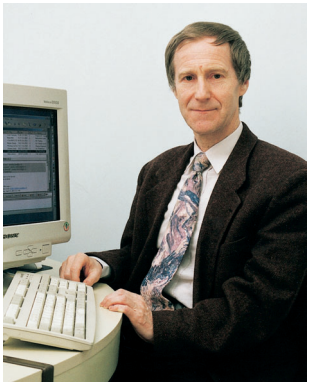
DEPARTMENT OF COMPUTER AUTOMATION AND CONTROL E-2

The Department of Computer Automation and Control is engaged in research, development, applications and education in the area of control technology. These activities are carried out in close cooperation with the Faculty of Electrical Engineering of the University of Ljubljana and the engineering company INEA. The three institutions make a consortium referred to as "Technology Vertical", the aim of which is to merge expertise and knowledge transfer in developing control technology. To further stimulate cooperation with industry, a technology centre, referred to as the ConTech Centre, has been established within the Department.



Head:
Prof. Stanko Strmčnik

Basic and applied research

Research in the area of **fault detection** and **isolation** was focused on robust detection of faults in systems instrumentation by making use of simplified low-order process models. While simple to build, such models can cause occasional false alarms. In order to avoid this problem, effective statistical tests have been devised by making use of stochastic descriptions of the modelling errors. This has resulted in reliable detection of faults as early as in their initial stages.

In the area of **process control and optimization**, part of our research was concerned with general purpose control methods. Emphasis was placed on the development of algorithms for non-linear and multi-model control, and the use of Gaussian processes for mathematical modelling. The research was closely connected to the work within the 5th FP projects MAC and ASPECT.

The second area of research in this area concerned control of wastewater treatment processes. It was devoted to the design and testing of control algorithms for a wastewater treatment benchmark. For this problem, addressed in an international (COST) project, an advanced multivariable predictive controller was designed (Fig. 1). The controller uses a mathematical process model and, compared with simple PI controllers, improves N-removal in wastewater. Advanced control is also a research topic of the 5th FP project SMAC, where it will be applied on a wastewater treatment plant at Domžale-Kamnik.

Research in **computer integrated production** took three directions.

In the field of software (domain) engineering, a model for a domain is being designed and specifications of the ProcGraph notation, along with its transformation into the program code, were established. A new activity on the specifications for a domain specific metric for process control software was also started.

The majority of activities within the area of computer based management of industrial systems and processes was devoted to our work on the 5th FP project VIP-NET. Here our group is participating in the development of an on-line algorithm for batch scheduling in process industries.

The third sub-area concerns non-technical aspects of control technology. Here research was devoted to problems of economic justification of control and computer supported systems and to the analysis of concepts, methods and approaches which would make the design and implementation of systems more acceptable for people at large.

Our research and development activities have in the last years spread beyond our traditional area of work. We have therefore decided to change the name of the department to "Department of Systems and Control".

R & D projects

Substantial effort has been devoted to the development of advanced control algorithms for PLC's. The work was carried out in the frame of the 5th FP project ASPECT. Final users of the developed project will be three SME's from Slovenia, Bulgaria and Greece. The heart of the product is a set of models, which are adapted on-line and contain crucial information for setting parameters of the associated control algorithms.

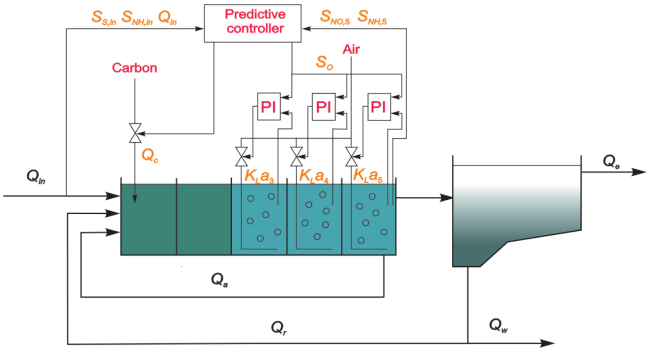


Figure 1: Structure of the predictive control of a waste-water treatment benchmark

As part of our long-term cooperation with the company INEA, Ljubljana, we have, together with their engineers, finalized a complete control system for extrusion blow moulding machines, which was successfully tested and implemented at the BBM company in Berlin, Germany. They intend to use our technology for building new machines and also for the retrofit. The main contributions in the past year have been new man-machine interface screens and highly optimised communication between the PLC-CPU and the SPAC20 coprocessor.

A prototype system for quality end-tests of electrical motors was developed for the company Domel, at Železniki. The core of the system entails signal processing modules that generate features from vibro-acoustic signals, voltage, current and commutation-induced

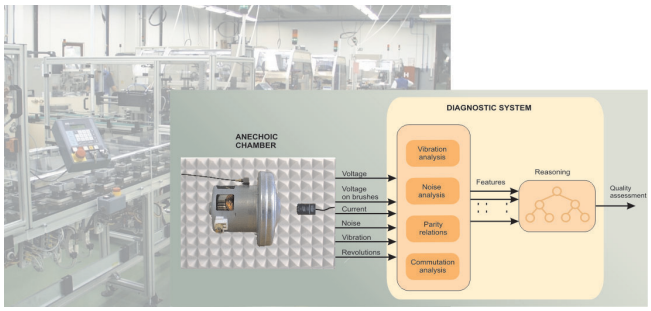


Figure 2: System for quality end-testing of electrical motors.

electromagnetic disturbances. Besides reliable detection of motors with unacceptable quality, the system is also able to identify root causes for lower quality. We have also developed an accelerometer interface, which helps to identify sources of vibration of the motors, and a spark intensity meter, which improves the diagnostic procedure for suction units. The innovative solution is patent pending at the Slovenian Intellectual Property Office.

Other, smaller projects included development of a rule-based algorithm for batch sequencing of a two stage suspension washing process (for Cinkarna Celje, Celje d.d.); cooperation in preparing requirements analysis and specifications for integrating an SW tool for production scheduling into an existing information system (Kovinoplastika Lož, d.d.); integration of ERP system with SCADA, and development of a control system for a flexible pilot production line for special glue production (for Mitol, d.d., Sežana).

Finally, three feasibility studies concerning computer integrated production were carried out for the companies Svea d.d., Krasoprema d.o.o. and Bohor d.o.o.

Education activities

We give lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana and the Polytechnic of Nova Gorica. Members of the department also act as supervisors of M.Sc and Ph.D. students. Special attention is given to post-qualification training for engineers from industry. In 2002 four one-week courses were organized. These activities were organized in close co-operation with the Information Technologies Knowledge transfer Center at the Institute.

Some outstanding publications in the past three years

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4. Darko Vrečko, Nadja Hvala, Juš Kocijan. Wastewater treatment benchmark : What can be achieved with simple control?. Water sci. technol., 2002, vol. 45, str. 127-134.

The most important technological achievement 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. Gregor Cundrič: Automatic control system for cement shipping (Juš Kocijan)
3. Boštjan Čečko: Assessment of velocity-based linearisation for sampled non-linear control systems (Juš Kocijan)
4. Tomaž Kerin: Sensitivity function based PID controller tuning (Juš Kocijan)

5. Bogdan Rojc: Personal computer based programmable logic controllers (Juš Kocijan)
6. Aljaž Stare: Biological wastewater treatment plant modelling and model evaluation (Rihard Karba, Nadja Hvala)
7. Matjaž Zadravec: Design of velocity-based linearisation based multivariable control system for combustion (Juš Kocijan)

M. Sc. Thesis

1. Iztok Špacapan: Fuzzy logic and haptic information based wheelchair control (Juš Kocijan)

Ph. D. Thesis

1. Dejan Dragan: Modelling and identification of industrial process for the purpose of fault diagnosis (Rihard Karba, Stanko Strmčnik)

MESS SUPPORTED RESEARCH AND DEVELOPMENT GRANTS AND CONTRACTS

1. System for electromotors final quality checking
   Dr. Mina Žele
2. Industrialization of advanced control algorithms for PLC
   Prof. Stanko Strmčnik

Research program

1. Computer automation and control
   Prof. Stanko Strmčnik

INTERNATIONAL PROJECTS

1. Smart Control of Wastewater Systems
   SMAC; EVK1-CT-2000-00056, 5. FP
   EC; Nielsen, Krüger A/S, Søborg, Denmark
   Dr. Nadja Hvala
2. Virtual Plant-Wide Management and Optimisation of Responsive Manufacturing Networks
   VIP-NET; G1RD-CT-2000-00318, 5. FP
   EC; Dr. George Zarkadas, Atlantis Consulting SA, Thessaloniki, Greece
   Dr. Vladimir Jovan
3. Advanced Control Algorithms for Programmable Logic Controllers (PLCs)
   ASPECT; IST-1999-56407 (CRAFT), 5. FP
   EC; Dr. Zoran Marinšek, INEA d. o. o., Domžale, Slovenia
   Prof. Stanko Strmčnik
4. Multi-Agent Control: Probabilistic Reasoning, Optimal Coordination, Stability Analysis and Controller Design for Intelligent Hybrid System
   MAC; HPRN-CT-1999-00107, (Research Training Network), 5. FP
   EC; Dr. Roderick Murray-Smith, University of Glasgow, Department of Computing Science, Glasgow, Great Britain
   Prof. Juš Kocijan
5. Optimal Management of Waste - Water Systems
   COST 624; EC
   Dr. Nadja Hvala
6. Advanced Tools for Control and Monitoring of Complex Systems
   Dr. Tatiana Guy, Institute of Information Theory and Automation, Prague, Czech Republic
   Dr. Đani Juričič
7. Intelligent Hierarchical Control of Wastewater Treatment Plants
   Prof. Robert E. King, Computer Technology Institute, Patras, Greece
   Prof. Juš Kocijan
8. Optimal Control of Biological Wastewater Treatment Plants
   Prof. Stefano Marsili-Libeli, University of Florence, Department of Systems and Computers, Florence, Italy
   Dr. Nadja Hvala
9. Nonlinear Model-based Condition Monitoring for Chemical and Process Industries
   Dr. Katalin Hangos, Computer and Automation Research Institute, Hungarian Academy of Sciences, Budapest, Hungary
   Dr. Đani Juričič
10. Design and Application of Model-Based Fault Detection and Isolation to Thermal Processes
    SLO-GER 2002/2
    Prof. Rolf Isermann, Technische Universität Darmstadt, Darmstadt, Germany
    Prof. Stanko Strmčnik
    Prof. Drago Matko

NEW CONTRACTS SIGNED

1. Software for communication chain support
   Inea Domžale
   Dr. Janko Petrovčič
2. Integrated computer-based production management
   Kovinoplastka Lož
   Dr. Alenka Žnidaršič
3. Flexible technological line for production of special emulsions
   Mitol Sežana
   Dr. Vladimir Jovan

VISITORS FROM ABROAD

1. Dr. Pavel Ettler, COMPUREG, Pilzen, Czech Republic, 7.5.2002
2. Dr. Alexandra Grancharova, Norwegian University of Science and Technology, Trondheim, Norway , 9.-29.6.2002
3. Dr. Marinus Nielsen, Krueger, Denmark, 20.-21.8.2002
4. František Jirkovski, Czech Academy of Sciences, Prague, Czech Republic, 7.10.2002
5. Arnold Engber, TU Darmstadt, Darmstadt, Germany , 3.-9.11.2002
6. Jurgen Schmitt, TU Darmstadt, Darmstadt, Germany, 3.-9.11.2002

ORGANIZATION OF CONFERENCES AND MEETINGS

1. Modelling and simulation of control systems: continuing education (specialisation) course in Control Technology, Ljubljana, February 11-15, 2002
2. Industrial control systems: continuing education (specialisation) course in Control Technology, Ljubljana, April 8-12, 2002
3. Advanced control methods: continuing education (specialisation) course in Control Technology, Ljubljana, July, 3-7, 2002
4. The 3rd International PhD Workshop, Strunjan, Slovenija, October, 1-4, 2002
5. Software for process control: continuing education (specialisation) course in Control Technology, Ljubljana, October 14-18, 2002

STAFF

Researchers

1. Dr. Janko Černetič
2. Dr. Nadja Hvala
3. Dr. Vladimir Jovan
4. Asst. Prof. Đani Juričić
5. Prof. Rihard Karba*
6. Prof. Juš Kocijan**
7. Prof. Drago Matko*
8. Dr. Janko Petrovčič**
9. **Prof. Stanko Strmčnik**, Head**
10. Dr. Damir Vrančić
11. Prof. Borut Zupančič*
12. Dr. Mina Žele

Postdoctoral associates

13. Dr. Gregor Dolanc
14. Dr. Dejan Dragan
15. Dr. Samo Gerkšič
16. Asst Prof. Andrej Rakar**
17. Dr. Alenka Žnidaršič***

Postgraduates

18. Boštjan Hauptman, M. Sc.
19. Gregor Kandare, B. Sc.
20. Aljaž Stare, B. Sc.
21. Dejan Tinta, B. Sc.
22. Darko Vrečko, B. Sc.
23. Sebastjan Zorzut, B. Sc.

Technical officers

24. Giovanni Godena, B. Sc.
25. Dr. Zoran Marinšek***

26. Matjaž Šubelj, M. Sc., pause 31.12.1998

Technical and administrative staff

27. Janez Grom
28. Maja Janežič
29. Miroslav Štrubelj

* Full-time faculty member
** Part-time faculty member
*** Member of industrial or other organisation