

DEPARTMENT OF SYSTEMS AND CONTROL

E-2



Head:
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The Department of Systems and Control is engaged in research, development, applications and education in the area of control technology. These activities are being performed in close cooperation with the Faculty of Electrical Engineering of the University of Ljubljana and the engineering company INEA. These three institutions make a consortium referred to as the “Technology vertical”, the aim of which is to merge expertise and knowledge transfer. To further stimulate cooperation with industry, a technology centre referred to as ConTech Centre, has been established within the Department.

Basic and applied research

Research in the area of **fault detection and isolation** has continued in the area of robust detection in the presence of modelling errors. Proper handling of modelling errors helps in reducing

false alarms. In the problem set up the stochastic description of the modelling errors has been employed. Research was focused on analysis of underlying statistical tests and extension of the concept to the parity relations approach. In addition, part of the research was devoted to investigating new approaches to the diagnosis of nonlinear systems represented by Gaussian mixture models. The ideas were experimentally verified on a gas-conditioning unit.

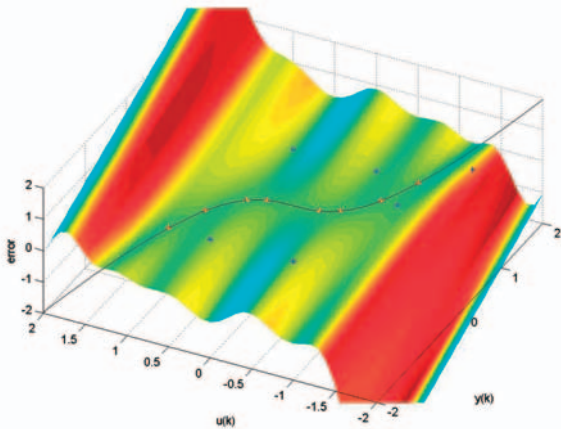


Figure 1: Error surface between system and Gaussian Process model. Modelling data are given with coloured asterixes.

In the area of **process control and optimization** the research efforts were directed towards nonlinear multimodel based control, industrial controller tuning systems and use of probabilistic models, namely Gaussian process models, for dynamic systems modelling and control (Fig. 1).

The second part of research in this area concerned control of wastewater treatment processes. Research within the EU 5th FP project “SMAC – SMARt Control of wastewater systems” addressed the design of advanced algorithms for control of the nitrification process in a wastewater treatment plant, with the aim of improving the effluent quality and reducing energy consumption. A mathematical process

model was developed, which was then used in predictive and nonlinear internal model control algorithms to control the real plant. Testing on the real plant was performed in MATLAB environment with the on-line internet connection to the existing control and information system on the real plant.

Research in **computer integrated production** took three directions. The majority of activities were devoted to the 5th FP project “Virtual Plant Wide Management and Optimization of Responsive Manufacturing Networks”. In this project our group was responsible for the development of an on-line algorithm for batch sequences in a case study process of two-stage gel washing at Cinkarna Celje d.d.

In the area of software (domain) engineering we have carried on the research concerning the design of a model of the process control domain, the specifications of the previously developed ProcGraph notation and the automatic transformation of the specifications into programme code.

The third sub-area concerns non-technical aspects of control technology. In this frame, two methods for design and evaluation of human-centred technologies, namely the Dual Design Method and the KOMPASS method, were evaluated using practical examples.

R & D projects

In the frame of a long term cooperation with the companies INEA and MITSUBISHI, the work on particular segments of the previously developed blow-moulding machine control systems was carried on. In this context a special hydraulic set-up was also designed. The set-up enables testing of high speed hydraulic positioning at 1 m/s and accelerations of over 10 m/s², while loads may be changed from 0-50 kg at vertical or horizontal positioning. The work related to industrialization of a prototype incorporating advanced control algorithms in programmable logic controllers (ASPECT) has been also continued, with emphasis on testing the prototype on pilot applications.

In the company Domel, Železniki, a method for the detection of characteristic mechanical faults of vacuum cleaner motors has been developed. The method is capable of detecting mechanical

The researchers of the department have contributed substantially to the establishment of the technology network “Process control technology”, which was initiated by the Ministry of Economics and consists of major business and academic players in this field in Slovenia.



Figure 2: Magneto-focused plasma annealer control system

imperfections in the turbo-wheel, detection of rubbing between the turbo-wheel and cover as well as isolation of faults in bearing. In addition, two prototype test cells were designed and tested, i.e. an axial play test cell and a vibration test cell.

For the company Danfoss Trata a system for pressure difference control of the hydraulic testing line was developed and implemented. Basically, the system adjusts the speed of rotation of existing pumps in such a manner that the pressure difference follows the set-point value as closely as possible. To meet the specific requirements some advanced control solutions, together with a set of additional control and supervision functions, had to be implemented.

For the Austrian company Plasmalt, a control system was developed for a new and modern magneto-focused plasma annealer capable of annealing and cleaning wire surfaces (Fig. 2). The control system is composed of the following functional units: electrode power management, adaptive pressure control and atmosphere preparation, control of peripheral systems, co-ordination of operating regimes and system diagnostics.

A part of our R&D work was devoted to problems of automatic tuning of controllers of HVAC systems in the pharmaceutical company LEK, d.d.. In this frame experimental modelling of the processes was carried out, together with development of the corresponding tuning algorithms, based on measured signals, and the design of a prototype tool in DELPHI.

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In addition to the larger projects mentioned above, part of our work was devoted to smaller projects for the companies Mitol, Kovinoplastika, Čistilna naprava Domžale-Kamnik and ALTEX d.o.o.

Finally, we have devoted a substantial part of our activities to establishing the technology network referred to as "Process Control Technology", which was initiated and co-financed by the Ministry of Economics. The network consists of 11 companies (solutions and equipment providers) and 3 academic institutions. It aims to constitute the basic instrument for making a breakthrough in the field of control, automation and computer supported processes in Slovenian companies.

Education Activities

Some members of the department are giving lectures and practical courses at the Faculty of Electrical Engineering, University of Ljubljana and the Polytechnic of Nova Gorica. 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 2003 three one-week courses were organized. These activities were organized in close co-operation with the Information Technologies Knowledge transfer Centre at the Institute.

Some outstanding publications in the past three years

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THESES

B. Sc. Theses

- Klavdijo Cigoj: Automatic control design for a jigsaw puzzle machine (Juš Kocijan)
- Boštjan Gnezda: Automation of the process of electromotor assembling (Stanko Strmčnik)

Ph. D. Thesis

- Darko Vrečko: Design and comparison of control strategies for biological wastewater treatment plants (Rihard Karba)