

# DEPARTMENT OF COMPUTER AUTOMATION AND CONTROL (E-2)



*The Department of Computer Automation and Control is concerned with research, development, applications and education in the area of control technology. These activities are carried out in close cooperation with two control laboratories at the Faculty of Electrical Engineering of the University of Ljubljana and the engineering company INEA, in the frame of a virtual organization, named Technology Vertical, for knowledge exchange and technology transfer. To further stimulate cooperation with industry a special organizational entity within the department (the ConTech Centre) has been established.*

## BASIC AND APPLIED RESEARCH

*Head:*

**Prof. Stanko Strmčnik**

In 2000 the main research activities covered three areas. Research in the area of process diagnosis has been focused on robust algorithms for detecting and isolating faults in the presence of noise and modelling errors. The key to the approach relies on the application of a statistical description of the modelling errors, which leads to interesting statistical tests. Much attention has been paid to the analysis of performances of the resulting detectors and to the problem of consistent selection of design parameters. New advances in approximate reasoning for fault isolation under conflicting process data have also been achieved. To solve this intriguing problem the idea of discounting belief has been employed, which proved efficient when treating real process data. The algorithms developed so far have been extensively tested in Matlab and partly applied to condition monitoring of an incineration unit at a tyre production plant, and to on-line diagnosis of a semi-industrial process for separating water from flue gases (Fig. 1).

The second area studied was model-based process control and optimization. One aspect of this research has been concerned with general purpose control methods. This work encompassed improving disturbance rejection in predictive control, designing non-linear control using a modified Hammerstein model or employing a fuzzy gain-scheduling approach, and tailoring the recently developed multiple integration controller tuning method to various types of controllers. The methods developed were mostly tested by simulation or on laboratory pilot plants.

The other sub-area of this research was related to simulation and control design for wastewater treatment processes. Simulations were performed for the Wastewater treatment plant at Domžale-Kamnik, which will be upgraded with nitrogen removal processes. With that in view, mathematical models of the two

different technologies were designed, and simulations performed to show which solution is the better. The design of control algorithms was studied for the wastewater treatment benchmark, which was defined in an international project COST 624 "Optimal management of wastewater systems". The aim is to design control algorithms which ensure high treatment

*The year 2000 was marked by dissertations leading to four successful PhDs from our Department.*

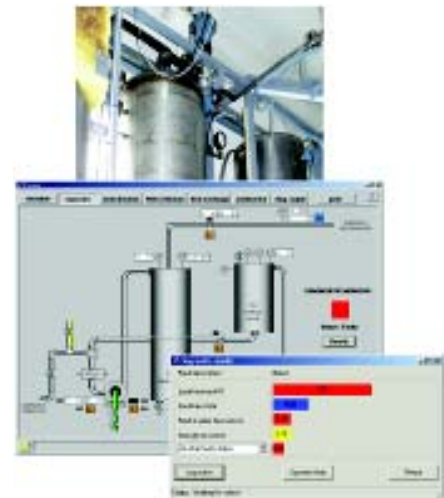


Figure 1: Prototype solution of a fault detection and isolation system

efficiency and low energy consumption during plant operation. Up to now, the performance of simple (PI) control algorithms has been assessed, and will be further compared with more advanced (predictive, multivariable, non-linear) control algorithms.

Research in the third area concerned problems of computer integrated production in process industry. One part of this work was devoted to domain engineering in the area of process control and, within this, to development of appropriate graphical notations for specifications based on enhanced (parallel) finite automata. This is going to form the basis for automatic program code generation. The knowledge acquired was also used in some industrial application projects. The second part was concerned with non-technical aspects of control technology. In this frame one of the existing change management approaches was adopted and modified to enable its use in projects involving implementation of process control systems. In addition, the anthropocentric paradigm was studied and applied in designing human-machine interfaces.

### **R & D PROJECTS**

An important part of the department's work is devoted to research and development projects for Slovene and foreign customers.

In the creation of custom designed process control systems the development is carried out in the department and the implementation by our engineering partners. In 2000 we were engaged in three such projects.

The first one encompassed preparation of specifications and design of several processes in the production of titanium dioxide at Cinkarna Celje. The second involved definition of requirements and design of conceptual architecture of control systems for a chemical reactor in the wood plant Lesonit, Ilirska Bistrica. In the third project a feasibility study for computer integrated production for the cement factory Salonit, Anhovo was prepared.



*Figure 2: "Cardiosignals" - A signal conditioning system for the acquisition of physiological signals*

In recent years, our cooperation in developing special solutions and building blocks for automation and control purposes with the companies

INEA and MITSUBISHI EUROPE has intensified. In 2000 we continued the development of a self-learning adaptive PLC controller, and concluded the development and extensive testing of a high-performance co-processor module for the MITSUBISHI AnS and QnS PLC's.

In addition to this, some special HW systems were also developed like, for example, a Mass Spectrometer Detector Interface aimed at improving operation of a high-performance spectrometer for a Hungarian customer, and a Signal Conditioning System for the acquisition of physiological signals in the human body for customers from Slovenia, United Kingdom and Norway.

### **EDUCATIONAL ACTIVITIES**

Members of the department are regularly involved in lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana and the Polytechnic, Nova Gorica. They also took part in advising diploma, M.Sc and Ph.D. students. Special attention is given to post-qualification training for engineers from industry. In 2000 four one-week courses were organized.

The education activities are organized in close co-operation with the Information Technologies Knowledge transfer Centre at the Institute.

#### **SOME OUTSTANDING PUBLICATIONS IN THE PAST THREE YEARS**

1. *G. Dolanc, S. Strmčnik, J. Petrovčič, Nonselective catalytic reduction control based on simple models, J. process control, vol. 11, (2000), 35-51*
2. *D. Dragan, Đ. Juričić, S. Strmčnik, Modelling for condition monitoring: application to a heat transfer process, Process control qual., vol. 11, (2000), 419-432*
3. *D. Vrančić, Y. Peng, S. Strmčnik, A new PID controller tuning method based on multiple integrations, Control Engineering Practice. [Print ed.], vol. 7, (1999), 623-633*
4. *D. Šel, N. Hvala, S. Strmčnik, S. Milanič, B. Šuk-Lubej, Experimental testing of flexible recipe control based on a hybrid model, Control Engineering Practice. [Print ed.], vol. 7, (1999), 1191-1208*

#### **THE MOST IMPORTANT TECHNOLOGICAL ACHIEVEMENTS IN THE PAST THREE YEARS**

1. *SPAC-20 – Co-processor for High-End Control and Special Process Applications (J. Petrovčič, J. Grom, M. Štrubelj)*

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2. Giovanni Godena, Matjaž Šubelj, Peter Kosin, Jure Lukač  
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3. Boštjan Hauptman, Giovanni Godena, Gregor Kandare  
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11. Alenka Žnidaršič, David Čuk, Vladimir Jovan, marjan Rihar  
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## THESES

### B. Sc. Theses

1. Boštjan Bobnar: Supervisory control design for power transformer relay station (Juš Kocijan)
2. Borut Fortuna: Use of Functional Block Diagram for quarry separation control (Juš Kocijan)
3. Bogdan Hlača: Evaluation of Simulation tool Scicos for control systems simulation (Juš Kocijan)
4. Jure Ivanušič: Evaluation of Scilab for control systems design (Juš Kocijan)
5. Kristjan Kravina: Two nonlinear control systems cases (Juš Kocijan)
6. Bojan Likar: Control design with programme package CUBE (Juš Kocijan)
7. Roman Mestnik: Preparation of requirements and solutions for production line automation (Juš Kocijan)
8. Aleksander Modic: Hardware and software design for an industrial device control (Juš Kocijan)
9. Marko Perko: Preparation of specifications and software structure for concrete production control software (Juš Kocijan)
10. Gregor Žunič: Nonlinear control of a gas-liquid separator (Juš Kocijan)

### Ph. D. Theses

1. Gregor Dolanc: The use of mathematical models in algorithms for automatic control of industrial processes (Borut Zupančič, Stanko Strmčnik)
2. Samo Gerškšič: Disturbance rejection in predictive control (Borut Zupančič, Stanko Strmčnik)
3. Andrej Rakar: Fault diagnosis of technical systems by means of approximate reasoning. (Borut Zupančič, Stanko Strmčnik)

- Mario Zec: Evaluation and use of mathematical models in biological wastewater treatment (Rihard Karba, Stanko Strmčnik)

## MST SUPPORTED RESEARCH AND DEVELOPMENT GRANTS AND CONTRACTS

### Research program

- Computer Automation and Control  
Prof. Stanislav Strmčnik

## INTERNATIONAL PROJECTS

- Optimal Management of Waste - Water Systems  
COST 624  
EC  
Dr. Nadja Hvala
- Multy-Agent Control: Probabilistic Reasoning, Optimal Coordination, Stability Analysis and Controller Design for Intelligent Hybrid System  
MAC, 5. FP  
EC; Dr. Roderick Murray-Smith, University of Glasgow, Department of Computing Science, Glasgow, Great Britain  
Asst. Prof. Juš Kocijan
- Integration of Qualitative and Analytical Methods in the Supervision of Technical Systems  
Prof. R. Isermann, Institut für Regelungstechnik, THD, Darmstadt, Germany  
Prof. Stanko Strmčnik  
Prof. Drago Matko
- Analysis and Control of SBR Waste - Water Treatment Systems  
Prof. Stefano Marsili - Libeli, University of Florence, Department of Systems and Computers, Florence, Italy  
Dr. Nadja Hvala
- Model-based Fault Detection and Isolation for Industrial Processes  
Dr. Miroslav Karny, Institute of Information Theory and Automation, Academy of the Sciences of the Czech Republic, Prague, Czech Republic  
Dr. Đani Juričić

## NEW CONTRACTS SIGNED

- Computer integrated control in Mitol, d.d.  
Mitol, Sežana  
Giovanni Godena
- Co-Financing of COST 624 Project  
Ministry of Science and Technology, Ljubljana  
Dr. Nadja Hvala
- Computer supported production management in Polycom d.o.o.  
Polycom, d.o.o., Poljane nad Škofjo Loko  
Dr. Vladimir Jovan
- Computer based supervision and control of a chemical reactor  
Lesonit, Ilirska Bistrica  
Dr. Vladimir Jovan
- Multi-agent control  
University of Glasgow, Glasgow  
Asst. Prof. Juš Kocijan
- Software tools set for coprocessor Spac 20  
Inea, Domžale  
Janko Petrovčič
- System requirements for an integral production management information system  
Salonit Anhovo, Anhovo  
Dr. Marjan Rihar
- Upgrade of basic production of TiO<sub>2</sub>  
Cinkarna, d.d., Celje  
Prof. Stanislav Strmčnik

## VISITORS FROM ABROAD

- Lars Ekelund, BELJERS, Sweden, 4.5.2000
- Kvetoslav Belda, B. Sc., Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic, Prague, Czech Republic, 22.-26.11.2000
- Dr. Imre Takacs, HYDROMANTIS, Canada, 4.12.2000

## ORGANIZATION OF CONFERENCES, CONGRESSES AND MEETINGS

- Industrial control systems: continuing education (specialisation) course in Control Technology, Ljubljana, April 3 - 7, 2000
- Advanced control approaches: continuing education (specialisation) course in Control Technology, Ljubljana, June 5 - 9, 2000
- Software for process control: continuing education (specialisation) course in Control Technology, Ljubljana, October 23 - 27, 2000

## STAFF

### Researchers

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