

*The department is engaged in the analysis, control and optimization of systems and processes. The activities of the department are focused on the research of new methods and algorithms for automatic control, the development of procedures and tools to support the design and construction of control systems, the development of specific measurement and control modules, and the development and construction of complete systems for the control and supervision of machines, devices and industrial processes.*



Head:  
**Dr. Vladimir Jovan**

### Basic and applied research

The basic and applied research in 2012 was devoted to three sub-areas: methodologies for analysis and control systems design; tools and building blocks for implementation; and applied research in the priority problem domains.

The sub-area methodologies for analysis and control systems design included three topics. The first topic addressed the modelling and identification of nonlinear and complex dynamical systems. The research in the dynamic systems modelling was directed towards the on-line training, analysis and application of Gaussian process models for the modelling of static and the identification of dynamic systems. The application of modelling with Gaussian process models of traffic, biological and environmental systems was pursued (Figure 1).

The second topic was (advanced) control. The developed methods for the implementation of the simplified explicit predictive controller were tested in pilot applications of liquid level control in a laboratory plant and the vertical stabilisation of the plasma position in the ITER tokamak fusion reactor model. We have shown the practical advantages enabled by systematic handling of constraints on the process signals, and successfully demonstrated control of the processes with fast dynamics, where a conventional predictive controller based on on-line optimisation is not useful due to the long computation time.

The third topic of interest was condition monitoring and fault diagnosis. A new robust method for bearings prognostics based on the concepts of the Jensen-Reny entropy, divergence and the complexity of vibrational signals is proposed. The relationships between the entropy indices and the remaining useful life of the bearing are described by means of nonlinear dynamical systems. The approach is robust to incomplete information about the underlying operating conditions. With this algorithm our colleagues achieved the second-ranked result on a data challenge organized in the context of the international IEEE PHM Conference.

A key feature of modern condition monitoring systems in the ability to predict the remaining useful life of the system or its components. To achieve this, we focus on the development of system-identification algorithms for prognostics and health management (PHM). We have developed a prognostics algorithm, which relies on Gaussian Process models and applied it to bearings monitoring. More recently, we focused on the utilization of the Marginalized particle filtering framework for PHM.

We continued with the development of the prototype of a versatile low-cost platform (labelled MEMS-PHM) for the prognostics and health management of electro-mechanical drives. It relies on cutting-edge MEMS (micro-electromechanical sensor) technologies. The hardware and software design of the underlying smart sensor node as well as the MEMS sensor prototype were almost completed. The first version of the MEMS-PHM platform was successfully implemented on a milling machine in the company LitostrojPower.

A part of the work, which is also related to condition monitoring, dealt with the problem of monitoring the water conditions inside a PEM fuel-cell stack. In 2012, we continued working on the diagnostics of flooding and drying inside PEM fuel cells with use of electrochemical impedance spectroscopy (EIS). In-house-developed measurement equipment made it possible to start dealing with the diagnostics of individual fuel cells inside a larger fuel-cell stack, which was before this unfeasible. The mentioned equipment was used for an experimental study,

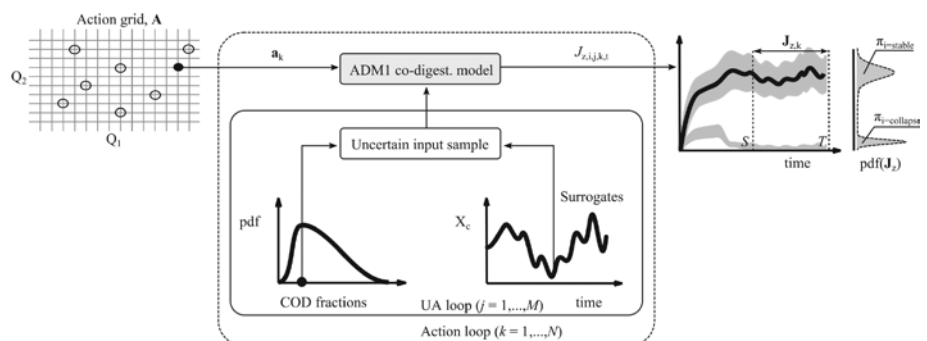


Figure 1: Uncertainty outcomes of the selected criterion for a given input action under input uncertainty. (Source: *Water Research*, 2012, vol. 46, no. 18, pp. 6121-6131)

which confirmed that the equipment itself is precise enough to perform the measurements the EIS requires. At the same time, valuable data was acquired for further research (Figure 2).

The sub-area tools and building blocks for implementation also included three parts. A method for the efficient control of under-damped systems has been developed. The method efficiently stabilizes systems in the open-loop and in the closed-loop configurations. In the frame of research dealing with tools and methodologies for process control software synthesis the work on a model-driven methodology for industrial process control software development



Figure 2: PEM fuel cells and measurement equipment during test operation

named MAGICS was continued. An empirical evaluation of this methodology was performed, which revealed an increase in productivity with savings between 18% and 33% of the total development effort and an improvement of the software quality due to the elimination of the code-generation errors. A new version of the development environment for this methodology was also developed (Figure 3).

In cooperation with the CONOT Center of Excellence Low Carbon Technologies we designed new components for fuel-cell-based power systems. In 2012 a diagnostic module for PEM fuel-cell-stack-based power units was developed as a low-cost solution for the on-line monitoring of each cell's voltage inside a stack. Besides the monitoring, the module provides the means for precise measurements of changes in the voltage of any individual cell inside a stack, which further enables the performance of the diagnostics of faults, such as cell flooding and membrane drying. The module is designed to perform measurements and data acquisition, further signal processing and diagnostics algorithm computation in real time (Figure 4).

Applied research in the priority problem domains was the third sub-area of our interest. In this frame a substantial part of our activities was devoted to the development of the specific control systems described below.

A numerically efficient version for signal de-noising based on an adaptive Kalman filter was implemented and assessed on plant data. The algorithm was applied to the pressure signal in order to improve the closed-loop control of the strip thickness in cold milling. The main idea is to manipulate the filter gain by means of the valve aperture. The work has been carried out in the frame of the international project PROBAsENSOR.

We have implemented function blocks that enable the implementation of a simplified explicit predictive controller with constraints handling on industrial programmable-logic controllers in the IDR BLOK development environment, and have tested them in pilot applications.

Control of wastewater treatment plants is our traditional research area. A model of the entire Domžale-Kamnik wastewater treatment plant (WWTP) has been built, including both the water line and the sludge line. The model shows a relatively good agreement with the real-plant daily average measurements. It has been used for studying

the possibilities of how to reduce the impact of the sludge line on the water line in the Domžale-Kamnik WWTP. Simulation results show that by properly increasing the digested sludge flow-rate to dewatering, the amount of sludge and ammonia that are back-cycled from the sludge line to the water line are significantly reduced, whereas the amount of the dehydrated sludge, which is disposed to the landfills and the amount of the biogas produced remain almost the same.

Production control is also an important domain of our research work. The major problems in manufacturing today still relate to unexpected breakdowns and the degradation of product quality with no obvious reasons. In collaboration with the company Kolektor KFH, we have developed procedures for the automatic analysis of data from the production process. From these, the parameters that have a significant influence on the quality of the final product are determined. Additionally, the identified mathematical models are then used by the advanced production monitoring and control modules.

In the field of production control, we were continuing the evaluation of a concept of model-based production control. More emphasis was given to the modelling and production dynamics analysis, i.e., determination of the model structure, usage of modelling tools such as neural networks, fuzzy

logic and Petri nets. We were also designing a tool for production dynamic analysis to help us implement all the key activities necessary for holistic production control.

In recent years, a part of our work was focused on the area of fuel cells. In 2011 and 2012 we started cooperation on two newly 7th European projects FCGEN-Fuel Cell Based On-board Power Generation and FluMaBack-Fluid

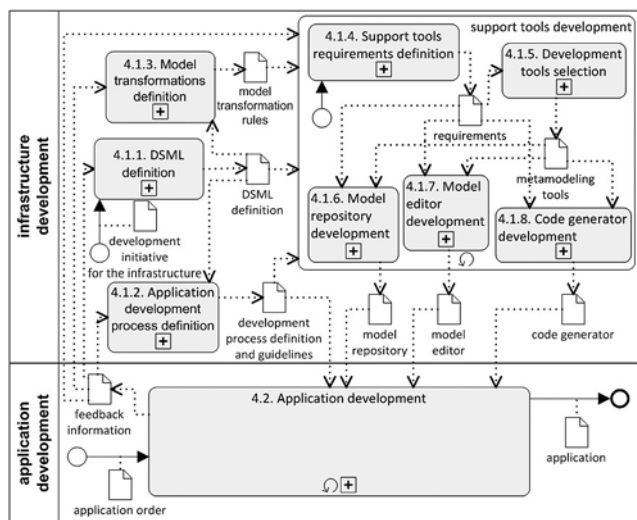


Figure 3: Two engineering levels of the MAGICS methodology

Management component improvement for back-up fuel cell systems. The objective of the FCGEN project is the development and demonstration of an auxiliary power unit (APU) for trucks, which uses an auto-thermal reformer to produce hydrogen from fuel and a fuel-cell stack for electric energy production. The goal is the substitution of low-efficiency main engine idling for covering electrical needs. Within the project both key components and system design will be further developed. The role of our group is the development of power conditioning, complete electronics and a control for all subsystems and for the integrated APU system. In the first half of 2012 the work mainly focused on the specification of the final process design of the APU system. Our group cooperated by making revising stages and providing solutions from the aspects of control and electric design. Additionally, the electrical APU layout has been designed and the APU load study performed. In the second half of 2012 the work was focused on determining the specifications for the APU's electrical layout and control system. In this context we determined the control concept, prepared a document with the specifications, developed part of the PLC software code and the HMI to monitor the entire process. In the FluMaBack project our group is responsible for improving the performance, cost efficiency and life time of essential balance of plant (BOP) components used in fuel-cell-based uninterruptable power back-up systems. In 2012 we started with the development of a PHM system for the condition monitoring of an air blower.



Figure 4: Diagnostic module for monitoring the fuel voltage of individual cells in a fuel-cell stack

Within the multidisciplinary project Ceracon- Integration and control of liquid fuel processor based on ceramic micro-systems which is financed by the European Space Agency we continued the development of the prototypes of critical components of the miniature size fuel reformer, which will serve as a source of hydrogen for miniature fuel cells. In 2012 we studied the efficiency of the reforming process as a function of the operating conditions and the type of catalyst.

#### R&D projects for industry and other users

A substantial part of the department's R&D activities for industry and other users is conducted within the Competence Centre for Advanced Control Technologies. In the second year of its operation, the first demonstration systems were developed, like an intelligent motor-drive valve, produced by the Danfoss Trata company, with an embedded system for the automatic reduction of oscillations, and a wireless sensor network implemented for diagnostic and prognostic maintenance of machines at the Litostroj Power company. At other application domains, like production management with integrated models, the optimisation of energy consumption in buildings, the optimisation of gas production in bioreactors and the control of fusion reactors, the appropriate simulation environments were set-up with the preliminary design of advanced control algorithms.

As described below, an important part of our activities is also devoted to direct cooperations with various companies.

An important part of our activities in the past year was performed in close cooperation with the INEA company. One of the activities to mention was the development of a new version of the batch control software tool. In the area of the development of recipe-based batch process control package for the PLC platform (PLCbatch) the automatic generation of the phase logic software skeleton was realized. This tool significantly reduces the amount of the routine and repetitive development tasks and the resulting errors. A preliminary concept of the dynamic unit allocation was also realized, aimed at improving the flexibility of batch-control systems.

In the framework of the project for Danfoss, the hardware and the firmware for "heavy-duty" motor-drives is under development. A flow-controller has been developed, implemented and tested on a family of motor-driven valves. The department has been involved in the promotion of intelligent motor-driven valves and in user training.

At Domel Electric Motors Suzhou Company Ltd., China, a new diagnostic system for the end quality control of electrical motors was completed in 2012 (Figure 5). The new system is the seventh in the series of similar, very successful diagnostic systems used in Domel.



Figure 5: Diagnostic system for end quality control on the production line at Domel Electric Motors Suzhou Company Ltd.

### Other projects

In 2012 the department has successfully concluded the tasks within the transnational project “Promoting Innovation in the Industrial Informatics and Embedded Systems Sector through Networking - I3E”. We have completed the final works regarding the main project outcomes that are the Strategic Research Agenda and Methodology Guideline for Innovation. In the final project phase our department has coordinated the final networking tasks and was actively involved in the promotion of the key project outcomes.

### Educational and training activities

Some members of the department are giving lectures and practical courses at different faculties and universities: the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica and the “Jožef Stefan” International Postgraduate School. They also act as supervisors of M.Sc. and Ph.D. students.

### Some outstanding publications in the past year

1. Boškoski, P., Juričič, Đ.: Fault detection of mechanical drives under variable operating conditions based on wavelet packet Rényi entropy signatures. *Mech. syst. signal process.*, 2012, vol. 31, pp. 369–381
2. Južnič-Zonta, Ž., Kocijan, J., Flotats, X., Vrečko, D.: Multi-criteria analyses of wastewater treatment bio-processes under an uncertainty and a multiplicity of steady states. *Water research (Oxford)*. [Print ed.], 2012, vol. 46, no. 18, pp. 6121–6131
3. Perne, M., Šarler, B., Gabrovšek, F.: Calculating transport of water from a conduit to the porous matrix by boundary distributed source method. *Eng. anal. bound. elem.* [Print ed.], 2012, vol. 36, no. 11, pp. 1649–1659
4. Gerkšič, S., Pregelj, B.: Tuning of a tracking multi-parametric predictive controller using local linear analysis. *IET control theory & applications*. [Print ed.], 2012, vol. 6, no. 5, pp. 1–11
5. Glavan, M., Gradišar, D., Strmčnik, S., Mušič, G.: Production modelling for holistic production control. *Simulation modelling practice and theory*, 2013, vol. 30, pp. 1–20

### Awards and appointments

1. Damir Vrančič, Aleš Svetek: the Puh award for 2012, which is the highest state award for development achievements issued by the Ministry of Education, Science, Culture and Sport within the Zois awards - the state highest awards for scientific and research achievements. The Puh award was bestowed on our department members and the partners from Danfoss Trata for the invention of intelligent motor drives for valves
2. Pavle Boškoski, Matej Gašperin, and Dejan Petelin were runners up in the IEEE PHM 2012 Prognostic Challenge (Data Challenge). They were invited to present their work at the 2012 IEEE International Conference on Prognostics and Health Management, Denver, Colorado, USA
3. Juš Kocijan: Best paper award during the conference Applied Mathematics, Simulation, Modelling 2012, North Atlantic University Union NAUN with paper Dynamic GP models: an overview and recent developments, Vouliameni, Greece

### The most important achievements in the past year

1. Puh Award for 2012, the highest national award for achievements in the field of development activities, was granted to Damir Vrančič and Aleš Svetek for the invention of intelligent actuators for valves
2. Implementation of an automatic diagnostic system for end quality control of electrical motors at Domel Electric Motors Suzhou Company Ltd., China. (Janko Petrovčič, Gregor Dolanc, Bojan Musizza, Stane Černe, Miroslav Štrubelj)
3. Pavle Boškoski, Matej Gašperin and Dejan Petelin were ranked in 2nd place among 20 teams on the IEEE PHM 2012 Prognostic Challenge for their solution for bearing's lifetime prediction. Their solutions were also presented as an invited lecture at the International Conference 2012 IEEE International Conference on Prognostics and Health Management, Denver, Colorado
4. Darko Vrečko and Juš Kocijan published an article in the journal *Water Research*, which is the most eminent scientific journal in the field of water resources

## INTERNATIONAL PROJECTS

1. Completion of the Acroni controls; Project: 10AP100000-SIAC-J  
Plasmait GmbH  
Dr. Gregor Dolanc
2. 7. FP - FCGEN: fuel cell based on-board power generation  
European Commission  
Dr. Boštjan Pregelj
3. 7. FP - FLUMABACK: Fluid management component improvement for back up fuel cell systems  
European Commission  
Dr. Pavle Boškosi
4. I3E - promoting innovation in the industrial informatics and embedded systems sectors through networking  
See Joint Technical Secretariat  
Dr. Vladimir Jovan
5. COST IC0702, SOFTSTAT: Combining soft computing techniques and statistical methods to improve data analysis solutions  
Cost Office  
Prof. Juš Kocijan
6. CERACON: Integration and control of liquid fuel processor based on ceramic micro-systems  
ESA/ESTEC  
Dr. Gregor Dolanc
7. COST IC0806, IntelliCIS: Intelligent monitoring, control, and security of critical infrastructure systems  
Cost Office  
Dr. Nadja Hvala

## R&D GRANTS AND CONTRACTS

1. Identification and model analysis for dynamic systems control design with Gaussian process priors  
Prof. Juš Kocijan

2. Integrated diagnostic system for drive assemblies  
Prof. Đani Juričić
3. Prognostics and health management of mechanical drives based on novel MEMS sensor networks  
Prof. Đani Juričić
4. Modeling and control of wastewater treatment plants for improving the effluent quality and energy effective operation  
Dr. Darko Vrečko
5. Advanced model based procedures for product quality control and management in complex production processes  
Prof. Đani Juričić
6. Simplified explicit predictive controller  
Prof. Stanislav Strmčnik
7. Probasensor: EUROSTARS; Probabilistic bayesian soft sensor - a tool for on-line estimation of the key process variable in cold rolling mills  
Prof. Đani Juričić
8. Competence centre for advanced control technologies: CC ACT  
Asst. Prof. Damir Vrančić

## RESEARCH PROGRAM

1. Program systems and control  
Prof. Đani Juričić

## NEW CONTRACTS

1. Prognostics and health management of mechanical drives based on novel mems sensor networks  
Domel, d. o. o.  
Prof. Đani Juričić
2. R&D Activities in the frame of the KC STV sub-projects No. 1.1, No. 1.2, and No. 4.2.  
Inea, d. o. o.  
Giovanni Godena, M. Sc.

## VISITORS FROM ABROAD

1. Prof. Giuseppe Ambrosino, Associazione Euratom-ENEA-CREATE, Dipartimento di Informatica e Sistemistica, Università di Napoli Federico II, Napoli, Italy, 16.-18. 1. 2012
2. Dr. Gianmaria De Tommasi, Associazione Euratom-ENEA-CREATE, Dipartimento di Informatica e Sistemistica, Università di Napoli Federico II, Napoli, Italy, 16.-18. 1. 2012
3. Daniel Toublant, scholarship IAESTE, Swansea University, Swansea, UK, 2. 7.-15. 8. 2012
4. Henry Rafael Concepcion Gomez, Department of Telecommunications and Systems Engineering, Universitat Autònoma de Barcelona, Barcelona, Spain, 1. 8.-31. 11. 2012
5. Prof. Vesna Mandić, University of Kragujevac, Kragujevac, Serbia, 23. 7. 2012
6. Prof. Milentije Stefanović, University of Kragujevac, Kragujevac, Serbia, 23. 7. 2012
7. Prof. Dragan Milosavljević, University of Kragujevac, Kragujevac, Serbia, 23. 7. 2012
8. Dr. Elisabet Capon Garcia, ETH, Zürich, Switzerland, 22. 10. 2012
9. Dr. Edrisi Munoz Mata, CIMAT, Zacatecas, Mexico, 22. 10. 2012

## STAFF

### Researchers

1. Dr. Gregor Dolanc
2. Dr. Samo Gerškšič
3. Giovanni Godena, M. Sc.
4. Dr. Dejan Gradišar
5. Dr. Nadja Hvala
6. **Dr. Vladimir Jovan, Head**
7. Prof. Đani Juričić
8. **Dr. Gregor Kandare, left 18.06.12**
9. Prof. Juš Kocijan
10. Dr. Janko Petrovčić
11. Prof. Stanislav Strmčnik
12. Asst. Prof. Damir Vrančić
13. Dr. Darko Vrečko

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14. Dr. Pavle Boškosi
15. Dr. Matej Gašperin

16. Dr. Bojan Musizza
17. Dr. Marko Nerat
18. Dr. Boštjan Pregelj

### Postgraduates

19. Andrej Debenjak, B. Sc.
20. Miha Glavan, B. Sc.
21. Dr. Tomaž Lukman
22. *Jernej Mrovlje, M. Sc., left 01.11.12*
23. Dr. Matija Perne
24. Dejan Petelin, B. Sc.
25. Aleš Svetek, M. Sc.

### Technical officers

26. Stanislav Černe, B. Sc.
27. Primož Fajdiga, B. Sc.

### Technical and administrative staff

28. Maja Janežič, B. Sc.
29. Miroslav Štrubelj

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## ORIGINAL SCIENTIFIC ARTICLE

1. Darko Belavič, Marko Hrovat, Gregor Dolanc, Marina Santo-Zarnik, Janez Holc, Kostja Makarovič, "Design of LTCC-based ceramic structure for chemical microreactor", *Radioengineering (Prague)*, vol. 21, issue 1, pp. 195-200, 2012.
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4. Samo Gerškšič, Boštjan Pregelj, "Tuning of a tracking multi-parametric predictive controller using local linear analysis", *IET control theory & applications*, vol. 6, no. 5, pp. 1-11, 2012.
5. Karina Gibert, Dante Conti, Darko Vrečko, "Assisting the end-user in the interpretation of profiles for decision support, An application to wastewater treatment plants", *Environ. Eng. Manag. J. (Print)*, vol. 11, no. 11, pp. 931-944, 2012.
6. Miha Glavan, Matej Gašperin, Matej Vidmar, Maks Tuta, Stojan Kokošar, Đani Juričić, Andrej Brložnik, "Analiza proizvodnih podatkov za nadzor in upravljanje kvalitete izdelkov", *Ventil (Ljubl.)*, vol. 18, no. 5, pp. 396-402, nov. 2012.
7. Živko Južnič-Zonta, Juš Kocijan, Xavier Flotats, Darko Vrečko, "Multi-criteria analyses of wastewater treatment bio-processes under an uncertainty and a multiplicity of steady states", *Water res. (Oxford)*, vol. 46, no. 18, pp. 6121-6131, 2012.
8. Gregor Kandare, Nadja Hvala, Marijan Vidmar, "Vključevanje večjih rezidenčnih in manjših industrijskih uporabnikov v pametna omrežja", *Ventil (Ljubl.)*, vol. 18, no. 3, pp. 210-214, jun. 2012.
9. Gregor Kandare, Daniel Viúdez-Moreiras, Félix Hernández-del-Olmo, "Adaptive control of the oxidation ditch reactors in a wastewater treatment plant", *Int. j. adapt. control signal process.*, vol. 26, no. 10, pp. 879-989, 2012.
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13. Gabrijel Peršin, José Salgueiro, Jože Vižintin, Đani Juričić, "A system for automated online oil analysis", *Insight (Northamp.)*, vol. 54, no. 8, pp. 428-432, 2012.
14. Jan Prikryl, Juš Kocijan, "Stochastic analysis of a queue length model using a graphical processing unit", *Trans. Transp. Sci. (Print)*, vol. 5, no. 2, pp. 55-62, 2012.
15. Edvin Raubar, Damir Vrančić, "Anti-sway system for ship-to-shore cranes", *Stroj. vestn.*, vol. 58, no. 5, pp. 338-344, 2012.

## PUBLISHED SCIENTIFIC CONFERENCE CONTRIBUTION (INVITED LECTURE)

1. Pavle Boškosi, Matej Gašperin, Dejan Petelin, "Bearing fault prognostics based on signal complexity and Gaussian process models", In: *PHM'12, 2012 IEEE International Conference on Prognostics and Health Management*, June 18-21, 2012 - Denver, Colorado, Denver, IEEE, 2012, 8 pp.
2. Đani Juričić, Pavle Boškosi, Matic Ivanovič, Janko Petrovčič, Bojan Musizza, Matej Gašperin, Jože Vižintin, "Sprotni nadzor stanja industrijskih pogonov", In: *Zbornik predavanj Posvetovanja o tribologiji, hladilno mazalnih sredstvih in tehnični diagnostiki*, Posvetovanje o tribologiji, hladilno mazalnih sredstvih in tehnični diagnostiki = Conference on Tribology, Metal Working Fluids and Technical Diagnostics [tudi] SLOTRIB 2012, Ljubljana, Slovenija, 15.

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3. Juš Kocijan, "Dynamic GP models: an overview and recent developments", In: *Recent researches in applied mathematics and economics: proceedings of the 6th International Conference on Applied Mathematics, Simulation, Modelling, (ASM'12), proceedings of the 6th International Conference on Management, Marketing and Finances, (MMF'12), March 7-9, 2012*, Tsutomu Kambe, ed., Cornelia A. Bulucea, ed., Charalampos Arapatsakos, ed., [S. l.], WSEAS Press, = World Scientific and Engineering Academy and Society, 2012, pp. 38-43.
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2. Pavle Boškosi, Đani Juričić, "Rényi entropy based statistical complexity analysis for gear fault prognostic under variable load", In: *Condition monitoring of machinery in non-stationary operations: proceedings of the Second International Conference Condition Monitoring of Machinery in Non-stationary Operations, 2012, [March 26-28, 2012, Hammamet, Tunisia]*, Tahar Fakhfakh, ed., Heidelberg [etc.], Springer, 2012, pp. 25-32.
3. Andrej Debenjak, "Diagnostika sistemov z gorivnimi celicami in izboljšanje njihovega delovanja", In: *Zbornik, 4. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana = 4th Jožef Stefan International Postgraduate School Students Conference, 25. maj 2012, Ljubljana, Slovenija, Dejan Petelin, ed., Aleš Tavčar, ed., Boštjan Kaluža, ed., Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2012, pp. 119-124.*
4. Andrej Debenjak, Vladimir Jovan, Janko Petrovčič, Matej Gašperin, Boštjan Pregelj, "An assessment of water conditions in a PEM fuel cell stack using electrochemical impedance spectroscopy", In: *Proceedings of IEEE 2012 [3rd Annual] Prognostics and System Health Management Conference, (PHM-2012 Beijing), 23-25 May 2012, Beijing, China*, Suzanne Zhang, ed., Rui Kang, ed., Michael Pecht, ed., Danvers, IEEE, 2012, pp. MU3036-1-MU3036-6.
5. Andrej Debenjak, Boštjan Pregelj, Matej Gašperin, Janko Petrovčič, "Koncept diagnostike sistemov s PEM gorivnimi celicami", In: *Vir znanja in izkušnje za stroko: zbornik foruma*, Industrijski forum IRT, Portorož, 11. in 12. junij 2012, Tomaž Perme, ed., Darko Švetak, ed., Škofljica, Profidtp, 2012, pp. 217-222.
6. Matej Gašperin, Đani Juričić, Pavle Boškosi, "Prediction of the remaining useful life: an integrated framework for the model estimation and failure prognostics", In: *PHM'12, 2012 IEEE International Conference on Prognostics and Health Management*, June 18-21, 2012 - Denver, Colorado, Denver, IEEE, 2012, 8 pp.
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## MENTORING

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