dSPACE and Siemens Simatic S7 300 for the purpose of application of theoretical results. Modelling and simulation of hybrid (mixed continuous/discrete) systems. Analysis and design of control and optimisation of hybrid systems. Dynamic optimisation of a continuous and hybrid processes systems and with special attention to bioreactors and wastewater treatment plants. Design of a software package for simulation and dynamic optimisation of hybrid systems. Interface of the software package DYNO with MATLAB. Global dynamic optimisation – study of existing approaches. Design of supervisory control with industrial control systems. Design of a software package for multiparametric optimisation and explicit predictive control.

3. LPP-0092-07: Model Predictive Control of Hybrid Systems (M. Kvasnica)

The aim of this project is to extend the knowledge about parametric solutions to MPC problems for the class of hybrid systems. This involves, among other tasks, design of new algorithms for synthesis of robust control laws for the class of hybrid systems and new methods for state estimation for such systems. Modeling of compositional hybrid systems will be investigated as well. The goal is to create a software package which provides these algorithms to a broad range of users.

Period: 2008-2011

4. APVV-0029-07: Algorithms for optimal control of heat and mass transfer processes with hybrid dynamics (M. Fikar)

The project is focused on research in the areas of methods, algorithms and means for modelling and identification of technological units in process industries, as well as on design and implementation of algorithms for synthesis, analysis and final implementation of control systems to aforementioned processes. Partial methods and algorithms will be designed with high focus on effectiveness of their respective implementation, which will decrease the purchasing and operating costs of control systems for processes with heat and mass transfer that can be described by hybrid models.

Period: 2008-2010

VI.3 International Scientific Programs

1. Project of French – Slovak Scientific Cooperation Štefánik

Dynamic and Global Optimisation of Processes

Partners:
- Slovak University of Technology in Bratislava, Faculty of Chemical and Food Technology, Department of Inform. Eng. and Process Control (M. Fikar, M. Čižniar, M. Podmajerský, R. Paulen)

- Institut National Polytechnique de Lorraine (INPL) - Ecole Nationale Supérieure des Industries Chimiques (ENSIC) (M. A. Latifi, M. Daroux, F. Lesage)

This research project deals with unsteady-state operation of dynamic processes that are described by a detailed mathematic models, typically with non-linear and differential equations. The optimisation of performances of such processes consists in the determination of optimal profiles of decision variables (temperature, pressure, flow, heat, ...) or optimal parameter values of the dynamic model which optimise (minimise, maximise) a given performance index (time of operation, yield, energy consumption,...), over a time horizon, under specified constraints (safety, environment, process physical limits,...). This kind of problems is known as dynamic optimisation (or open-loop optimal control). Some selected problems include determination of optimal control in batch processes, estimation of optimal kinetic parameters in chemical reactions based on experimental data, determination of optimal control trajectory during set-point change, security analysis of processes, model based predictive control based on continuous model, etc.

Period: 2008-2009

2. Project of Swiss – Slovak Scientific Cooperation

Software for modeling and simulation of hybrid systems

Partners:
- Slovak University of Technology in Bratislava, Faculty of Chemical and Food Technology, Department of Inform. Eng. and Process Control (M. Kvasnica, M. Herceg)

- ETH Zurich, Automatic Control Laboratory (M. Morari)
- ABB Switzerland

This project is aimed at extending the HYSDEL language such that modeling of complex hybrid systems can be performed in an easy and efficient way. The language will be extended to allow to create compositional hybrid systems (i.e. systems which consist of several sub-modules). Moreover, the user will have the possibility to create such composition graphically by joining selected blocks in the MATLAB/SIMULINK environment.

Period: 2007 – 2009

3. Project of Slovak – Czech Scientific Cooperation

Algorithms for control of processes with mass and heat transfer

Partners:
- Slovak University of Technology in Bratislava, Faculty of Chemical and Food Technology, Department of Inform. Eng. and Process Control (project leader: M. Bakošová)

- T. Bata University in Zlín, Fakulty of Applied Informatics (project leader: R. Prokop)

Principal investigator from IIEAM: M. Bakošová
Scientific co-workers from IIEAM: M. Fikar, A. Mészáros, M. Kvasnica, A. Vasičkaninová, K. Vaneková, J. Závacká

The project is focused on development of advanced control algorithms for control of typical processes in chemical and food technologies, as e.g. heat exchangers, distillation columns, chemical reactors, etc. Control algorithm design is based on chosen robust control methods and optimal

control methods. The core of the project represents development of robust control methods for systems with parametric uncertainty and of optimisation methods with evolution algorithms. Designed control algorithms, controllers and control structures will be tested via simulations and on real laboratory processes.

Period: 2008-2009

4. Project of Hungarian - Slovak Scientific Cooperation

Modelling, Optimisation, and Control of Heat and Mass Transfer Processes

Partners:
- Slovak University of Technology in Bratislava, Faculty of Chemical and Food Technology, Department of Inform. Eng. and Process Control (M. Fikar, M. Bakošová, A. Mészáros, M. Herceg)

- Budapest University of Technology and Economics, Faculty of Chemical Engineering (P. Mizsey, Z. Szitkai, M. Gábor, M. Horváth)

The collaboration is planned to be conducted in two phases:
I. Continuation and completion of research activities on the following topics:

- Study of separation processes for non-ideal mixtures
- Analysis, simulation and control of hybrid separation processes
- Modelling and dynamic analysis of a multicolumn distillation process
- Hybrid process modelling using artificial neural networks (ANN)
- Development and implementation of dynamic optimisation packages

II. Modification and extension of the above topics as follows:

- Adaptive process control design using ANN
- Robust intelligent control design
- Static and dynamic optimisation of separation processes
- Testing of the proposed new algorithms for non-linear chemical processes through simulation experiments
- Implementation of computer control for laboratory fermenter
- Publication of the results obtained

Period: 2007-2009

VI.4 Educational Projects in Slovak Republic

1. ESF - JPD BA Target 3-2005/NP1-018: Preparation of university teachers for ICT in education

Partners:
- Institute of Control and Industrial Informatics, FEI STU, Ing. Žáková

- Department of Information Engineering and Process Control, IIEAM FCFT STU, prof. Fikar

- MtF STU, doc. Schreiber

Project aims:
- To improve quality of university teachers in Slovakia via two mirror projects.
- To provide ECDL certificate of university teachers in presence and distance learning using new e-learning technologies so that they will be able to modernise teaching process.
- Later, to provide such possibility to a wider community to improve qualification structure in Slovakia.
- To increase skills of university teachers in e-learning with focus on LMS systems and pedagogical aspects of modern education.
- To create a permanent consultancy services and help desks in ICT.

The aim of the project is to create an open network of virtual laboratories in Slovakia connected together via Internet and to laboratory networks abroad. The project will also implement and test properties of centralised network managed by an educational portal and distributed network created from servers on the participant's laboratories.

Period: 1.11.2006 – 30.11.2008

2. ESF Project: PhD students for modern industrial automation in Slovak Republic

Partners:
- Department of Automation, Informatics and Instrumentation, SjF STU, doc. Belavý

- Department of Information Engineering and Process Control, IIEAM FCPT STU, prof. Fikar

- Institute of Control and Industrial Informatics, FEI STU, doc. Huba

The main aim of the project is to improve quality of employment and competitiveness of Bratislava region via development of education and support of PhD students and young researchers. The project is focused on industrial automation, current and prospective industrial parks and institutions not only in the target region but in the whole Slovakia as well.
Education is targeted to motivation of PhD students in modern automation in automotive, process, biotechnological, and energetic industries. The main aspect is to make possible to study at the most advanced institutions in Europe including not only universities but industries as well.
Improvement of education and support of specifically oriented PhD students and young researchers in the area of automation, telematics and related industries in Slovakia. This will be accomplished by study stays at the most advanced industrial companies and universities in Europe and thus a new knowledge will be gained that cannot be obtained in Slovakia. On the other hand, this will improve competitiveness and quality of employment of industries in Bratislava region.
Transfer of on-line knowledge via Internet to other regions in Slovakia, educational portal in automation and information technologies.

Period: 2007-2008

VII. COOPERATION

VII.1 Cooperation in Slovakia

- Institute of Control and Industrial Informatics, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Bratislava

- Institute of Automation, Measurement, and Applied Informatics, Faculty of Mechanical Engineering, Slovak University of Technology, Bratislava

- Institute of Informatics, Slovak Academy of Sciences, Bratislava

- Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Košice

- Institute of Control and Informatization of Production Processes, BERG Faculty, Technical University of Košice, Košice

- Slovnaft, Inc., Bratislava

- NCHZ, Inc., Nováky

- Fuzzy, Ltd., Diakovce

- ProCS, Ltd., Šaľa

VII.2 International Cooperation

- Department of Process Control and Computer Techniques, Faculty of Chemical Technology, University of Pardubice, Pardubice, Czech Republic
  (Control system design)

- Department of Computing and Control Engineering, Prague Institute of Chemical Technology, Prague, Czech Republic
  (Control system design)

- Faculty of Applied Informatics, Tomas Bata University, Zlín, Czech Republic
  (Adaptive control, Robust control)

- Institute of Information Theory and Automation of the Academy of Sciences of the Czech Republic, Prague, Czech Republic
  (Polynomial synthesis, Predictive Control)

- Trnka Laboratory for Automatic Control, Faculty of Electrical Engineering, Czech Technical University, Prague, Czech Republic
  (Adaptive control, Model Predictive Control)

- LSGC-CNRS, Ecole Nationale Superieure des Industries Chimiques (ENSIC), Nancy, France
  (Dynamic optimisation and control)

- Ecole Nationale Superieure des Ingenieurs de Genie Chimique-Chemin de la Loge (ENSIGC), Toulouse, France
  (Neural networks, Learning automata, Model Predictive Control)

- Automatic Control Laboratory, ETH Zurich, Switzerland
  (Model Predictive Control, Modeling, analysis, and control of hybrid systems)

- Ruhr University, Bochum, Germany
  (Closed-loop identification, Model Predictive control)

- University of Dortmund, Dortmund, Germany
  (Model Predictive Control)

- Technical University of Budapest, Budapest, Hungary
  (Modelling of chemical processes)

- University of Veszprem, Hungary
  (Environmental engineering, Bioengineering projects)

VII.3 Membership in Domestic Organizations and Societies

- Slovak Society for Cybernetics and Informatics (A. Mészáros, J. Mikleš)

- Slovak Society of Chemical Engineering (M. Bakošová, J. Dvoran, M. Fikar, M. Karšaiová, A. Mészáros, J. Mikleš)

- Slovak Society of Industrial Chemistry (M. Bakošová, Ľ. Čirka, J. Dvoran, M. Fikar, M. Karšaiová, A. Mészáros, J. Mikleš, A. Vasičkaninová)

VII.4 Membership in International Organizations and Societies

- European Union Control Association (M. Fikar)

- International Federation of Automatic Control, Laxenburg, Austria (J. Mikleš)

- European Federation of Biotechnology, Brussels, Belgium (A. Mészáros)

- New York Academy of Sciences, New York, USA (A. Mészáros)

VIII. THESES AND DISSERTATIONS

VIII.1 Graduate Theses (Bc Degree)

for state examinations after three years of study
(supervisors are written in brackets)

Bangová, K.	Control of a technological process with disturbances (Vasičkaninová, A.)
Bodnár, P.	The creation of web pages with the help of XHTML/CSS (Hirmajer, T.)
Briš, M.	Control by control system FOXBORO (Vaneková, K.)
Černá, K.	Identification of a chemical reactor by ANFIS (Vasičkaninová, A.)
Csizmadiaova, V.	Modelling and control of laboratory tanks (Závacká, J.)
Doležalová, R.	Control system Foxboro (Vaneková, K.)
Dvoran, R.	Design of Dynamic Web Pages (Čirka, Ľ.)
Dzurov, J.	An universal Matlab to SQL interface (Kvasnica, M.)
Hulata, T.	Control of a crossroads model in Stateflow (Kvasnica, M.)
Hulíková, M.	Predictive control of a chemical reactor (Vasičkaninová, A.)
Jakubcová, Z.	Analysis of Moodle translation into Slovak (Fikar, M.)

Kalúz, M.	Electronic coursebook for subject “Experimental Identification” (Čirka, Ľ.)
Kmeťová, J.	Web application for data processing and analysis (Čirka, Ľ.)
Kórka, T.	Control of time-delay systems (Bakošová, M.)
Kuzma, J.	The creation of web pages with the help of XHTML/CSS (Hirmajer, T.)
Merčák, J.	Analysis of systems with uncertainties and robust control (Závacká, J.)
Miklovitz, L.	Model Predictive Control of chemical processes (Kvasnica, M.)
Mušáková, M.	Modelling and control of CSTR (Vöröš, J.)
Oravec, J.	Design of a programm system for controller synthesis (Bakošová, M.)
Pavúková, L.	Dynamic generation of the response characteristics with the help of PHP (Hirmajer, T.)
Rauová, I.	Optimal control of chemical processes (Kvasnica, M)
Repčíková, I.	Time Responses of Liquid Storage Systems (Mikleš, J.)
Schmidt, D.	Adaptive network based fuzzy inference systems (Vasičkaninová, A.)
Sónak, M.	Control of laboratory fan heater using SIMATIC (Vöröš, J.)
Sopranov, W.	Control of a crossroads model in Stateflow (Kvasnica, M.)

Struhár, M.	Survey of open-source language localisation approaches and software (Fikar, M.)
Szabová, A.	XML-RPC services in Matlab (Kvasnica, M.)
Szakálová, E.	Control by indistrial control system SIMATIC (Vaneková, K.)
Szucs, A.	Control by indistrial control system SIMATIC (Vaneková, K.)
Švardová, R.	Robust control of a time-delay process (Bakošová, M.)
Taraba, R.	Discrete logic control using Stateflow (Kvasnica, M.)
Tinak, M.	Discrete logic control using Stateflow (Kvasnica, M.)
Turayová, E.	Model Predictive Control of chemical processes (Kvasnica, M.)
Uhrecký, R.	The creation of web pages with the help of XHTML/CSS (Hirmajer, T.)
Vlková, L.	Web application for data processing and analysis (Čirka, Ľ.)

VIII.2 Graduate Theses (MS Degree)

for state examinations after five years of study
(supervisors are written in brackets)

Beňová, G.	Data processing from the fuel delivery system using the PetrocountSMS device at the company Oktan a.s., Kežmarok (Kvasnica, M.)

Lučanský, V. Control system Allen-Bradley for Bioethanol Storage
(Vaneková, K.)

Paulen, R. Global Optimization of Processes
(Fikar, M.)

Šlapanský, P. Information System for Storage of Motor Fuel in Oktan a.s. Kežmarok
(Čirka, Ľ.)

VIII.3 Graduate Theses (PhD Degree)

for state examinations after three years of study
(supervisors are written in brackets)

Kvasnica, M. Efficient Software Tools for Control and Analysis of Hybrid Systems.
(Morari, M.)

IX. PUBLICATIONS

IX.1 Books

1 Bakošová, M., Fikar, M.: Process Control (in Slovak), Vydavateľstvo STU, Bratislava, 2008.

IX.2 Chapter or pages in book

1 Bakošová, M.: E-learning in Education Process (in Slovak), In Pokroky v chémii a v biológii, Editor(s): Ondrejkovičová, I., Izakovič, M., Vydavateľstvo STU, pp. 91–98, 2008.

IX.3 Article in journal

1 Bakošová, M., Puna, D., Vasičkaninová, A.: Robust control of chemical reactors. Acta Chimica Slovaca, no. 1, vol. 1, pp. 12–23, 2008. pp. 33–38, 2008.

2 Mészáros, A., Vöröš, J.: Design of Intelligent Controllers for Biotechnological Process. Acta Chimica Slovaca, no. 1, vol. 1, pp. 208–220, 2008.

3 Tiňo, R., Fikar, M., Burčík, V.: Communication Means and Information System for the Project KnihaSk (in Slovak). Knižnica, no. 6-7, vol. 9, pp. 16–19, 2008.

4 Vaneková, K., Závacká, J., Bakošová, M., Puna, D.: Robust Control of Laboratory Process by Simatic Control System (in Slovak). Automatizace, no. 1, vol. 51, pp. 34–37, 2008.

5 Vöröš, J., Mikleš, J., Čirka, Ľ.: Parameter Estimation of Nonlinear Systems. Acta Chimica Slovaca, no. 1, vol. 1, pp. 309–320, 2008.

IX.4 Article in conference proceedings

1 Bakošová, M., Puna, D.: Robust PI and PID control of a mixing device. Editor(s): Markoš, J., In Proceedings of the 35th International Conference of SSCHE, SSCHE, Bratislava, pp. 056p.pdf, 2008.

2 Bakošová, M.: Using the LMS Moodle in the Course Modelling in the Process Industry. Editor(s): M. Huba, In Proceedings of the 9th International Conference Virtual University 2008, E-academia Slovaca, pp. fid000891.pdf, 2008.

3 Čirka, Ľ., Fikar, M., Kvasnica, M., Herceg, M.: Experimental Identification – an Interactive Online Course. In Proceedings of the 17th World Congress of te International Federation of Automatic Control, Seoul, Korea,

pp. 9812–9816, 2008.

4 Čirka, Ľ., Kvasnica, M., Fikar, M.: WebLab Module for the Moodle Learning Management System. Editor(s): M. Huba, In Proceedings of the 9th International Conference Virtual University 2008, E-academia Slovaca, pp. fid000131.pdf, 2008.

5 Čižniar, M., Hirmajer, T., Podmajerský, M., Fikar, M., Latifi, M. A.: NMPC based on global optimisation. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. c025b-1–c025b-6, 2008.

6 Čižniar, M., Fikar, M., Latifi, M. A.: Design of constrained nonlinear model predictive control based on global optimisation. Editor(s): Bertrand Braunschweig and Xavier Joulia, In 18th European Symposium on Computer Aided Process Engineering, Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, The Netherlands, vol. 25, pp. 563–568, 2008.

7 Čižniar, M., Fikar, M., Kvasnica, M., Latifi, M. A.: Design of Globally Optimal Nonlinear Model Predictive Control. Editor(s): L. Magni, D. Raimondo, F. Allgoewer, In International Workshop on Assessment and Future Directions of Nonlinear Model Predictive Control, Pavia, Italy, pp. PV3-1–PV3-8, 2008.

8 Fikar, M., Čirka, Ľ., Herceg, M., Podmajerský, M.: E-learning in Course Operating Systems. Editor(s): M. Huba, In Proceedings of the 9th International Conference Virtual University 2008, E-academia Slovaca, pp. fid000091.pdf, 2008.

9 Herceg, M., Kvasnica, M., Fikar, M.: Stabilization of an Inverted Pendulum via Fuzzy Explicit Predictive Control. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C021_b-1–C021_b-5, 2008.

10 Herceg, M., Mikleš, J., Fikar, M., Kvasnica, M., Čirka, Ľ.: Real-time 2DoF Control of a Quadruple Tank System with Integral Action. In Proceedings of the 17th World Congress of the International Federation of Automatic Control, Seoul, Korea, pp. 8666–8671, 2008.

11 Herceg, M., Kvasnica, M., Fikar, M.: Parametric Approach to Nonlinear Model Predictive Control. Editor(s): L. Magni, D. Raimondo, F. Allgoewer, In International Workshop on Assessment and Future Directions of Nonlinear Model Predictive Control, Pavia, Italy, pp. PI1-1–PI1-8, 2008.

12 Hirmajer, T., Fikar, M., Balsa-Canto, E., Banga, J. R.: Application of a control vector parameterization method using an interior point algorithm. Editor(s): Bruzzone L., In Proceedings of the Fifth IASTED International

Conference Signal Processing, Pattern Recognition, and Applications, ACTA Press, Innsbruck, pp. 122–127, 2008.

13 Hirmajer, T., Čižniar, M., Fikar, M., Balsa-Canto, E., Banga, J. R.: Brief Introduction To DOTcvp - Dynamic Optimization Toolbox. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C011a, 2008.

14 Kvasnica, M., Herceg, M., Čirka, Ľ., Fikar, M.: Model Predictive Control of a CSTR: a Hybrid Modelling Approach. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C021_a-1–C021_a-9, 2008.

15 Kvasnica, M., Christophersen, F. J., Herceg, M., Fikar, M.: Polynomial Approximation of Closed-form MPC for Piecewise Affine Systems. In Proceedings of the 17th World Congress of the International Federation of Automatic Control, Seoul, Korea, pp. 3877–3882, 2008.

16 Kvasnica, M., Herceg, M., Čirka, Ľ., Fikar, M.: Adaptive Model Predictive Control of Piecewise Affine Systems. Editor(s): L. Magni, D. Raimondo, F. Allgoewer, In International Workshop on Assessment and Future Directions of Nonlinear Model Predictive Control, Pavia, Italy, pp. PIV3-1–PIV3-8, 2008.

17 Mariethoz, S., Herceg, M., Kvasnica, M.: Model Predictive Control of buck DC-DC converter with nonlinear inductor. In Proceedings of the Eleventh IEEE Workshop on Control and Modeling for Power Electronics, Zurich, Switzerland, pp. 1–8, 2008.

18 Mészáros, A., Bakošová, M., Šperka, Ľ.: Simple PI-like inverse neural controllers. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C049a-1–C049a-9, 2008.

19 Mészáros, A., Bakošová, M., Šperka, Ľ.: Inverse Model Based Neural Controllers with Adaptive Integral Part. In Proceedings of the 16th IEEE Mediterranean Conference on Control and Automation, Congress Centre, Ajaccio, France, pp. 303–308, 2008.

20 Mészáros, A., Šperka, Ľ.: Intelligent Control of PH in a Laboratory Fermenter. Editor(s): Markoš, J., In Proceedings of the 35th International Conference of SSCHE, SSCHE, Bratislava, pp. 226–1–226–10, 2008.

21 Mikleš, J., Vöröš, J., Čirka, Ľ.: Robust LQ Control with Real Parametric Uncertainty. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C186a - 1–C186a - 4, 2008.

22 Podmajerský, M., Fikar, M.: Measurement-based Run-to-run Optimisation

of Hybrid Two-stage Reactor System. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C025a – 1–C025a – 11, 2008.

23 Puna, D., Bakošová, M.: Robust control of a mixing unit. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C008a – 1–C008a – 9, 2008.

24 Puna, D., Bakošová, M., Mészáros, A., Závacká, J.: Robust stabilization of a mixing unit. In 18th International Congress of Chemical and Process Engineering, Orgit s.r.o., Praha, Czech Republic, pp. 1043-1–1043-10, 2008.

25 Rauová, I., Kvasnica, M., Čirka, Ľ., Fikar, M.: Real-Time Model Predictive Control of a Laboratory Liquid Tanks System. In Proceedings of the 16th Annual Conference Technical Computing Prague 2008, pp. 89–95, 2008.

26 Valík, Ľ., Medveďová, A., Čižniar, M.: Growth modelling of Lactobacillus rhamnosus GG: A Comparison of Some Temperature Effects. In Food Micro 2008, Programme and Abstract Book. The 21st International ICFMH Symposium: Evolving microbial food quality and safety., pp. 209, 2008.

27 Vaneková, K., Bakošová, M., Závacká, J., Jančová, K.: Robust Control of a Laboratory Time-Delay Process. Editor(s): Kozák, Š., Kozáková, A., Rosinová D., In Zborník abstraktov Medzinárodnej konferecie SSKI Kybernetika a informatika, SSKI Bratislava, ŽDIAR, Slovak Republic, 2008.

28 Vaneková, K., Bakošová, M., Závacká, J.: Robust control of a laboratory time-delay process using control systme SIMATIC. Editor(s): Markoš, J., In Proceedings of the 35th International Conference of SSCHE, SSCHE, Bratislava, pp. 024p.pdf, 2008.

29 Vaneková, K., Bakošová, M., Závacká, J., Jančová, K.: Robust PI Control of a Time-delay Process Using Industrial System SIMATIC. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C078_a - 1–C078_a - 11, 2008.

30 Vaneková, K., Bakošová, M., Závacká, J., Jančová, K.: Robust control of a laboratory time-delay process using an industrial control system. In 18th International Congress of Chemical and Process Engineering, Orgit s.r.o., Praha, Czech Republic, pp. 0524-1–0524-11, 2008.

31 Vasičkaninová, A., Bakošová, M.: Fuzzy model based predictive control. Editor(s): Markoš, J., In Proceedings of the 35th International Conference of SSCHE, SSCHE, Bratislava, pp. 016p.pdf, 2008.

32 Vasičkaninová, A., Bakošová, M.: Control of a chemical reactor with disturbances. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C031a 1–C031a 6, 2008.

33 Vasičkaninová, A., Bakošová, M., Mészáros, A., Závacká, J.: Model-based predictive control of a chemical reactor. In 18th International Congress of Chemical and Process Engineering, Orgit s.r.o., Praha, Czech Republic, pp. 0623-1–0623-6, 2008.

34 Vasičkaninová, A., Bakošová, M., Mészáros, A., Závacká, J.: Model-based predictive control of a chemical reactor. In 18th International Congress of Chemical and Process Engineering, Orgit s.r.o., Praha, Czech Republic, pp. 0623-1–0623-6, 2008.

35 Vöröš, J., Mikleš, J., Čirka, Ľ.: Parameters Estimation for Nonlinear Systems using Extended Kalman Filter. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C174a -1–C174a - 8, 2008.

36 Závacká, J., Bakošová, M., Vaneková, K.: Design of PI, PID controllers for control of systems with parametric uncertainties. Editor(s): Markoš, J., In Proceedings of the 35th International Conference of SSCHE, SSCHE, Bratislava, pp. 050p.pdf, 2008.

37 Závacká, J., Vaneková, K., Bakošová, M.: Robust PI, PID controllers for control of systems with parametric uncertainty. In Proceedings of the 8th International Scientific - Technical Conference Process Control 2008, University of Pardubice, Kouty nad Desnou, Czech Republic, pp. C033a - 4–C033a - 10, 2008.

38 Závacká, J., Bakošová, M., Vaneková, K.: Design of Robust PI, PID Controllers for Control of Systems with Parametric Uncertainty. In 18th International Congress of Chemical and Process Engineering, Orgit s.r.o., Praha, Czech Republic, pp. 0457-1–0457-10, 2008.

IX.5 Phd thesis

1 Kvasnica, M.: Efficient Software Tools for Control and Analysis of Hybrid Systems. ETH Zurich, ETH Zurich, Physikstrasse 3, 8092 Zurich, Switzerland, 2008.