

# DEPARTMENT OF SYSTEMS AND CONTROL

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*The Department of Systems and Control is engaged in research, development, applications, and education across various areas of control technology. Its mission is 'to bridge the gap between theory and practice'. Hence, the research activities are rather application oriented, and the work is closely related to the needs of production companies. The activities of the department are focused on four closely integrated targets: basic and applied research, R&D projects for industrial and other users, education and training of engineers, and the networking and integration of Slovenian institutions and companies dealing with control technology.*

## Basic and applied research

Research within this area during the year 2005 was devoted to three sub-areas: analysis and control of complex systems and processes, fault detection and isolation, and computer-integrated production control.

The aim of research in the sub-area **analysis and control of complex systems and processes** was to improve existing and develop new algorithms for systems or process control. Here, the emphasis of our work was to develop new approaches in experimental modelling of linear and nonlinear systems based on identification by Gaussian processes, to develop methods for control design based on identification with multimodel algorithms, to optimise tuning algorithms for industrial controllers, and to apply control algorithms in stereoscopy. Part of our work was

Nowadays, continuous quality control in manufacturing as well as in the processing industries and other high-technology systems has become standard in helping to better productivity and competitiveness. Therefore, **fault detection and isolation** is currently a fast developing sub-area of research in the Department of Systems and Control of increasing significance for our industrial partners. In the year 2005, our research on robust fault detection in control actuators with consideration of model error was continued. In addition, some work was done on robust fault detection of nonlinear systems. A thorough industrial case study done in our laboratory has revealed that invented fault detection procedures allow reliable isolation of faults in the production of household vacuum cleaner-motors. These new procedures also offer high diagnostic sensitivity and precision in isolating mechanical problems in these products. On the basis of our acquired knowledge and experience, we were able to construct a universal systems concept for automatic online supervision of production processes and product quality (Fig. 1).

Our research in **computer-integrated production control** is aimed at enhancing existing manufacturing information and execution systems (MES) with functions for efficient decision-making. In 2005, a procedural model was developed for a selected manufacturing system. The new model is designed as a functional building block of MES, supporting decision-making, which will use technology as well as production cost parameters to help production managers in optimising efficient closed-loop production control (Fig. 2).

The second research topic within this sub-area was modelling the process of polymerisation using the modelling tool "gPROMS". The aim of this modelling effort was to improve the production technology and the production control procedures. The third topic led to the design of a flexible recipe management and control system for use with industrial programmable controllers. Our work on the fourth research topic within the sub-area computer-integrated production control resulted in improved methods for design and evaluation of human-centred technology.



Head:  
**Prof. Stanislav Strmčnik**

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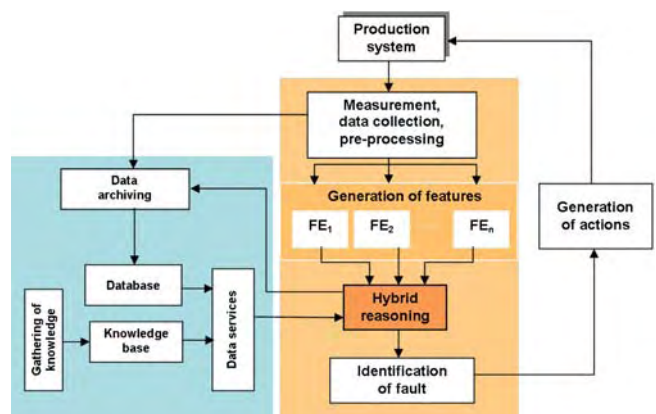


Figure 1: Structure of the system for online process supervision and quality control in manufacturing and processing industries.

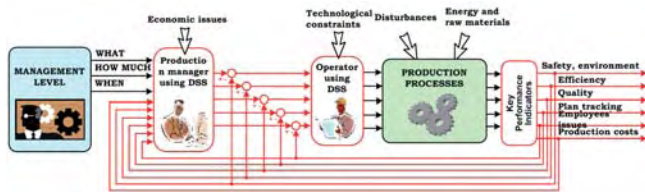


Figure 2: Outline of a system for decision support (DSS) in production control based on key performance indicators.

at our department. Work was continued with the company **DOMEL** from Železniki on the development of control devices and procedures aimed at preventive fault diagnosis and isolation in the production of household vacuum-cleaner motors (Fig. 3). For the same company, industrial prototype devices and a patented method were developed for the analysis of sparking in universal commutator electric motors.

Researchers from our department are cooperating for more than two decades with the development team at the Chemical Works Cinkarna Celje on improving control procedures and process control equipment in the production of titanium dioxide. During the year 2005, they developed algorithms for pH control and for smoothing the peaks in steam consumption. For



Figure 3: System for automatic final quality control of vacuum cleaner motors in the company Domel, Želeniki, Slovenia.

the pharmaceutical company LEK, improved algorithms for controller tuning have been developed and validated at their production site in Mengeš near Ljubljana (Fig. 4). At the subsidiary of the company Danfoss in Ljubljana, a complete control system (including hardware, control procedures and software) was developed by our department. The new control system helps to manage a complex semi-industrial setup for systematic functional testing of the elements needed for building heating and climatisation (Fig 5). In addition to the projects mentioned above, part of our work was devoted to smaller projects, such as functional specifications for automatic control of a pharmaceutical plant, and improvement of batch control procedures, both for the company Metronik.

### Education and training activities

Some members of the department are giving lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana, the Polytechnic of Nova Gorica, and the “Jožef Stefan” International Postgraduate School. They also act as supervisors of M.Sc and Ph.D. students. Special care was dedicated to post-qualification training for engineers from industry. In 2004, three one-week courses were organized. These courses were organized in close co-operation with the Information Technologies Knowledge Transfer Center at the Jožef Stefan Institute.

### Integration of Slovenian institutions and companies dealing with control technology

Members of the Department of Systems and Control play one of the key roles in the management, professional, and organisational coordination of the technology network called “Process control technology”, together with its research and application projects. This technology network integrates eleven companies (who are suppliers of either control technology services or control equipment) and three R&D or education/training institutions. The technology network and its projects are co-financed by the European Regional Development Fund. One of these projects, managed by our department, aims at establishing the Centre of Excellence for Advanced Control Technologies in Slovenia.

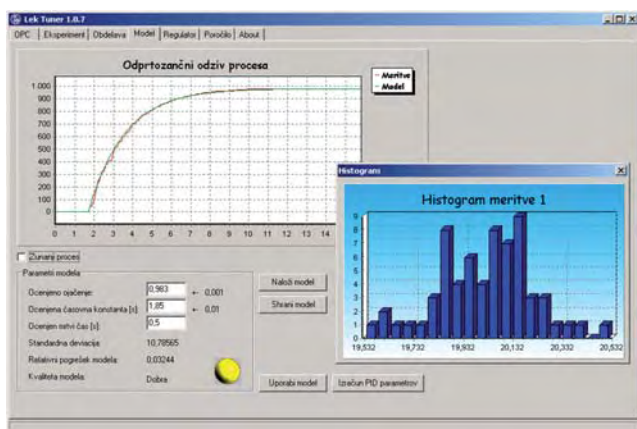


Figure 4: Monitor display generated by the software for automatic controller tuning developed for the pharmaceutical company LEK, Slovenia.

### Some outstanding publications in the past three years

1. Dolanc, Gregor, Strmčnik, Stanko. Identification of nonlinear system using a piecewise-linear Hammerstein model. Syst. control. lett. [Print ed.], 2005, vol. 54, str. 145-158.
2. Hvala, Nadja, Strmčnik, Stanko, Šel, Davorka, Milanič, Srečko, Banko, Blaže. Influence of model validation on proper selection of process models - an industrial case study. Comput. chem. eng. [Print ed.], 2005, vol. 29, str. 1507-1522.
3. Benko, Uroš, Petrovčič, Janko, Juričič, Dani, Tavčar, Jože, Rejec, Jožica. An approach to fault diagnosis of vacuum cleaner motors based on sound analysis. Mech. syst. signal process., 2005, vol. 19, str. 427-445.

### The most important technological achievements in the past three years

1. A control system for magneto-focused plasma annealer (Gregor Dolanc, Samo Gerškšič)
2. A system for quality control of vacuum cleaner motors (Janko Petrovčič, Gregor Dolanc, Bojan Musizza, Dani Juričič, Dejan Tinta, Uroš Benko, Janez Grom, Miro Štrubelj)

### Awards and appointments

1. Janko Petrovčič, Gregor Dolanc, Bojan Musizza in cooperation with team members of the company Domel, Železniki: The Golden Award for Innovations 2004 awarded by The Chamber of Economy of Gorenjska Region awarded. The aim of this award is to strengthen the competitiveness of industry in Gorenjska region with the promotion of innovation activities, Kranj, 14. 6. 2005

### Organization of conferences, congresses and meetings

1. Information Technologies & Control: Young Generation Viewpoint: 6<sup>th</sup> International PhD Workshop, Izola, October 4 - 8, 2005
2. Production management and information systems: continuing education (specialisation) course in Control Technology, Ljubljana, January 31 - February 4, 2005
3. Automation and information technology projects: continuing education (specialisation) course in Control Technology, Ljubljana, April 18-22, 2005
4. Building blocks for computer automation: continuing education (specialisation) course in Control Technology, Ljubljana, October, 17-21, 2005

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## ORIGINAL ARTICLES

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2. Gregor Dolanc, Stanko Strmčnik: Identification of nonlinear system using a piecewise-linear Hammerstein model. Syst. control. lett., Vol. 54, pp. 145-158, 2005.
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4. Juš Kocijan, Agathe Girard, Blaže Banko, Roderick Murray-Smith: Dynamic systems identification with Gaussian processes. Math. comput. model. dyn. syst., Vol. 11, Vol. 4, pp. 411-424, 2005.
5. Aljaž Stare, Nadja Hvala, Darko Vrečko: Modeliranje in validacija poenostavljene modela za prediktivno vodenje amonijevega dušika v čistilni napravi odpadnih voda. Elektroteh. vestn., Vol. 72, pp. 225-230, 2005.
6. Dejan Tinta, Janko Petrovčič, Uroš Benko, Dani Juričič, Andrej Rakar, Mina Žele, Jože Tavčar, Jožica Rejec, Aneta Stefanovska: Fault diagnosis of vacuum cleaner motors. Control Engineering Practice, Vol. 13, pp. 177-187, 2005.
7. Mina Žele, Dani Juričič: Estimation of the confidence limits for the quadratic forms in normal variables using a simple Gaussian distribution approximation. Comput. stat. (Z.), Vol. 20, pp. 137-150, 2005.
8. Mina Žele, Darko Vrečko, Dani Juričič: Spremljanje delovanja senzorjev v čistilni napravi odpadnih voda z uporabo adaptivne metode glavnih komponent. Ventil (Ljubl.), Letn. 11, No. 2, pp. 84-88, 2005.



Figure 5. Semi-industrial setup for systematic functional testing of elements needed in the heating and climatisation of buildings. The control system for the setup shown here was developed by the Department of Systems and Control.

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**Members of the Department of Systems and Control, Janko Petrovčič, PhD, Gregor Dolanc, PhD, and Bojan Musizza, together with the leading engineers from company DOMEL were awarded by the Slovenian Chamber of Economy, Regional Chamber for Gorenjska, Kranj, with the 'Golden Award for Innovation'.**

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**Members of the Department of Systems and Control play one of the key roles in the management, professional, and organisational coordination of the technology network called "Process control technology"**

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9. Robert Blatnik, Janko Černetič: Vrednotenje antropocentričnosti računalniške podpore dobavljanja sestavnih delov. Organizacija (Kranj), Let. 38, No. 5, pp. 225-231, 2005.

## REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Juš Kocijan, Roderick Murray-Smith: Nonlinear predictive control with a Gaussian process model. Switching and learning in feedback systems: European Summer School on Multi-Agent Control, Maynooth, Ireland, September 8-10, 2003: revised lectures and selected papers (Lecture notes in computer science, vol. 3355), Roderick Murray-Smith, ed., Robert Shorten, ed., Berlin, Heidelberg, New York, Springer, cop. 2005, pp. 185-200.

## PUBLISHED CONFERENCE PAPERS

### Invited Paper

1. Andriy Bandrivskyy, M. Entwistle, P. V. E. McClintock, Bojan Musizza, Milan Paluš, Janko Petrovič, Samo Ribarič, A. Smith, Aneta Stefanovska: Stochastic dynamics of anesthesia, pp. 553-558.

### Regular Papers

1. Kristjan Ažman: Incorporating prior knowledge into Gaussian process models. Proceedings of the 6th International PhD Workshop on Systems and Control, October 4-8, 2005, Izola, Simonov zaliv, Slovenia: young generation viewpoint, Dejan Tinta, ed., Uroš Benko, ed., Ljubljana, Institut Jožef Stefan, 2005, 6 pp.
2. Kristjan Ažman, Juš Kocijan: Comprising prior knowledge in dynamic Gaussian process models. CompSysTech'05: proceedings of the International Conference on Computer Systems and Technologies and Workshop for PhD Students in Computing: Varna, Bulgaria, 16-17 June, B. Rachev, ed., A. Smirakov, ed., [Varna], Bulgarian Chapter of ACM, 2005, pp. IIB.2-1-IIB.2-5.
3. Kristjan Ažman, Juš Kocijan: An example of Gaussian process model identification. MIPRO 2005: 28. mednarodni skup, May/Svibanj 30 - June/Lipanij 03, 2005, Opatija, Croatia: Proceedings/Zbornik radova, Leo Budin, ed., Slobodan Ribarič, ed., Rijeka, MIPRO, 2005, pp. 79-84.
4. Kristjan Ažman, Juš Kocijan: Identifikacija dinamičnega sistema s histerezo z modelom na osnovi Gaussovih procesov. Zbornik štirinajste mednarodne Elektrotehniške in računalniške konference ERK 2005, 26. - 28. september 2005, Portorož, Slovenija (Zbornik... Elektrotehniške in računalniške konference ERK...), Baldomir Zajc, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2005, Zv. A, pp. 253-256.
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7. Janko Černetič, Robert Blatnik: Human-centred collaborative system supporting JIT delivery in manufacturing. Preprints of the 16th IFAC World Congress: Prague, Czech Republic, July 3-8, 2005, P. Horacek, ed., M. Simandl, ed., P. Zitek, ed., [Prague], IFAC, 2005, 6 pp.
8. Vladimir Jovan, Boštjan Hauptman: An algorithm for reactive batch sequencing. EFTA 2005: 10th IEEE International Conference on Emerging Technologies and Factory Automation: proceedings: September 2005, 2005, Catania, Italy, Lucia Lo Bello, ed., Thilo Sauter, ed., Piscataway, IEEE, 2005, Zv. 2, pp. 833-840.
9. Gregor Kandare: Automatic programme synthesis. Proceedings of the 6th International PhD Workshop on Systems and Control, October 4-8, 2005, Izola, Simonov zaliv, Slovenia: young generation viewpoint, Dejan Tinta, ed., Uroš Benko, ed., Ljubljana, Institut Jožef Stefan, 2005, 6 pp.
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11. Bojan Musizza, Uroš Benko, Dejan Tinta: Interactions between cardiac, respiratory and brain activity in humans. Proceedings of the 6th International PhD Workshop on Systems and Control, October 4-8, 2005, Izola, Simonov zaliv, Slovenia: young generation viewpoint, Dejan Tinta, ed., Uroš Benko, ed., Ljubljana, Institut Jožef Stefan, 2005, 6 pp.
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## TEXTBOOKS AND LECTURE NOTES

1. Juš Kocijan: Dodatno gradivo iz osnov avtomatskega vodenja: Nova Gorica, [J. Kocijan], 2005.

## THESES

### B. Sc. Theses

1. Manca Makarovič: Preparing users manual for Scilab program package for beginners (Juš Kocijan)
2. Rado Usicc: Replacement and renewal of power transformer units for Casino Park entertainment centre (Juš Kocijan)
3. Janko Vončina: Feasibility study for computer control of buildings (Juš Kocijan)

## INTERNATIONAL PROJECTS

1. Towards Knowledge - Based Processing Systems  
PRISM  
6. FP; MRTN-CT-2004-512233  
EC; Imperial College of Science Technology and Medicine, London, Great Britain  
Dr. Mina Žele, Dr. Gregor Kandare

2. The Control System for the Plasma Cleaning Machine  
Primož Eiselt, PlasmaBull GmbH, Lebring, Avstria  
Dr. Vladimir Jovan
3. Data-Driven Modelling for Decision-making Support and Process Monitoring  
BI-CZ/05-06/008  
Dr. Tatiana Valentine Guy, Institute for Information Theory and Automation,  
Department of Adaptive Control, Prague, Czech Republic  
Asst. Prof. Andrej Rakar, Asst. Prof. Dani Juričič

4. Optimal Control of Biological Wastewater Treatment Plants  
SLO-ITA 4B/2002-2005, BI-IT/02-05-022  
Prof. Stefano Marsili-Libeli, University of Florence, Department of Systems and Computers, Florence, Italy  
Dr. Nadja Hvala
5. Advanced Modelling Techniques for Distributed Parameter Systems with Application to Fault Diagnosis  
BI-MK/04-05-014  
Prof. Georgi Dimirovski, Faculty of Electrical Engineering, Institute of Automation & Systems Engng., Skopje, Macedonia  
Asst. Prof. Đani Juričić
6. Design of PDI Controllers: Interchange of Technology and Experience  
BI-PT-04-06-020  
Prof. José Paulo B. De Moura Oliveira, Engineering Department, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal  
Asst. Prof. Damir Vrančić

## R & D GRANTS AND CONTRACTS

1. Design of fault detection and isolation systems with application to quality assessment of electrical motors  
Asst. Prof. Đani Juričić
2. Development of an intelligent diagnostic system for rotational machines  
Asst. Prof. Đani Juričić
3. Optimization of HVAC systems using dynamic models  
Prof. Stanko Strmčnik
4. Early diagnosis of lung cancer in subjects with professional asbestosis  
Asst. Prof. Đani Juričić
5. Development and optimisation of personal military equipment  
Asst. Prof. Đani Juričić
6. Industrialization of advanced control algorithms for PLC  
Prof. Stanislav Strmčnik, Dr. Samo Gerškšič

## RESEARCH PROGRAM

1. Systems and Control  
Prof. Stanko Strmčnik

## NEW CONTRACTS

1. The methodology for software standardisation  
Raci, d. o. o., Danfoss Trata, d. d.  
Dr. Gregor Dolanc
2. LITE – A programme package for PLC batch control  
Inea, d. o. o.  
Giovanni Godena, B. Sc.
3. Improving the control of complex continuous processes  
Robotina, d. o. o.  
Giovanni Godena, B. Sc.
4. Advancement of the process of HVAC control systems development  
Goap, d. o. o., Telem, d. o. o.  
Giovanni Godena, B. Sc.
5. Reusability in the software development process  
Liko Pris, d. o. o.  
Giovanni Godena, B. Sc.
6. Development of steam consumption smoothing algorithms in Cinkarna Celje  
Cinkarna, d. d.  
Dr. Nadja Hvala
7. Analysis and validation of »case study« projects  
Synatec elektronika, d. o. o.  
Dr. Vladimir Jovan
8. The integration of production information system modules  
Inea, d. o. o.  
Dr. Vladimir Jovan
9. Development of a conceptual model of an integrated production information system  
Synatec elektronika d. o. o., Metronik d. o. o., Inea d. o. o.  
Dr. Gregor Kandare
10. Upgrade of a system for product-quality assessment  
Domel, d. d.  
Dr. Janko Petrovčič
11. HVAC systems optimisation based on dynamic system models  
Goap, d. o. o.  
Prof. Stanislav Strmčnik
12. Heat transfer model for hotel rooms  
Goap, d. o. o.  
Dr. Mina Žele

## VISITORS FROM ABROAD

1. Yasunobu Iwata, Lars Wolk, Mitsubishi Electric European Development Center, Ratingen, Germany, 12. 5. 2005

2. Dr. Pavel Ettler, COMPUREG, Plzen, Czech Republic, 6. 6. 2005
3. Prof. Wang Qing-Guo, Department of Electrical and Computer Engineering, National University of Singapore, Singapore, 1. 7. 2005
4. Dr. Andrew Crossan, Hamilton Institute, National University of Ireland, Maynooth, Co.Kildare, Ireland, 14. 10. 2005

## STAFF

### Researchers

1. Dr. Janko Černetič\*\*
2. Dr. Gregor Dolanc
3. Dr. Samo Gerškšič
4. Dr. Nadja Hvala\*\*
5. Dr. Vladimir Jovan
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7. Prof. Juš Kocijan\*\*
8. Dr. Janko Petrovčič\*\*
9. Prof. Stanislav Strmčnik\*\*, Head
10. Asst. Prof. Damir Vrančić\*\*
11. Dr. Mina Žele

### Postdoctoral associates

12. Dr. Gregor Kandare
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14. Dr. Darko Vrečko
15. Dr. Alenka Žnidaršič\*\*\*

### Postgraduates

16. Kristjan Ažman, M. Sc.
17. Uroš Benko\*\*, B. Sc.
18. Satja Lumbar, B. Sc.
19. Bojan Musizza, B. Sc.
20. Boštjan Pregelj, B. Sc.
21. Aljaž Stare, B. Sc.
22. Dejan Tinta, M. Sc.
23. Sebastjan Zorzut, M. Sc.

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

### Technical and administrative staff

26. Janez Grom
27. Maja Janežič, B. Sc.
28. Miroslav Štrubelj

\*\* Part-time faculty member

\*\*\* Member of industrial or other organisation