General Information

Institute of Information Theory and Automation is a research institute of the **Academy of Sciences of the Czech Republic**. It is concerned with the development of control, information and computer sciences including in particular system theory and random processes from the point of view of mathematical modelling, decision making, automatic control and signal processing.

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How To Get There

The Institute is situated in the Horní Libeň neighborhood of Prague, close to Ďáblice, Kobylisy and Prosek.

By public transportation: From the center of Prague, use the **METRO line C** to the terminal station **"Ládví"**. The Institute is within a walking distance (see **Map 1**).

By car: From the center of Prague, go across **"Barikádníků"** bridge and along **"V Holešovičkách"** street to the **"Vychovatelna"** crossing. Then continue by **"Davídkova"** street (see **Map 2**).

History and Professional Background

The Institute of Information Theory and Automation (ÚTIA) was **established in 1959** by a merger between two academic laboratories: the Department of Information Theory of the Institute for Radiotechnics and Electronics, and the Laboratory for Automation and Telemechanics. ÚTIA has been pursuing basic research **in systems, control, and information sciences**. In the 1960s it achieved significant results on the entropy of various sources and on the capacity of information channels with memory. An algebraic approach to control system design was mainly developed in the 1970s; it yielded many important results, among them parametrization of all stabilizing controllers. The main contributions of the 1980s included Bayesian approach to self-tuning control, theory of Renyi distances in probability spaces, and a method of mathematical modelling of large-scale gas-distribution networks. Main developments in the 1990s were in recursive nonlinear estimation, usual data reconstruction and pattern recognition. Recently, the main attention has been focused on various **advanced methods of data processing and mathematical modelling of real-world phenomena** (see also pages of particular research departments).

The scientific **library** of ÚTIA contains more than 32,000 books and journals. The **IT system** includes a Local Area Network with HP 720 workstations and PCs and is periodically upgraded and extended. ÚTIA is also the administrator of the Academy of Sciences network domain, and in 1997 – 2002 the Institute was responsible for the administration of the whole Mazanka Campus with 7 institutes of the Academy. Since 2006, the Institute is responsible for the new Economic Information System of the Academy of Sciences.

ÚTIA publishes the scientific journal **Kybernetika**, and supports the edition of the **Bulletin of the Czech Econometric Society** .

The information bellow concerns year 2006. In January 2007 ÚTIA becomes **Public Research Institution** which includes new legal status and new control bodies.

Institute Representatives

Director:
  Prof. RNDr. Milan Mareš, DrSc.

Vice–Directors:
  RNDr. Martin Janžura, CSc.– *research*
  Mgr. Jiří Fidler, CSc. – *management*

Scientific Board:
  Prof. Ing. Jan Flusser, DrSc. – *chairman*
  Doc. Ing. Michal Haindl, DrSc.
  Prof. Radim Jiroušek, DrSc.
  Ing. Jiří Kadlec, CSc.
  Prof.Ing. Vladimír Kučera, DrSc.
  – *external member*
  Ing. Rudolf Kulhavý, DrSc.
  – *external member*
  Doc.Ing. Edita Pelantová , CSc.
  – *external member*
  Karel Sladký, CSc.
  Igor Vajda, DrSc.

Staff and Departments

The Institute staff consists of (as of December 31, 2006):

Category	Quantity
Research:	
Full-time researchers:	63
Part-time researchers:	33
Research assistants:	25
Doctoral students:	26
Support:	
Administrative and technical:	43
IT department, information-retrieval system:	12
Economic Information System of Academy:	10

Among the 121 researchers, 15 are women. The average age of the members of research departments is 39 years.

List of **research departments** (in alphabetic order) and brief characterizations of their orientations:

Adaptive Systems
system identification, adaptive control and signal processing

Control Theory
linear systems, robust control, nonlinear systems, optimal control

Decision-Making Theory
artificial intelligence, discrete systems, variational methods, optimization

Econometrics
stochastic models in econometrics

Image Processing
restoration of multi-source images

Pattern Recognition
pattern recognition, random fields, neural nets

Signal Processing
signal processing implementation, rapid prototyping, programmable logic design

Stochastic Informatics
mathematical statistics, information theory, stochastic systems.

Budget

The total annual budget amounts to about 140 mil. CZK including the costs connected with the implementation of the Economic Information System of Academy.

Out of this total budget, the research grants, projects and analogous activities amount 65 mil. CZK (i.e., about 46 %).

Annual Publication Activities

Full list of publications is available at the Institute website.

Breakdown of publications' quantity by type is shown in the table below:

Type	Quantity
Book / monograph	1
Part (chapter) of a book	3
Dissertation	2
Proceedings of an internat. conference	3
Proceedings of a Czech conference	3
Article in a scientific journal	74
Contribution at an internat. conference	122
Contribution at a Czech conference	24
Abstract	26
Research report	21
Electronic document	5
Total	**284**

Conferences Organized and Co-Organized by the Institute

- 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes "Prague Stochastics 2006", 21.-25. 8. 2006, Praha

- 7th Int. PhD Workshop "Young Generation View-point", 25.-30. 9. 2006, Hrubá Skála

- The third European Workshop on Probabilistic Graphical Models, 12.-15. 9. 2006, Praha

- Spring School on Variation Analysis, April 2006, Paseky

- 7th Workshop on Uncertainty Processing "WUPES06", 16.-20. 9. 2006, Mikulov

- International Workshop "Data-Algorithms-Decision Making" (organized by Research Centre DAR), 9.-12. 12. 2006, Třešť

- Robotics in IST FP7, 7. 11. 2006, Praha

- Transition of the Academy Institutes to v.v.i.-implications for running FP6 projects, 14. 11. 2006, Praha

Cooperation with Czech Universities

The Institute **closely cooperates with 8 faculties of 4 universities**. Beyond that framework, Institute members participate in individual projects that involve further 7 faculties and 3 universities. The top forms of the cooperation are:

Joint Research Centers

- "SALOME" - Joint Laboratory with Management Faculty of the Prague Economic University

- "Center for Monetary Macro-dynamics" - Joint Laboratory with Faculty of Finance of the Prague Economic University

- "CAK II" - Applied Cybernetics Center with the Czech Technical University in Prague and other 12 partners

- "DAR" - Research Center: Data-Algorithms- Decision Making, ÚTIA and other 8 partners

- "CQR" - The Center of Quality and Reliability with the Czech Technical University in Prague and other 5 partners

- "CZVDEE" - Center for Basic Research in Dynamic Economics and Econometrics with the Prague Economic University and other 2 universities

Joint Accreditations

This form of cooperation covers accreditations for training of doctoral students. Details can be found under Doctoral Studies.

Doctoral Studies

ÚTIA provides training to about **70 doctoral students** in cooperation with the universities.The Institute has achieved **joint accreditation** licence for organizing post-graduate study programmes with the following faculties:

- **Faculty of Mathematics and Physics, Charles University, Prague** programmes Computer science; Software systems; Probability and mathematical statistics; Econometrics; and Operations research

- **Nuclear Engineering Faculty, Czech Technical University, Prague** programme Applications of Science

- **Electrical Engineering Faculty, Czech Technical University, Prague** programme Artificial intelligence and biocybernetics within the programme Electrical Engineering and Informatics

- **Faculty of Management, University of Economics, Jindřichův Hradec** programme Management

Doctoral studies at the Institute have been quickly developing as a promising direction of mutually advantageous cooperation between the Academy of Sciences and various universities. All students interested in taking their doctoral studies at the Institute of Information Theory and Automation are encouraged to contact the Institute representatives; they will be provided with more detailed information and answers to their questions concerning such studies.

International Cooperation

The Institute participates in research and/or coordination under **20 international contracts and agreements** with foreign subjects (research institutes and universities).

The international joint projects are mentioned in Grants and Projects.

45 outstanding foreign researchers have visited the Institute in 2006. The members of the Institute have travelled abroad 210 times including 175 active participations at international conferences with 149 lectures (24 of them were invited). Moreover 2 members of the Institute presented lectures at foreign universities.

23 researchers are members of committees of international scientific organizations.

Grants and Projects

The Institute is the principal holder of a large research project - Center of Applied Research "Data-Algorithms-Decisions" supported by the Ministry of Education, Youth and Sports under the number 1M0572. We coordinate the related research teams from the Institute and eight co-holders, namely:

- West Bohemian University, Faculty of Applied Science, Plzeň,

- Technical University, Faculty of Electrical Engineering and Communication technologies, Brno,

- University of Ostrava, Institute for the Research and Applications of Fuzzy Models,

- Empo Company, Praha,

- Compureg Company, Plzeň,

- ELTODO, Transport Systems Company, Praha,

- OASA Computers Company, Ostrava,

- DELTAX Systems Company, Praha,

aiming to optimize the intermediation of the basic research and applied development.

Moreover, the research teams of ÚTIA actively participate in 3 analogous Centers, see the list above. The research centers represent in general the most important form of projects and activities of the Institute.

The research teams and individual researchers of the Institute participate in the solution of grants and other research projects supported by Czech or foreign grant agencies. Namely,in 2006, the Grant Agency of the Czech Republic supported 17 grants, Grant Agency of the Academy of Sciences supported 10 grants. The Academy of Sciences supported other 3 grants and further 8 under the Information Society Programme. Ministry of Education supported 9 grants, other grant agencies in the Czech Republic supported 2 grants. There were 9 international grant projects (7 of them were supported by EU) solved in the Institute, and further 6 research and development project were solved on the base of two-sided cooperation with foreign partners.

From the above mentioned 64 grants and project there were 13 of them solved in cooperation with business firms.

The wide grant and project activities covered almost one half (about 46 %) of the Institute budget and this fact had facilitated the Institute to form its active personal policy as well as the effective strategy of its own technical innovation.

Department of Adaptive Systems

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Profile

Research Topics

The Department of Adaptive Systems concentrates predominantly on the design of decision-making systems, which modify their behavior according to the changing properties of their environment. This essential ability — *adaptivity* — enhances their efficiency. Decades of research brought a number of conceptual, theoretical, algorithmic, software and application results. At present, the applicability of adaptive systems is being extended towards complex scenarios by improving the classical adaptive systems and by developing their new versions.

Departmental "know-how" serves to solution of national and international research projects, running in collaboration with industry and government agencies. The interplay between theory and limited computing power is the common issue behind the various project domains. They include traffic control, management and control of technological systems, radiation protection, nuclear medicine, analysis of financial data, electronic democracy etc. Increasing complexity of problems addressed directs the main stream of the research towards decentralized control of large scale systems and normative decision-making with multiple participants.

The information presented here can by complemented by looking at http://as.cas.cz. Our publications are now registered at http://library.sk/i2/i2.entry.cls?ictx=cav.

International Cooperation

International collaboration is supported by agreements of Academy of Sciences and Ministry of Education of the Czech Republic.

The Czech-Slovenian cooperation is supported by Intergovernmental S & T Cooperation programme, project "Data-driven Modelling for Decision-making Support and Process Monitoring". The cooperation with Italy runs within the Czech-Italian bilateral collaboration Consiglio Nazionale delle Ricerche – Academy of Sciences of the Czech Republic, project "Advanced Techniques of Bayesian Decision Making in Complex Systems". The multi-lateral cooperation runs mainly within the project TED – Towards electronic democracy: Internet-based Complex Decision Support, http://bayes.escet.urjc.es/ted, supported by European Science Foundation, ESF, http://www.esf.org. The Department's major partners are in Austria, Bulgaria, Finland, France, Germany, Hungary, Italy, Russia, Slovakia, Slovenia, Spain and UK.

University Boards

M. Kárný is a member of three boards for doctoral theses defenses at the Czech Technical University and the University of West Bohemia.

Editorial Boards

L. Bakule – Intersections; Zentralblatt für Mathematik

M. Kárný – Int. Journal of Adaptive Control and Signal Processing; Int. Journal of Knowledge-Based Intelligent Engineering Systems, associate editor; Int. Series on Advanced Intelligence, advisory board.

Representation in International Societies

L. Bakule, vice-chair of Technical Committee on Large Scale Complex Systems, IFAC; chair of WG, Technical Committee on Large Scale Complex Systems, IFAC

J. Böhm, member of Technical Committee on Controller Design, IFAC

T. V. Guy, R. Kulhavý, senior members of IEEE

M. Kárný, R. Kulhavý, members of Technical Committee on Stochastic Systems, IFAC

F. Kraffer, member of the Marie Curie Fellowship Association

P. Zagalak, member of Technical Committee on Linear Systems, IFAC

Recent Activities

Grants and Projects

The following list acknowledges our sponsors.

L. Bakule – *Decentralized control of large-scale systems* (GA AV ČR A2075304)

L. Bakule – *IFAC.* (MŠMT, INGO, LA 282)

K. Belda – *Model-based control of mechatronic systems for robotics* (GA ČR 102/06/P275)

J. Böhm – *Predictive control: Algorithm and implementation* (GA ČR 102/05/0273)

T. V. Guy – *Data-driven modelling for decision-making support and process monitoring* (MŠMT ME 8/2005-06)

L. Jirsa – *Intelligent decision support of diagnosis and therapy in nuclear medicine by Bayesian processing of uncertain data and probabilistic mixtures* (AV ČR 1ET100750404)

M. Kárný – *TED: Towards electronic democracy* (ESF project, concluded)

M. Kárný – *BADDYR: Bayesian adaptive distributed dynamic decision making* (AV ČR 1ET100750401)

M. Kárný – *BAYES: Fully probabilistic design of adaptive decision-making strategies under informationally demanding conditions* (MŠMT 2C06001)

R. Kulhavý – *Stochastic modeling of dynamic value networks* (GAČR)

I. Nagy – *Transportation control in the centers of historical cities* (MD ČR 1F43A/003/120)

E. Suzdaleva – *Urban traffic feedback control* (GA ČR 201/06/P434)

L. Tesař – *Artificial intelligence methods in diagnostics from medical images* (AV ČR 1ET101050403)

Teaching and Supervising Activities

Courses at Czech Technical University

Faculty of Electrical Engineering:
Robots in Practice given by K. Belda
Electronic Systems given by P. Dohnal.

Faculty of Transportation Sciences:
Probability Theory and Statistics given by I. Nagy, J. Homolová, P. Pecherková
Coding Theory and Cryptography given by J. Přikryl and L. Kárná.

Faculty of Nuclear and Physical Engineering:
Predictive Control, given by J. Böhm
Large Scale Systems Control, given by L. Bakule
Dynamic Decision Making, given by M. Kárný.

Supervising

J. Andrýsek defended his thesis [1]. K. Belda defended his second thesis [8]. M. Novák submitted it [19]. J. Homolová, J. Kracík, F. Varga, L. Pavelková and P. Pecherková are expected to submit them during the year 2007. R. Hofman and J. Šindelář represent our new generation of postgraduate students.

Conferences, International Contacts

L. Bakule serves as an IPC member of: The 11th IFAC Symposium on Large Scale Systems, Gdansk, Poland, 2007; The 1st IFAC Workshop on Applications of Large Scale Industrial Systems, Oulu, Finland, 2006; an Advisory Committee member and a TPC member of: The Int. Conference on Autonomic and Autonomous Systems 2006, IARIA, Santa Clara, CA, USA; The Third Int. Conference on Autonomic and Autonomous Systems 2007, IARIA, Athens, Greece; a TPC member of The First Int. Workshop on Safety in Industrial Systems 2007, IARIA, Sainte-Luce, Martinique.

M. Kárný served as a general-track chairman at The 10th KES Conference, Bournemouth, UK and has the same role for The 11th KES Conference to be held in 2007, Italy.

P. Zagalak serves as an IPC member of the 3rd IFAC Symposium on System Structure and Control, which will be held in Brazil in 2007.

Conferences – Organization

The Department organized the 7th Int. PhD Workshop, Young Generation Viewpoint: Interplay of Societal and Technical Decision-Making, September 25 – 30, 2006, Hrubá Skála, Czech Republic, http://as.utia.cz/phd2006/program, [4]. It was supported by the TED project and by the research center DAR.

L. Bakule organized two invited sessions at the 11th IFAC Symposium on Large Scale Systems, Gdansk, Poland, 2007.

Conferences – Participation

L. Bakule: The Int. Conference on Hybrid Systems and Applications, Lafayette, LA, USA, invited lecture; 2nd IFAC Conference on Analysis and Design of Hybrid Systems, Alghero, Italy, lecture; 25th IASTED Int. Conference Modelling, Identification, and Control, Lanzarote, Spain, lecture

K. Belda: Int. Conference on Parallel Kinematic Machines in Research and Practice. Chemnitz, Germany, lecture; 7th Int. Conference on Process Control, Dlouhé Stráně, Czech Republic, lecture; 10th WSEAS Conference on Circuits, Athens, Greece, lecture

J. Böhm: 7th Int. Conference on Process Control, Dlouhé Stráně, Czech Republic, lecture; 15th Int. Conference on Process Control, Štrbské pleso, Slovakia, lecture

P. Dohnal: 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, poster; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; 10th Int. Student Conference on Electrical Engineering - Poster 2006, Prague, Czech Republic, poster

J. Homolová: The 11th Int. Conference of Hong Kong Society for Transportation Studies, Hong Kong, lecture; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture

L. Jirsa: ISBA 8th Valencia meeting 2006, Benidorm, Spain, lecture [11]

M. Kárný, T.V. Guy: Towards e-Democracy: Participation, Deliberation, Communities (TED 2006), Mantova, Italy invited lecture

M. Kárný: KES 2006 Conference, Bournemouth, UK, Chairman of Signal processing and control sessions; Seminar of FET Open section DG, Brussels, Belgium, invited lecture; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, invited lecture;

F. Kraffer: 7th Int. Conference on Process Control, Dlouhé Stráně, Czech Republic, lecture

M. Novák: 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, lecture,

L. Pavelková: ISBA 8th Valencia meeting 2006, Benidorm, Spain, poster; NSSPW 2006, Cambridge, UK, poster; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, lecture

P. Pecha: XXVIII DRO Int. Conference on radiation protection, Luhačovice, Czech Republic, lecture

P. Pecherková: 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; The 11th Int. Conference of Hong Kong Society for Transportation Studies, Hong Kong, lecture

J. Přikryl: 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; IEEE IECON'06, Paris, France, lecture; 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, lecture

E. Suzdaleva: 2nd Int. Conference "From Scientific Computing to Computational Engineering", Athens, Greece, poster; 10th WSEAS Int. Conference on Engineering Education, Athens, Greece, lecture; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture

V. Šmídl: IEEE ICASP'06, Toulouse, France, lecture; NSSPW 06, Cambridge, United Kingdom, lecture; 7th Int. PhD Workshop – Young Generation Viewpoint, Hrubá Skála, Czech Republic, lecture; IEEE IECON'06, Paris, France, lecture; 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, lecture

L. Tesař: The Fourth IASTED International Conference on Signal Processing, Pattern Recognition, and Applications 2006, Innsbruck, Austria, lecture; The Sixth IASTED International Conference on Modelling, Simulation, and Optimization 2006, Gaborone, Botswana, lecture; Nineteenth IEEE International Symposium on Computer-Based Medical Systems, Salt Lake City, USA, poster; 11th Congress of World Federation for Ultrasound in Medicine and Biology (WFUMB'2006), Seoul, Korea, poster;

J. Zeman: 2nd Int. Workshop on Data – Algorithms – Decision Making 2006, Třešť, Czech Republic, poster.

International Contacts

The Department hosted a number of visitors: A. Bodini, IT, A.L. Fradkov, RU, V. Lyubenova, BG, , A. Magyar, HU, S. Popova, BG, A. Quinn, IE, A. Rafterry, USA, sabbatical leave, F. Ruggeri, IT, K. Warwick, UK.

L. Bakule consults to Frontier Research Center, Osaka University, Osaka, Japan and Osaka Prefecture University a The Japan Society for Aeronautical and Space Sciences, Osaka, Japan.

Stays abroad of our members were mostly project-driven and included long stays:

- L. Bakule, Technical University, Barcelona, Spain, invited stay

- L. Tesař, Tokyo University of Agriculture and Technology, Koganei, Tokyo, Japan, research

as well as short-term stays

- T. V. Guy, M. Kárný, Italian National Research Council, Milano, Italy – study stay within a common project

- M. Novák, Institute of Control Systems Research, Bulgaria – cooperation within a common project

- J. Homolová, Lithuanian Academy of Science, Vilnius, Lithuania Institute of Mathematics and Informatics, Systems Analysis Department; exchange programme

- V. Šmídl, Russian Academy of Science, St. Petersburg, Moscow, Irkutsk, exchange programme.

- P. Zagalak, Institut de Recherche en Communications et Cybernétique de Nantes, CNRS UMR 6597 – invited stay.

Results

Design of Decision-Making Strategies

Theoretical and algorithmic framework of dynamic Bayesian decision making is systematically built and gradually converted into a practically applicable tool. Specifically: (i) fully probabilistic design of decision strategies, has been extended to state-space models [15]; (ii) automatic translation of technical knowledge into the probabilistic machinery was improved and unified; (iii) forgetting, the key building block of adaptive systems, was improved by optimizing theoretically justified version of the Kullback-Leibler divergence; (iv) factorized versions of filtering, needed for models with mixed discrete and continuous values, was developed [23, 24]; (v) important estimation and filtering with probabilistic models having restricted supports were improved [20].

Distributed Bayesian Decision Making

This research tries to cross complexity barriers inherent to centralized (single participant) decision making. Our research orientation is based on the following, fully scalable, simple idea. Individual participants with a limited perceiving, evaluating and acting abilities use their strategies as if their were alone. The cooperation with their neighbors is reached during strategy re-design when they can exchange and harmonize their knowledge and aims. The research focuses mainly on development of tools for this type of cooperation. The key progress has been made in using probabilistic information about data for improving parametric estimation [13]. Ideal distributions expressing participants' aims are expected to be modified in a similar way. In this respect, translation of technical aims into such ideal distribution has been elaborated. Initial experiments encourage us to follow the chosen research direction [28].

Stochastic Modelling of Dynamic Value Networks

This research deals with modelling and simulation of dynamic value networks, which are increasingly replacing the traditional vertically integrated enterprizes. The project's objective is to develop a stochastic model of the dynamic behavior of a value network, which would account for both the formation of a functioning network out of available nodes and the changes in performance of individual nodes over time. The proposed approach to modelling combines Ulf Grenander's general pattern theory with stochastic extension of Jay Forrester's system dynamics. Estimation of the network state and parameter values is formulated as the Bayesian inference problem, whose numerical solution is assumed using a sequential Monte Carlo algorithm. The model is generic enough to cover value networks in diverse industries. The project explores various definitions of the "value" concept and the relationship between the value transformation over a specific node and the node performance characteristics.

Factorized Filtering

The factorized version of filtering, needed for models with mixed discrete and continuous

states, was developed [24]. It applies chain rule to the state and observation models in order to describe respective state entries individually. Originally it was expected, that a special reduced form of the system model might have be needed for the general solution. The results, published in [24], demonstrated the reverse. Specialization to the discrete Kalman filter has been described in [23]. The algorithm was implemented in toolboxes Mixtools and Mixtools 3000.

Decentralized Control of Large-Scale Systems

Inclusion Principle was extended to the design of robust overlapping controllers for state-delayed discrete-time systems with norm bounded uncertainties using the concept of guaranteed cost.

Expansion-contraction relations for systems and contractibility conditions for output-guaranteed-cost memoryless controllers are proved, including conditions on the equality of guaranteed performance bounds. The controllers are designed in the expanded space using a linear matrix inequality (LMI) delay independent procedure adapted to this class of problems. Then, the controllers are contracted and implemented. The results are specialized to the overlapping decentralized control design. The method enables an effective construction of block tri-diagonal controllers. An illustrative example is presented [7].

Reduced–order design of decentralized H_∞ static output switching controllers was proposed for uncertain discrete–time symmetric composite systems with state-dependent switching rule. First, a reduced-order control design model is constructed with the dimension equal to a subsystem's dimension of the original system. It serves for LMIs-based design of quadratically stabilizing switching controller with a given H_∞ disturbance attenuation level. This decentralized controller – implementing the reduced-order controller into each subsystem together with a switching rule operating on local states – is proved to be quadratically stabilizing with H_∞ norm bound γ [6].

A new low-order resilient controller–observer design method was developed for a class of continuous–time state delayed uncertain nonlinear, but nominally linear, symmetric composite systems with norm bounded uncertainties. Additive controller–observer gain perturbations are considered. Both subsystems and interconnections include time–delays. A low-order control design model approach is used to design a stabilizing controller–observer with norm bounded gain

uncertainties LMIs. The overall resilient controller obtained by local implementations of the low–order resilient controller–observer is proved to be quadratically stable [5].

Linear Systems

The problem of pole structure assignment by state feedback in generalized and uncontrollable system has (in some special cases) been solved. A paper, [16], on that topic was provisionally accepted for publishing in Automatica. A similar work goes on in the case of networked systems.

Software System Mixtools

The software toolbox represents a full algorithmic image of Bayesian, single participant, decision making, developed at the Department. It is run by an unified interface Jobcontrol recently equipped by a Graphical User's Interface.

The re-formulated and re-solved task of the fully probabilistic knowledge incorporation was implemented and successfully tested [18].

Software System Mixtools 3000

Mixtools 3000 is designed as a successor of the package Mixtools. The goal of this project is to re-design the Mixtools package to make it applicable to multiple-participant decision making. This together with improved flexibility, extensibility, and user friendliness will be achieved using object-oriented approach. As a first step, our own implementation of basic properties of object-oriented approach in Matlab has been completed [2]. Using this framework, classes for decision making with participants based on controlled autoregressive models were implemented [3] and tested [28]. Unified and general Graphical User's Interface was designed.

Libre Software for Free Education

Although the motivating project Edukalibre ended, the research continues. It resulted in an advanced educational system for dynamic Bayesian decision making [25, 26]. Moreover, the teaching system is tailored to special conditions of The Faculty of Transportation, especially for magister and doctoral students, [17].

Hierarchic Urban-Traffic Control

A systematic approach of tackling traffic control problem has been elaborated. Now, special tasks are solved. One of the most important is the

solution for exceptional traffic states, as over-saturation, accidents or some obstacles in a road. For a solution to this problem, we use mixture model of the whole traffic area and we compute its likelihood for changes detection. The second stream of our effort is building a software system in which the tasks of estimation and control with traffic model can be easily run.

Control Application in Robotics

A mathematical model of a newly designed parallel robot structure was derived. The structure will help in construction of a laboratory model serving for tests of control in real-time.

The optimized predictive controller relying on input–output model was designed, implemented and verified on the laboratory beam-and-ball model [9]. A state-space version of the predictive controller was also designed and implemented. The algorithm needs neither change of the physical meaning nor extension of initial state [10].

Decision Making in Societal Systems

Transfer of know-how acquired in technical and medical application to societal domain has proved to be fruitful. Specifically, modelling of reviewers serving to a granting agency as noisy sensors led to a more objective evaluation of grant proposals. Moreover, the results allow assessing quality and reliability to respective reviewers. Similarly, fully probabilistic analysis of participatory democracy brought a fresh perspective on this important domain. For instance, it justifies a limited response of citizens on various political stimuli.

Control of Large-Scale Mechanical Structures

Particular results concerning the real-world, cable-stayed bridge control benchmark, whose aim is to protect the bridge against seismic activities, were extended to a general design methodology suitable for large scale flexible structures. The disjoint and the overlapping decomposition approaches form the core of this control design. Intermediate cases between the normal functioning and total disconnection of the controller from the plant are included within the well-known concept of connective stabilization. The scenarios for the control design and the performance evaluation sequences are given. The methodology is convenient for any low authority controller.

Data assimilation in radiological risk assessment

Data assimilation methods for improvement of mathematical model predictability have been investigated. Input uncertainties involved in the model were analyzed and their propagation through the model quantified. Sensitivity study to random input-parameters variations was performed on their relevant selection. Basic techniques of empirical interpolation techniques were applied to several accidental release scenarios. Methodology has progressed towards optimal statistical interpolation. The results were published in the conference proceedings of XXVIII. Days of Radiation Protection. The successful algorithms are gradually implemented into the assimilation subsystem of environmental model HARP. Data assimilation activities are summarized in [21, 22].

Advising in Nuclear Medicine

Bayesian analysis of the treatment of thyroid gland carcinoma has been extended to advising on therapeutic amount of radioactive ^{131}I administered to a patient. Patients' biophysical records, characterizing their accumulation dynamics of ^{131}I etc., have been modelled by probabilistic mixture [14]. In cooperation with medical doctors, a set of processing variables has been extended and corresponding data are being collected and used for some clinical studies, e.g. [27]. Improvement in modelling and identification of a key dosimetric quantity, used both as an important input for mixture processing and as a practical medical information, has been achieved [12] and implemented in practice.

References

[1] J. Andrýsek. *Estimation of Dynamic Probabilistic Mixtures*. PhD thesis, FJFI, ČVUT, POB 18, 18208 Prague 8, Czech Republic, 2005.

[2] J. Andrýsek, M. Pištěk, V. Šmídl, O. Šterbák, M. Tkáč, M. Týnovský, and I. Váňová. Mixtools 3000 Foundation. Technical Report 2179, ÚTIA AV ČR, Praha, 2006.

[3] J. Andrýsek, J. Přikryl, and V. Šmídl. Mixtools 3000 Interactive Reference Manual. Technical Report 2178, ÚTIA AV ČR, Praha, 2006.

[4] J. Andrýsek, V. Šmídl, and J. Přikryl, editors. *Proceedings of the 7th International PhD Workshop on Interplay of Societal and Technical Decision-Making, Young Generation Viewpoint*. ÚTIA AV ČR, December 2006.

[5] L. Bakule. Resilient stabilization of uncertain state-delayed symmetric composite systems. In H. M. H., editor, *Proceedings of the 25th IASTED International Conference on Modelling, Identification, and Control*, pages 149–154, 2006.

[6] L. Bakule. Robust h-infinity control of uncertain discrete-time switching symmetric composite systems. In *Proceedings of the 2nd IFAC Conference on Analysis and Design of Hybrid Systems*, pages 130–135, 2006.

[7] L. Bakule, J. Rodellar, and J. Rossell. Robust overlapping guaranteed cost control of uncertain state discrete-time systems-delay systems. *IEEE Transactions on Automatic Control*, 12 (2006):1943–1950, 2006.

[8] K. Belda. *Control of Parallel Robotic Structures Driven by Electromotors*. PhD thesis, 2005.

[9] K. Belda and J. Böhm. Adaptive Generalized Predictive Control for Mechatronic Systems. *WSEAS Transactions on Systems*, 5(8):1830–1837, 2006.

[10] K. Belda and J. Böhm. Predictive control of redundant parallel robots and trajectory planning. In R. Neugebauer, editor, *Proceedings of the Parallel Kinematic Machines in Research and Practice. PKS 2006*, pages 497–513, Chemnitz, April 2006. IWU.

[11] L. Jirsa, A. Quinn, and F. Varga. Identification of thyroid gland activity in radiotherapy. In J.-M. Bernardo, editor, *Valencia 8 ISBA 2006 World Meeting on Bayesian Statistics*, pages 140–140, Spain, June 2006. University of Valencia.

[12] L. Jirsa, A. Quinn, and F. Varga. Identification of thyroid gland activity in radiotherapy. *Bayesian Analysis*, 2, 2007. accepted.

[13] M. Kárný, J. Andrýsek, A. Bodini, T. V. Guy, J. Kracík, and F. Ruggeri. How to exploit external model of data for parameter estimation? *International Journal of Adaptive Control and Signal Processing*, 20(1):41–50, 2006.

[14] M. Kárný, J. Böhm, T. V. Guy, I. Nagy, and P. Nedoma. *Case Studies in Optimized Bayesian Dynamic Advising. (Program)*. ÚTIA AV ČR, Praha, 2005.

[15] M. Kárný and T. V. Guy. Fully probabilistic control design. *Systems & Control Letters*, 55(4):259–265, 2006.

[16] J. J. Loiseau and P. Zagalak. On pole structure assignment in linear systems. *Automatica*, 0(0):000–000, 2006.

[17] I. Nagy, J. Homolová, and E. Suzdaleva. Teaching system for advanced statistics. In L. Botturi, R. Mazza, and S. Tardini, editors, *FOSLET 2006. Proceedings of the Workshop on Free and Open Source Learning Environments and Tools*, pages 13–20, Lugano, June 2006. Impressum.

[18] P. Nedoma, M. Kárný, and N. M. Interactive Case Studies in Prior Knowledge Processing. Technical Report 2173, ÚTIA AV ČR, Praha, 2006.

[19] M. Novák. *Multivariate Adaptive Controller Design with Constraints under Uncertainty*. PhD thesis, FJFI ČVUT, Praha, Prague, Czech Republic, 2006. submitted.

[20] L. Pavelková, M. Kárný, and V. Šmídl. Towards bayesian filtering on restricted support. In *Proceedings of NSSPW '06. Cambridge*, pages 1–4, Cambridge, October 4-8 2006. University of Cambridge.

[21] P. Pecha and R. Hofman. Asimilace matematického modelu s měřeními daty při odhadech znečistění životního prostředí. *Bezpečnost jaderné energie*, November 2006. přijato k publikaci.

[22] P. Pecha and L. Housa. Modely šíření znečistění životním prostředím - od deterministických odhadů k pravděpodobnostnímu hodnocení. *Bezpečnost jaderné energie*.

[23] E. Suzdaleva. Factorized Kalman filtering. In *Proceedings of the 7th International PhD Workshop on Interplay of societal and technical decision-making*, Hruba Skala, Czech Republic, September 25-30 2006. ÚTIA AV ČR. ISBN 80 903834 1 6.

[24] E. Suzdaleva. Towards state estimation in the factorized form. In D. Tsahalis, editor,

Proceedings of the 2nd International Conference on From Scientific Computing to Computational Engineering, pages 1–6, Athens, July 2006. University of Patras.

[25] E. Suzdaleva and P. Nedoma. Educational tools for dynamic Bayesian decision-making. *WSEAS Transactions on Advances in Engineering Education*, 5(3):288–295, 2006.

[26] E. Suzdaleva and P. Nedoma. Interactive educational system for dynamic Bayesian decision-making. In N. Bardis and V. Mladenov, editors, *Proceedings of the WSEAS CSCC & EE International Conferences*, pages 1–6, Athens, July 2006. WSEAS.

[27] P. Sýkorová, P. Vlček, K. Personová, and L. Jirsa. Impact of TNM classification categories on thyroid gland carcinoma. In *Endocrine Abstracts 8th European Congress of Endocrinology incorporating the British Endocrine Societies*, volume 11, page P938, Glasgow, UK, April 2006. BioScientifica. www.endocrine-abstracts.org.

[28] V. Šmídl and J. Andrýsek. Distributed Bayesian decision making: Early experiments. In V. Šmídl, J. Andrýsek, and J. Přikryl, editors, *Proceedings of the 7th International PhD workshop, Young generation viewpoint*, 2006.

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Profile:

Research Topics:

The research in linear control theory has a long tradition at the Institute. In early 1960s, under the leadership of Professor Strejc, researchers at the Institute made significant developments in both transfer-function and state-space methods. During the 1970s and the 1980s members of the Department, lead by Professor Kučera, obtained significant results which launched an entirely new area of research worldwide. Among these is a parametrization of all controllers that stabilize a given plant (known as the Youla-Kučera parametrization) and the design of control systems via polynomial equations. In the 1990s, the research activities of the department range from robust control to nonlinear systems.

Application research in the Department concentrates on numerical methods for control system simulation and design. This results in various original software packages for control and simulation.

The current research objectives in the Department of Control Theory are in the analysis and design of control systems. Three main research directions are as follows:

a) Analysis and design of linear systems including robust control.

b) Numerical methods for control systems analysis and design including chaotic systems.

c) Analysis and design of nonlinear control systems.

Interest is focused on both theoretical studies and computer implementation of the results obtained.

International Cooperation:

Members of the Department participate in joint research with their colleagues from Universities and Institututes in:
Hong Kong, China (Prof. G. Chen), Toulouse, France (Dr. D. Arzelier, D. Peaucelle), ETH Zurich, CH, (Dr. F. Kraus), Enschede, The Netherlands, (Prof. H. Kwakernaak), Thessaloniki, Greece, (Prof. A. Vardulakis), Nantes, F, (Prof. J. J. Loiseau, Prof. C. Moog), CINVESTAV Mexico (Dr. Javier Ruiz), Laboratory of microrobotics at EPFL (Prof. Jean-Marc Breguet): collaboration on control for micro and nanopositioning devices, Laboratory of Micro- & Nano-Scale Engineering, Mechanical Engineering, Eindhoven

University of Technology (Prof. Yves Bellouard): collaboration in application of control methods in self-assembly process of smart materials, preparation of joint European project, submission of a proposal.

Study Stays:

P. Šindelářová: University of North Carolina at Chapel Hill, North Carolina, USA.

O. Šprdlík: University of Twente, Enschede, Faculty of Electrical Engineering, Mathematics and Computer Science, NL.

P. Augusta: School of Electronics and Computer Science, University of Southampton, UK.

J. Zikmund: in double degree PhD. program "Cotutelle" with Ecole Central de Nantes, France.

University Boards:

Vladimír Kučera - member of Research and Development Council, Technical Committee for Science and Engineering; member of the Advisory Board of DG-INFSO for Information Society Technologies; member of Scientific Council, University of Technology in Brno, University of Western Bohemia in Plzeň, University of Tomas Bata in Zlín; member of Scientific Council, Faculty of Mechatronics of the Technical University of Liberec, Faculty of Management in Jindřichův Hradec of the School of Economics in Prague, Faculty of Applied Informatics of the University of Tomas Bata in Zlín.

Michael Šebek is a member of Scientific Council, Technical University of Liberec and a member of a Subject Area Council of the University of Tomáš Baťa, Zlín.

Jaroslav Doležal is a member of VUT Brno Scientific Board.

Editorial Boards:

Sergej Čelikovský – Kybernetika, IEEE Transactions on Automatic Control,

Jaroslav Doležal — Journal on Optimization Methods and Software, Journal of Computational Optimization and Applications,

Jan Ježek — Kybernetika.

Vladimír Kučera — International Journal of Robust and Nonlinear Control; Bulletin of the Polish Academy of Sciences; Slaboproudý obzor; Automa.

Representation in Scientific Societies:

Activity of the Department in international technical and scientific societies is remarkable. Our members serve in governing bodies of the International Federation of Automatic Control (IFAC) and of the Institute of Electrical and Electronic Engineers (IEEE).

Sergej Čelikovský – member of IFAC Technical Committee on Nonlinear Systems, IFAC TC on Robust Control, Secretary of the Czech Committee for Automation and the IFAC; Vice-chairman of the Executive Committee of the Czech Chapter of the IEEE Control Systems Society.

Jaroslav Doležal — Elected Nov. 14, 2005 a member of Engineering Academy of the Czech Republic.

Branislav Rehák – member of IFAC Technical Committee on Nonlinear Systems;

Vladimír Kučera – Past President of IFAC; member of the IFAC Council; member of the Technical Committee on Linear Systems; member of the Board of Trustees, IFAC Foundation; member of the Administrative Council, European Union Control Association.

Michael Šebek – Vice Chair of the IFAC Policy Committee and a member of the Technical Committee on Robust Control, Executive Committee member of the Central European Chapter of the IEEE SME, Executive Committee member of the Czech Chapter of the IEEE Control Systems Society, Executive Council member of the EUCA (European Union Control Association).

Zdeněk Hurák – Member IEEE: Control System Society, Engineering in Medicine and Biology Society, Circuits and Systems Society. Chair of Polynomial Action Group of IEEE TC on CACSD.

R&D Activities and Industry Cooperation:

Jaroslav Doležal - member of Contact development and facilitation of Honeywell business (automation & aerospace), founding member of Media Lab ČVUT Foundation to support applied student projects, a member of sponzoring committee of High-Tech Czech-US seminar on innovation and university-industry relations; Activity as member of R&D Council of the Czech Government. Promotion of university-industry cooperation on various management fora and events.

Recent Activities:

Grants and Projects:

V. Kučera: "Center for Applied Cybernetics" (Ministry of Education of the Czech Republic, 1M0567 2005 – 2008)

S. Čelikovský, M. Šebek: "Structure and Universality in Complex System Control Design" (GA ČR, 102/05/0011, 2005 – 2007)

J. Doležal: "Prague Technology Center (Honeywell)" (Coordination of Prague Technology Project at ÚTIA AV ČR, Bilateral Agreement UTIA-Honeywell, permanent); Grant Agency Project; Ministry of Industry and Trade development project

Teaching and Supervising Activities:

University Courses:

11 semestral courses on subjects related to the research field of the department were read by department members.

Czech Technical University in Prague – Faculty of Electrical Engineering:

- Electrical Engineering and Informatics: Dynamical Systems Theory; Algebraic Approach to Control System Design – Master degree course (V. Kučera)

- Electrical Engineering and Informatics: Linear Systems; Algebraic Approach to Control System Design – Doctor degree course (V. Kučera)

- Algebraic Approach to Control System Design – graduate course (V. Kučera)

- Algebraic Approach to Control System Design – postgraduate course (V. Kučera)

- Linear Systems – graduate course (V. Kučera)

- Systems and Control – undergraduate course (M. Šebek)

- Robust Control – postgraduate course (M. Šebek)

- Numerical Algorithms for Control Systems – postgraduate course (M. Šebek)

- Nonlinear Systems – graduate course (S. Čelikovský)

- Nonlinear systems – postgraduate course (S. Čelikovský)

- Robust control – graduate course (Z. Hurák)

Universita di Pavia (Italy)

- Methods for Management of Complex Systems: Polynomial Control – International master degree course (V. Kučera)

Brno

- V. Kučera - What did pointed the 16th IFAC World Congress in Prague 2005, World Machine-Industries Trade Fair in Brno, 2006.

Supervising:

6 PhD students are currently being supervised by the department members.

Conferences and International Contacts:

Conferences – Participations:

- 50 Years of IFAC – Heidelberg, D (S. Čelikovský, V. Kučera, M. Šebek, V. Strejc)

- 1st IFAC Conference on Analysis and Control of Chaotic Systems – Reims, F (S. Čelikovský)

- 45th IEEE Conference on Decision and Control – San Diego, CA, USA (S. Čelikovský, M. Šebek, J. Zikmund)

- Asian Control Conference AsCC 2006 – Bali, Indonesie (S. Čelikovský)

- 40. regelungstechnisches Kolloquium –Boppard, D (V. Kučera)

- Second International Symposium on Communications, Control and Signal Processing – Marrakech (V.Kučera)

- SWAN 2006 - Systems Workshop on Adaptive & Networks – Arlington, Texas, USA (V.Kučera, M. Šebek)

- 14th IEEE Mediterranean Conference on Control and Automation – Ancona, I (V. Kučera)

- 11th International Student Olympiad on Automatic Control, State University of Information Technologies, Mechanics and Optics – Saint-Petersburg, Russia (P. Augusta)

- MTNS'06, 17th International Symposium on Mathematical Theory of Networks and Systems, Kjóto, J (P. Augusta)

- Control Applications – Montreal, USA (B. Rehák)

- 1st IFAC Workshop on applications of Large Scale Industrial Systems – Helsinky, S (B. Rehák)

- Midwest Dynamical System Seminar – Indiana University-Purdue University Indianapolis, USA (P. Šindelářová)

- ITA 2006, Soul, Republic of Korea (L. Ferkl)

International Contacts:

The following scientists were guests in department in 2006: Prof. Helm, NL, University of Technology, Laboratory of Process Control, Prof. Zampieri, I, University of Padova, Dr. M.David Tlalolini Romero, F, RCCyN Nantes, Dr. Didier Henrion, F, LAAS Toulouse,Professor František Kraus, CH, ETH - Zurich, Professor Javier Ruiz, MX, CINVESTAV-IPN, Unidad Guadalajara, Prof. Noboru Sakamoto, J, Department Aerospace Eng., Nagoya University,Prof. Fornasini, I, Universita of Padova.

Awards:

V. Kučera was awarded the Chevalier dans ľordre des Palmes Académiques medal based by Napoleon Bonaparte in 1808.

V. Kučera was awarded the Gold Felber medal of the Czech Technical University.

P. Augusta was awarded the Diploma III degree of the Scientific Section of the XI. International Student Olympiad on Automatic Control for the Theoretical Contribution in Saint-Petersburg, Russia.

Results:

The H_2 Control Problem: A Comparison of State-space and Transfer-function Solutions

The H_2 control problem consists of stabilizing the control system while minimizing the H_2 norm of its transfer function. Several solutions to this problem are available. For systems in state space form, an optimal regulator can be obtained in observer form by solving two algebraic Riccati equations. For systems described by transfer functions, either Wiener-Hopf optimization or projection results can be applied. The optimal regulator is then obtained using operations with proper stable rational matrices: inner-outer factorizations and stable projections. The aim of this research was to compare the two approaches. It is well understood that the inner-outer factorization is equivalent to solving an algebraic Riccati equation. However, why are the stable projections not needed in the state-space approach? The difference between the two approaches derives from a different construction of doubly coprime proper stable factors used to represent the plant. The transfer-function approach takes any fixed doubly coprime factors, while the state-space approach parametrizes all such factors and those selected obviate the need for stable projections. In addition to this conceptual advantage, the state-space approach is computationally more efficient than the transfer-function one. The operations with rational matrices generically result in common factors that must be cancelled to obtain the optimal controller in reduced form. In general, the computational complexity of the state space design depends largely on the size of the state vector whereas the transfer-function algorithms depend critically on the number of the control inputs and the measurement outputs. That is why the latter algorithms are most efficient in the single-input single-output case. Kučera V.: The H2 control problem: state-apace and transfer-function solutions. In Proceedings of the IEEE Mediterranean Conference on Control and Automation, Ancona 2006, CD-ROM, Paper FEA3-4.

Polmat: Symbolic Algorithms for Polynomial Matrices

Polmat is a freely available library for symbolic computation with polynomial matrices. The library is developed for computer algebra system MuPAD. The Polmat library is focused on algorithms useful in control and filter design such as solvers for linear equations with polynomials and polynomial matrices and spectral factorization of polynomial matrices. Recently, algorithms for two-sided polynomials and multidimensional polynomials have been implemented.

Polynomial Approach to Modelling, Analysis and Control of Non-causal Systems

Motivation for this project is the fact that the spatial structure should be preserved in the model used for computational design of control and that the same structure should be inherited by the controller. The project deals with deformable mirror playing the role of a wavefront corrector, the most important part of an adaptive optics system.
A multidimensional transfer function describing dynamics of vertical deformation of a continuous plate supported by a triangular grid of actuators, has been derived. A rigorous analysis of von Neumann's stability of the discretisation scheme based on finite differences was performed and numerical simulation was used to illustrate the analytical results. The firsts attempts on control design have been done and will be published in the near future.

Output regulation problem

The Regulator Equation is the fundamental equation in the solution of the output regulation problem. It is a rather nonstandard partial first orded differential equation combined with an algebraic condition. Three methods for its solution were proposed. Their common feature is the use of the finite element method. Research in this area progressed in cooperation with foreign partners, a controller using the tracking error only was proposed. It has been verified on a real system - a model of a gyroscope. Further, a progress has been done in proving convergence of the iterative methods for the solution of the regulator equation that were proposed in the previous year. (theoretical result)

An algorithm for the decentralized control of large-scale systems was proposed. It is based on penalization of the interconnections between subsystems. On the other hand, it is required that the increase of the quadratic cost does not exceed a prescribed limit. A characteristic feature of this method is the use of the linear matrix inequalities. (theoretical result)

A controller for the magnetic bearing was proposed in cooperation with the Czech Technical University. This controller uses the exact linearization method. (applicational result)

A controller for the magnetic bearing was de-

signed in cooperation with CTU FEE. This controller uses the exact linearization method. The results were presented at a conference.

Numerical and Symbolical Polynomial Methods; Special Systems of Polynomial Equations for Multilevel Voltage Converters

Principal aim is calculating the optimum sequence of switching angles of the multilevel converter of direct to alternating voltage in the three-phase connection. The chosen optimal solution minimize undesirable total harmonic distortion (THD). This electrical devise has wide use nowadays. For example, the output of solar cells are DC voltages, and if this energy is to be fed into an AC power grid, a power electronic interface is required.

Main problem lies in solving the trigonometric set of equations or, after substitution for the Chebyshev polynomials, in solving the polynomial set of equations. There are several possibilities how to solve this but this task is very complicated. Therefore we concentrte on construction of a new set of polynomial equations leading to the optimal solution of switching angles. The number of equations obtained by this method is lower than using usual methods. Than it is possible to solve the problem more simply. This method is based on analytical solution of PWM problem in single-phase connection which is very fast and efficient and give the conjunction between both problems.

LQ-optimal 2-D linear systems via polynomial approach

In the branch of LQ-optimal 2-D linear systems via polynomial approach the bulk of the toolbox for Matlab was written and offers a user-friendly handling, now. Further, the category of factorization of 2-D two-sided polynomials respecting causality was investigated.

A method of synthesis of LQ-optimal 2-D linear systems via polynomial approach has been developed. The symmetrical factorization of 2-D polymials leads to algebraical solutions, unlike the 1-D case with polynomial solutions. Therefore, some part of the theory of two complex variables were developed (2-D principle of argument, 2-D residue theorem) and the 2-D discrete Fourier transform.

Special issue of International Journal of Robust and Nonlinear Control focused on polynomial methods

The group succeeded at organizing a special issue of a prestigious International Journal of Robust and Nonlinear Control. Organizers (guest editors) are Michael Šebek and Martin Hromčík, but other members of the group contributed by their papers: Vladimír Kučera tutorial, Zdeněk Hurák technical paper. The issue was put in press by Wiley at the beginnig of 2007.

Optimal posicast controller: input command shaping with a special structure

The researchers of the group (Zdeněk Hurák and Martin Hromčík) developed a new algorithm for design of an input command shaper, which is sort of a feedforward controller that preshapes the reference signal such that the oscillations observed at the output of the plant are avoided. The algorithm aims at minimization of l2 norm of the error signal and is based on the theory of linear and quadratic equations with polynomials.

The structure of 2-bodies mechanical systems systems

Our main contribution is to find explicit change of coordinates that transform one class of mechanic underactuated systems into cascade nonlinear systems with structural properties that are convenient for control design purposes. Using algebraic approach we extending the previous works interested in colocated and noncolcated partial feedback linearization of underactuated systems. The key analytical tools that allow reduction of high-order underactuated systems using transformations in explicit forms are "normalized generalized momentums and their integrals" (whenever integrable). The maximal linearization problem was investigated and it was shown that these systems may be classified into two subfamilies depending whether or not they have an actuated shape variable or not. In one case, it is possible to solve the maximal linearization problem with internal stability. In next, we derived new control scheme for stabilization such underactuated systems called "Composite control". The control is based on the superposition of n control schemes based on the well-known exact linearization theory of nonlinear systems and combines two different control strategies. Main control based on maximal exact linearization of the system is design for control the trajectory of

the centre of gravity of the system. Critically stable internal dynamics is control by a set of auxiliary inputs derived from partially exact linearization of the system. All parts of control (main control and set of auxiliary inputs) working simultaneously. In opposition to standard control methods available for the control and stabilization of this class of underactuated systems, this control does not include any switching scheme.

Publications:

Altogether 24 publications 3 journals and 21 conference papers) have appeared during 2006 as a result of research activities of CTD.

Selected Publications:

Journal Papers

1. Fernández-Anaya G., Martínez-García J.C., Kučera V.: Characterizing families of positive real matrices by matrix substitutions on scalar rational functions. Systems & Control Letters, 55 (2006), 871-878.

2. Ferkl L., Sládek O.: Simulace a řízení větrání tunelů pražského vnitřního okruhu. Vytápění, větrání, instalace. Vol. 15, No. 2 (2006), pp. 101-103.

3. Šebek M.: Conference Report - 16th IFAC World Congress: The Largest Automatic Ever. IEEE CONTROL SYSTEMS MAGAZINE. 2006, vol. 26, no. 1, s. 107-110.

Conferences Papers

6. Augusta P.: Polynomial approach to a deformable mirror modelling and control design. Preprints of the 11th International Student Olympiad on Automatic Control 2006, pp. 194-203.

7. Augusta P., Hurák Z.: Multidimensional transfer function model of a deformable mirror in adaptive optics systems. Proceedings of the 17th International Symposium on Mathematical Theory of Networks and Systems 2006, pp. 1556-1561.

8. Čelikovský S., Lynnyk V., Šebek M.: Anti-synchronization chaos shift keying method based on generalized Lorenz system. Proceedings of the 1st IFAC Conference on Analysis and Control of Chaotic Systems. CHAOS '06. Reims, pp. 333-338.

9. Čelikovský S., Lynnyk V.: Observer-based chaos synchronization and its application to multi-valued alphabet chaos shift keying secure encryption. Proceedings Book of the 6th Asian Control Conference. ASCC 2006. Bali : ASCC, 2006, pp. 52-57.

10. Čelikovský S., Lynnyk V., Šebek M.: Observer-based chaos synchronization in the generalized chaotic Lorenz systems and its application to secure enryption. Proceedings of the 45th IEEE Conference on Decision & Control, San Diego, CA, USA, 2006, pp. 3783–3788.

11. Ferkl L., Meinsma G., Sládek O.: Static Controller for Ventilation of Highway Tunnels. Tunnelling and Underground Space Technology. Incorporating Trenchless Technology Research. Seoul, Republic of Korea, AITES-ITA 2006 World Tunnel Congres and ITA General Assembly 32, pp. 1-7.

12. Ferkl L., Sládek O., Pořízek J.: Tunnel ventilation simulation of the City Ring in Prague. Tunnelling and Underground Space Technology. Incorporating Trenchless Technology Research. Seoul, Republic of Korea, pp. 1-6. (AITES-ITA 2006 World Tunnel Congres and ITA General Assembly /32).

13. Kučera V.: The H_2 Control Problem: State-space and Transfer-function Solutions. Proceedings of the IEEE Mediterranean Conference on Control and Automation. Ancona, Universita Politecnica delle Marche, 2006, pp. 1-5.

14. Kujan P., Hromčík M., Šebek M.: Výpočet speciální soustavy polynomiálních rovnic pro vícehladinový konvertor. (Solving special equations for multi-level converter.) Setkání uživatelů systému Mathematica. Praha : Elkan, 2006, pp. 1-8.

15. Rehák B., Synek L., Pachner D.: Design of a Control of a Magnetic Bearing via Exact Linearization. Proceedings of the IASTED International Conference on Control and Application. Quebec : IASTED, 2006, pp. 297-302.

16. Rehák B.: Optimization-based decomposition of a large-scale system. Proceedings of the ALSIS'06 1st IFAC Workshop on Applicatons of Large Scale Industrial Systems. Helsinky : IFAC, 2006, pp. 1-6.

17. Rehák B., Čelikovský S.: A numerical method for the solution of the error-feedback output regulation problem. Proceedings Book of the 6th Asian Control Conference. AsCC 2006. Bali, AsCC, 2006, pp. 58-63.

18. Řezáč M., Holub O., Augusta P., Hurák Z.: Uživatelské rozhraní pro návrh frekvenčních filtrů. (Graphical user interface for filter design in frequency domain.) Proceedings of the 7th International Scientific - Technical Conference. Process Control 2006, Pardubice, pp. 1-6.

19. Zikmund J., Moog H. C.: The structure of 2-bodies mechanical systems. Proceedings of the 45th IEEE Conference on Decision & Control, San Diego, CA, USA, 2006, pp. 6494-6499.

20. Zikmund J., Čelikovský S.: Design and Realization of Experimental Robotic Walking Platform, CVUT-Workshop, Prague, January 2006.

21. Zikmund J.: Analyse et Commande de Systemes Mécaniques Sous-Actionnés, JDOC-06, Saint Nazaire, June 2006.

Department of Decision-Making Theory

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Research Fellows:

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PhD Students:

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Michal Červinka – Optimization.
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Jan Koutný – Mathematical modeling.
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Petr Šimeček – Structures of conditional independence.
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Jan Fiala – Optimization.
jfiala@utia.cas.cz

Profile:

Most of the research activities of the department belong to the field of applied mathematics. The focus is on theoretical problems as well as problems connected with implementation of methods in the following areas:

mathematical optimization,
nonsmooth analysis,
differential equations,
variational problems,
probabilistic models of decision support systems,
conditional independence structures,
alternative calculi of uncertainty in artificial intelligence.

Recent Activities:

Grants and Projects:

R. Jiroušek: Multidimensional compositional probabilistic models. (Grant GA AV ČR No. A207 5302)

M. Kočvara: EU FP6 project PLATO-N. A platform for Topology Optimization incorporating Novel, Large-Scale, Free Material Optimization and Mixed Integer Programming Methods.

T. Kroupa: Formal theory of mathematical structures with vagueness. (Junior grant GA AV ČR No. KJB 100300502)

F. Matúš: Information geometry of multidimensional models in statistics and artificial intelligence. (Grant GA AV ČR No. IAA 100750603)

J. Outrata: Variational problems in non-smooth mathematical physics: Theory, numerical methods and applications. (Grant GA AV ČR No. A107 5402)

M. Studený: Conditional independence structures: information-theoretical approach III. (Grant GA ČR No. 201/04/0393)

R. Jiroušek, M. Studený, T. Kroupa, J. Vomlel, R. Lněnička: participate at the project DAR (Data, Algorithms, Decision Making), coordinated by M. Mareš

Teaching Activities:

Faculty of Mathematics and Physics – Charles University

Variational methods in physics. (M. Kružík)

Mathematical elasticity. (M. Kružík, T. Roubíček)

Analytical and statistical theory of exponential families. (F. Matúš)

Selected parts from optimization theory. (T. Roubíček)

Nonlinear differential equations and inequalities. (T. Roubíček)

Conditional independence structures. (M. Studený)

Faculty of Informatics and Statistics of the University of Economics

Bayesian networks. (J. Vomlel)

Faculty of Physical and Nuclear Engineering of the Czech Technical University

Probabilistic models in artificial intelligence. (R. Jiroušek)

Faculty of Electrical Engineering

Mathematical logic. (T. Kroupa)

Faculty of Management of the University of Economics

Mathematics. (R. Jiroušek)

Supervised Postgraduate Students:

Petr Beremlijski - VŠB Ostrava

Martin Čermák - Charles University

Michal Červinka - Charles University

Vladislav Chýna - Charles University

Jan Koutný - Charles University

Radim Lněnička - Charles University

Michal Stingl - University of Erlangen

Jan Fiala - Charles University

Petr Šimeček - Charles University

Václav Kratochvíl - Czech Technical University

T. Surowiec - Humboldt University, Berlin

Supervised diploma students:

One diploma-thesis student has been supervised.

Visitors:

Prof. Alberto Roverato (University of Modena and Reggio Emilia, Italy)

Dr. Agneszka Kałamajska (University of Warsaw, Poland)

Prof.Dr. Wolfgang Achtziger (University of Dortmund, Germany)

Sven Grönewäller (University of Dortmund, Germany)

Prof. Heléne Massam (York University, Toronto, Canada)

Dr. Mathias Drton (Chicago University, USA)

Michael Stingl (University of Erlangen, Germany)

Prof. Boris Mordukhovich (Wayne State University Detroit,USA)

Prof. Gernot Kleiter (University of Salzburg, Austria)

Dr. Niki Pfeifer (University of Salzburg, Austria)

Prof. Peter Naeve (University of Bielefeld, Germany)

Results:

Graphical characterization of equivalence classes of AMP chain graphs

by Milan Studený and Alberto Roverato

This paper [1] deals with chain graph models under alternative AMP interpretation. A new representative of an AMP Markov equivalence class, called the *largest deflagged graph*, is proposed. The representative is based on revealed internal structure of the AMP Markov equivalence class. More specifically, the AMP Markov equivalence class decomposes into finer *strong equivalence* classes and there exists a distinguished strong equivalence class among those forming the

AMP Markov equivalence class. The largest deflagged graph is the largest chain graph in that distinguished strong equivalence class. A composed graphical procedure to get the largest deflagged graph on the basis of any AMP Markov equivalent chain graph is presented. In general, the largest deflagged graph differs from the AMP essential graph, which is another representative of the AMP Markov equivalence class.

Two constructions on limits of entropy functions

by František Matúš

The correspondence between the subvectors of a random vector and their Shannon entropies gives rise to an entropy function. Limits of the entropy functions are closed to convolutions with modular polymatroids, and when integer-valued also to free expansions. The problem of description of the limits of entropy functions is reduced to those limits that correspond to matroids [5]. Related results on entropy functions are reviewed with regard to polymatroid and matroid theories, and perfect and ideal secret sharing.

Efficient inference and learning of Bayesian networks

by Jiří Vomlel

In [17], we discussed an application of a family of Bayesian network models known as models of independence of causal influence (ICI) to classification tasks with large numbers of attributes.The key that enabled application of the ICI models is their compact representation using a hidden variable. We address the issue of learning these classifiers by an computationally efficient implementation of the EM-algorithm.

We studied a new additive decomposition of probability tables - tensor rank-one decomposition in [15].We have show that tensor rank-one decomposition can be used to reduce the space and time requirements in probabilistic inference. We provide a closed form solution for minimal tensor rank-one decomposition for some special tables.

A standard graphical representative of a Bayesian network model is a special chain graph, named the *essential graph*. An alternative algebraic approach to the mathematical description of this statistical model uses instead of it a certain integer-valued vector, named the *standard imset*. In [16]we give a direct formula for the translation of any chain graph describing a Bayesian network

model into the standard imset. The formula is applicable to the essential graph as well. Moreover, we present a two-stage algorithm which makes it possible to reconstruct the essential graph on basis of the standard imset. The core of this paper is the proof of the correctness of the algorithm.

Mathematical modeling in continuum physics

by Tomáš Roubíček

Mathematical theory of incompressible heat-conductive non-Newtonean fluids had been substantially advanced and allows now for fully coupled systems with viscosity of the p-growth with $p > 11/5$, which seems to be an optimal result in nowadays general knowledge. This was done both for single-component fluid and for ionized mixtures.

Theory of rate-independent processes had been substantially developed in connection with the so-called Gamma-convergence and with convergent numerical strategies. Particular application concerns shape memory alloys, where our long-lasted activity had also been advanced. Even, a thermally coupled model, which naturally goes beyond purely rate-independent framework, was proposed and analysed.

Non-additive Measures in Game Theory and Decision Making

by Tomáš Kroupa

1. In 2006 I started to cooperate on topics from coalition game theory with prof. Dan Butnariu (University of Haifa, Israel). We have studied the games with fuzzy coalitions in which the degree of membership of the player in a coalition is viewed as a level of risk each player assumes when he joins the coalition. The concept of value of a game captures "a fair distribution of profit" among individual players. We have proved that there is a sound axiomatization of a value for the studied class of games, which enables to derive a computational form of the value. The results will appear in [1].

2. Possibility measures count among frequently used non-additive set functions in decision-making under uncertainty. Every possibility measure gives rise to a certain compact convex sets of finitely additive probabilities. Geometrical properties of this

set are studied in [4] for possibility measures on finite universe. It was proved that this set of probabilities forms a very special kind of a polyhedral set; namely, a so-called simple polytope. This result enables to use more efficient computational procedures for processing possibility measures.

Coderivative analysis of quasivariational inequalities with applications to stability and optimization

by Boris S. Mordukhovich and Jiří V. Outrata

Equilibrium models governed by parameter-dependent quasivariational inequalities have been studied [8] from the viewpoint of stability and optimization. The main attention is paid to quasivariational inequalities with parameters entering both single-valued and multivalued parts of the corresponding generalized equations in the sense of Robinson. The main tools of the used variational analysis involve coderivatives of solution maps to quasivariational inequalities, which allow to obtain efficient conditions for robust Lipschitzian stability of quasivariational inequalities and also to derive new necessary optimality conditions for mathematical programs with quasivariational constraints. To conduct this analysis, we develop new results on coderivative calculus for structural settings involved in our models. The results obtained are illustrated by applications to some optimization and equilibrium models related to parameterized Nash games of two players and to oligopolistic market equilibria.

Oscillations and concentrations in sequences of gradients

by Agnieszka Kałamajska and Martin Kružík

We used generalized Young measures to describe oscillations and concentrations effects generated by gradients of Sobolev mappings. These results are then applied to obtain new weak lower semicontinuity results of integral functionals. Particularly, we give necessary and sufficient conditions for weak continuity of determinants of gradients; cf. [2].

List of Selected References

1. D. Butnariu, T. Kroupa, Shapley Mappings and the Cumulative Value for n-Person Games with Fuzzy Coalitions. To appear in *European Journal of Operational Research.*

2. A. Kałamajska, M. Kružík, Oscillations and concentrations in sequences of gradients. Accepted in *Control. Optim. Calc. Var.*

3. J. Koutný, M. Kružík, A. Kurdila, T. Roubíček, Identification of Preisach-type hysteresis operators. *Numer. Funct. Anal. Optim.*, submitted.

4. T. Kroupa, Geometry of Possibility Measure on Finite Set. *International Journal of Approximate Reasoning*, submitted.

5. F. Matúš. Two constructions on limits of entropy functions. *IEEE Trans. Inform. Theory*, **53** (2007) 320– 330.

6. A. Mielke, T. Roubíček: Numerical approaches to rate-independent processes and applications in inelasticity. (Preprint No.1169, WIAS, Berlin, 2006), *Math. Modelling Numer. Anal.*, submitted.

7. A. Mielke, T. Roubíček, U. Stefanelli: Gamma limits and relaxations for rate independent evolutionary problems. (Preprint No.1156, WIAS, Berlin, 2006) *Calc. Var. PDE*, submitted.

8. B. S. Mordukhovich, J. V. Outrata: Coderivative analysis of quasivariational inequalities with applications to stability and optimization. Accepted in *SIAM J. Optimization.*

9. T. Roubíček: On non-Newtonean fluids with energy transfer. *Journal of Mathematical Fluid Mechanics*, submitted.

10. T. Roubíček: Incompressible ionized non-Newtonean fluid mixtures. *SIAM J. Math. Anal.*, submitted.

11. T. Roubíček, M. Kružík, J. Koutný: A mesoscopical model of shape-memory alloys. *Proc. Estonian Acad. Sci. Math. Phys.*, submitted.

12. T. Roubíček: Modelling of thermodynamics of martensitic transformation in shape-memory-alloys. *Discrete and Cont. Dynam. Syst.* submitted.

13. A. Roverato, M. Studený: A graphical representation of equivalence classes of AMP chain graphs, *Journal of Machine Learning Research* **7** (2006), 1045-1078.

14. P. Savický, J. Vomlel, Tensor rank-one decomposition of probability tables, In the *Proceedings of the 11th IPMU conference*, Paris, France, July 2-7, 2006, 2292-2299.

15. M. Studený, J. Vomlel (Editors). *Proceedings of the third European Workshop on Probabilistic Graphical Models (PGM'06)*. Prague, September 12-15, 2006.

16. J. Vomlel, M. Studený. Graphical and Algebraic Representatives of Conditional Independence Models. A chapter accepted for publication in *Advances in Bayesian Networks, Studies in Fuzziness and Soft Computing*, Springer-Verlag, 2007.

17. J. Vomlel, Noisy-or classifier. *International Journal of Intelligent Systems*, **21**, (2006), 381-398.

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Vlasta Kaňková – Stochastic programming problems, stochastic decision procedures.
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Milan Sitař – Stochastic dynamic programming.
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Martin Šmíd – Approximation methods, multistage stochastic programming.
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Fellow:

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Postgraduate Students:

Karel Diviš – Capital markets theory.
(FSV UK, ČT)

Michal Houda –Stochastic programming, stability, empirical estimates, approximations.
(MFF UK, JČU, ÚTIA AV ČR)

Petr Chovanec – Stochastic programming, applications to social problems.
(MFF UK, CERGE)

Jakub Jeřábek – Economic dynamics.
(CERGE, ÚTIA AV ČR)

Alexej Kuchynka – Nonlinear econometrics.
(EF ZČU)

Robert Pecha – Management of information and decision under uncertainty.
(FM VŠE).

Martin Schimek – Derivatives, capital markets.
(FSV UK, ČNB)

Blanka Šedivá – Economic dynamics.
(FAV ZČU)

Karel Vaníček – Financial econometrics.
(MFF UK, GE Bank)

Profile:

Research Topics:

The members of department have concentrated on the following research fields:

a) real and monetary macrodynamics, dynamic economics and econometrics, stochastic economics and econometrics, and econometric modelling,

b) theoretical fuzzy set approach to decision making,

c) nonlinear and stochastic optimization, stochastic dynamic optimization,

d) stochastic differential-difference equations and its applications to the mathematical finance, and to stability of dynamic economics,

e) uncertainty processing in expert systems,

f) advanced methods in financial econometrics and wavelets analysis of capital markets.

Recent Activities:

Grants and Projects:

V. Kaňková: *Stochastic Decision Approaches in Nonlinear Economic Models* (Grant GA ČR No. 402/04/1294)

M. Mareš: *Mathematics, Informatics and Cybernetics: Tools and Applications* (Key Project of the Academy of Sciences of the Czech Republic No. K 1019101)

M. Mareš: *Semantic Part of Vague Verbal Data* (Grant GA AV ČR No. A 1075301)

M. Mareš: *Aggregation Principles in the Models of Mathematical Economy* (Grant GA ČR No. 402/04/1026)

K. Sladký: *Validation of Economic Decision Models and Results* (Grant GA ČR No. 402/05/0115 – with Charles University)

K. Sladký: *Economic Dynamics: Analytical and Computational Treatment of Macroeconomic Models* (Grant GA AV ČR No. A 7075202)

M. Vošvrda: *Nonlinear Economic Dynamics* (Grant GA ČR No. 402/03/H057 – with University of Economics in Prague and Faculty of Social Sciences of Charles University)

J. Kodera: *Nonlinear Dynamics and Stochastics of Economics Systems: Equilibria, Stability, and Bifurcations* (Grant GA ČR No. 402/06/0990)

M. Šmíd: *Mathematical Modeling of the Microstructure of the Financial Markets with the Non-synchronous Trading* (Grant Ga ČR No. 402/06/1417)

M. Vošvrda: *Center for Dynamic Economics and Econometrics* (Ministry of education LC06075 - with University of Economics in Prague, Faculty of Social Sciences of Charles University, and Faculty of Economics of West Bohemia University)

Teaching and Supervising Activities:

University Courses:

University of Economics, Prague:

J. Kodera – *Monetary Economics.*

Charles University, Faculty of Social Sciences:

A. Derviz – International Finance.

J. Hlaváček – Advanced Microeconomics.

V. Kaňková – Decision in Economics – Stochastic Optimization.

K. Sladký – Stochastic Processes in Economy.

M. Šmíd – Quantitative Finance.

L. Vácha – Business Cycle Theory.

L. Vácha – Quantitative Finance.

M. Vošvrda – Economic Dynamics.

M. Vošvrda – Business Cycles Theory (SOKRATES).

M. Vošvrda – Quantitative Finance Theory.

F. Žikeš – Quantitative Finance.

Czech Technical University, Faculty of Electrical Engineering:

M. Mareš – Coalitional Games Theory.

Diploma and Doctoral projects:

Diploma

Faculty of Mathematics and Physics, Charles University (supervisor V. Kaňková – 2, M. Vošvrda – 1).

Faculty of Nuclear Physics and Engineering, Czech Technical University (supervisor A. Derviz – 1).

Doctoral

Faculty of Mathematics and Physics, Charles University (supervisor V. Kaňková – 3, K. Sladký – 2).

Charles University, Faculty of Social Sciences (supervisor M. Vošvrda – 4).

Conferences and International Contacts:

Conferences – Participation

International Conference WEHIA. Bologna 2006 (Italy) (M. Šmíd, L. Vácha, M. Vošvrda)

Econometric Day 2006, Prague (V. Kaňková, J. Kodera, K. Sladký, M. Šmíd, L. Vácha, M. Vošvrda)

EURO XXI 2006, Reykjavik, (Iceland) (V. Kaňková, K. Sladký)

Prague Stochastics 2006 (The Czech Republic)(P. Chovanec, J. Jeřábek, V. Kaňková, K. Sladký, M. Šmíd)

Operations Research Proceedings 2006, Karlsruhe, (Germany)(V. Kaňková, K. Sladký)

IPMU'2006, Paris (France) (M. Mareš)

24th International Conference Mathematical Methods in Economics 2006, Plzeň (M. Houda, V. Kaňková, J. Kodera, M. Sitař, K. Sladký, M. Šmíd, L. Vácha, M. Vošvrda)

International Conference Computational Economics and Finance, Lomassol, Cyprus, 2006 (J. Kodera, M. Vošvrda)

11th International Conference IPMU 2006, Paris, Les Cordeliers, (France) (M. Komorníková, R. Mesiar)

17th Symposium COMPSTAT 2006, Roma, (Italy) (M. Komorníková)

East West Fuzzy Colloquium 2006, 13th Zittau Fuzzy Colloquium, (R. Mesiar)

Preferences, Games and Decisions. Linz Seminar on Fuzzy Set Theory 2006. Linz, Johannes Kepler Universität, (R. Mesiar)

9th Fuzzy Days 2006, Dortmund, (R. Mesiar)

Quantitative Methods in Economics 2006, Bratislava (P. Chovanec, V. Kaňková, K. Sladký)

Swiss Society for Financial Market Research Annual Conference 2006, (Curych), (A. Derviz)

Quantitative Methods in Finance 2006, Sydney, (M. Šmíd)

International Cooperations

Joint venture research group with University of Amsterdam (Department of Economic Sciences and Econometrics), JAIST (Japan), University of Gent (Belgium), Escola Superior de Technologia, Castelo Branco, Portugal, Technical University Ilmenau (Germany), JKU Linz (Seminar), University Alcala de Henares, University of Novi Sad, University La Sapienza Rome, University of Paris, University of Udine (Italy), University of Salermo and Artificial Intelligence Research Institute IIIA – CSIC, Bellaterra, Barcelona. NATO project "Aggregation Operators" with Uni Alcala (Spain). A cooperation for the macroeconomic model constructed for the Slovak Republic and for the Czech Republic continued with the Institute of Slovak and World Economics of Slovak Academy of the Sciences, Bratislava.

Guests and visitors

Prof. Dr. Nico M. van Dijk – University of Amsterdam, Department of Economic Sciences and Econometrics, The Netherlands

Dr. M. Dzemida – Mathematical Institute of Lithuanian Academy of Science

– University of Venice, Italy

– University of Houston, USA

Public Utility Services

Three members of the Department (V. Kaňková, J. Kodera, and M. Vošvrda) were elected in the Czech Econometric Society Board and Executive Committee, K. Sladký was elected in the Czech Society of Operations Research Board. M. Vošvrda and E. Dostálová are editors of the Bulletin of the Czech Econometric Society.

J. Hlaváček, V. Kaňková, and M. Vošvrda are members of the Economic Sciences Division of the Grant Agency of the Czech Republic.

V. Kaňková is a member of the American Mathematical Society. L. Komorníková is a member of the EUSFLAT, and the SEF, Mathematics Working Group, Stockholm.

M. Mareš is a member of the American Mathematical Society, a member of the European Academy of Sciences and Arts, a member of the European Society for Fuzzy Logic and Technologies, a member of the Editorial Board of the International Journal of Intelligent Systems and Information Processing, Editor-in-chief of the Kybernetika journal, a member of Boards of the Research Programmes INFRA, Chairman of the 1st Commission for Evaluation of Research Plans of the Czech Universities with the Ministry of Education.

R. Mesiar is a member of Editorial Board of the International Journal Fuzzy Sets and Systems, and of the Kybernetika journal and the EUSFLAT Board.

V. Novák is a member of Editorial Board of the International Journal Fuzzy Sets and Systems.

K. Sladký is Managing Editor of the Kybernetika journal.

M. Vošvrda is an elected member of Advisors Board of the Computational Economics Society, a member of Editorial Board of the Prague Economic Papers, and a member of the 7. scientific programme board of the EU.

Results

Dynamic Economics and Macroeconomics Modelling

Nonlinear model of closed economy is formulated on an extended and modified Kaldor's model of small closed economy with a simple structure and several nonlinearities. Nonlinear pattern of dependencies in this model is created by a logistic function. The model is realized by four differential equations. The first equation and second equation describe output and capital dynamics. A core of the output dynamics is formulated by investment and savings disequilibrium. Capital dynamics is formed by a net investment. The third equation describes price dynamics through disequilibrium powers on monetary markets. And the fourth equation describes expected inflation formulated as an adaptive expectation. Behavior analysis of this model is realized on numerical calibrated model. The considered model demonstrates chaotic solution of attractors by positive Lyapunov exponent. Kaldor's model is described in some classical macroeconomics. Chaotic behavior of extended and modified Kaldor's model is analyzed in [9]. A simple dynamic continuous nonlinear model for the description and investigate the possibility of more complex behaviour of such systems was chosen. The stability such systems was tested and Lyapunov exponents were computed using appropriate numerical methods. The non-linear approach to economic dynamics enables us to study traditional economic models using modified formulations and different methods of solution. We compare dynamical properties of Keynesian and Classical macroeconomic models. We start with an extended dynamical IS-LM neoclassical model generating behaviour of the real product, interest rate, expected inflation and the price level over time. Limiting behaviour, stability, and existence of limit cycles and other specific features of these models will be compared [8].

Heterogeneous Agents Models

A heterogeneous agents model with the worst out algorithm (WOA)was considered for obtaining more realistic market conditions. The WOA replaces periodically the trading strategies that have the lowest performance level of all strategies presented on the market by the new ones. New strategies that enter on the market have the same stochastic structure as an initial set of strategies. By wavelets applications, influences of measurement on the trading strategies with the WOA are shown. [16], [17].

Microstructure of Financial Markets

Two types of models were studied: those describing behavior of rational agents in limit order markets and those describing such a market as a whole. In particular: Papers [13] and [14] study continuous time portfolio selection problems with the possibility to place limit orders - it is found that those models are often equivalent to "tradi-

tional" portfolio selection problems (i.e. without limit orders). In work [15], a mathematical description of an evolution of limit order market is formulated and conditions for the state of the market to be Markov are formulated.

Risk-Sensitive Optimality Conditions in Markov Decision Processes

In [11] we focus our attention on discrete-time Markov decision processes when the stream of rewards generated by the Markov processes is evaluated by an exponential utility function. This problem can be treated as a classical Markov decision process on condition that the transition probabilities are replaced by general nonnegative matrices. Using the uniform block-triangular decomposition of a set of nonnegative matrices fulfilling "product property" we suggest a value iteration method for finding optimal policies.

Vagueness and Uncertainty

The investigation of the non-stochastic uncertainty continued in the research in the field of aggregation operators and copulas. Moreover, the analysis of the role of fuzzy zero, fuzzy unit and related weak equivalences resulted in the conclusion that their definition can be significantly simplified without any changes of their properties. The theory of fuzzy quantities was suggested for applications in the computational geography.

Stochastic Programming and Decision in Economy

Our attention was focused on:

1. A stability and empirical estimates in the case of optimization problems depending on a probability measure. To obtained new stability results the Wasserstein and Kolmogorov metrics with "underlying" 1-norm have been employed. This approach gives possibility to evaluate numerically an "approximation" error in the case of finite dimensional random element [6]. Furthermore, a relationship between empirical estimates in the stochastic programming and integrated empirical processes has been investigated in [5], [6]. The achieved stability results have been applied to the multistage stochastic programming problems in the case when the "underlying" random element follows an autoregressive random sequence and constraints sets correspond to a system of individual probability constraints [7].

2. A comparison of two different approaches to the optimization problems with random el-

ement, stochastic programming problems with probability constraints and robust models. The numerical studies are presented in [3] and [4].

Optimality Conditions in Semi-Markov Decision Processes

In [10] we consider semi-Markov decision processes with a finite state space and general multichain structure (i.e. the embedded Markov chain contains several classes of recurrent states). We formulate necessary and sufficient optimality conditions for average reward optimality of the embedded Markov chain. Then the optimality conditions are extended to semi-Markov decision processes when averaging is considered either with respect to the number of transition or with respect to the time elapsed. Conditions for equivalence of these optimality criteria are also established.

Publications:

List of Selected References:

References

[1] van Dijk, N.M., Sladký, K.: Monotonicity and comparison results for nonnegative dynamic systems. Part I: Discrete-time case. Kybernetika 42 (2006), No.1, 37-56

[2] van Dijk, N.M., Sladký, K.: On the total reward variance for continuous-time Markov reward chains. Journal of Applied Probability 43 (2006), No.4, pp.1044–1052.

[3] Houda, M.: Comparison of Approximations in Stochastic and Robust Optimization Programs. In: Proceedings of Prague Stochastics 2006 (M. Hušková and M. Janžura, eds.) MATFYZPRESS by publishing house of the Faculty of Mathematical and Physics, Charles University in Prague, Prague 2006, 418–425, CD ROM.

[4] Houda, M.: Comparison of Approximations in Stochastic and Robust Optimization Programs. Approximations in Stochastic and Robust Programming Problems. In: Proceedings of Mathematical Methods in Economics 2006 (L. Lukáš, ed.) TYPOS-Digital Print. spols.r.o., Pilsen (Czech Republic) 2006, 249–254.

[5] Kaňková, V., Houda, M.: Dependent Samples in Empirical Estimation of Stochastic Pro-

gramming Problems. Austrian Journal of Statistics *35* (2006), 2&3, 271–279.

[6] Kaňková, V., Houda, M.: Empirical Processes in Stochastic Programming. In: Proceedings of Prague Stochastics 2006 (M. Hušková and M. Janžura, eds.) MATFYZPRESS by publishing house of the Faculty of Mathematical and Physics, Charles University in Prague, Prague 2006, 426–436, CD ROM.

[7] Kaňková, V.: Multistage Stochastic Programming Problems; Stability and Approximations. In: Operations Research Proceedings 2006 (to appear).

[8] Kodera, J., Sladký, K., Vošvrda, M.: Neo-Keynesian and Neo-Classical Macroeconomic Models: Stability and Lyapunov Exponents. Working Paper IES, WP 10 2006, FSV UK.

[9] Kodera J., Vošvrda M.: Product, capital, and price motion in a simple nonlinear model closed economy. Politická ekonomie 3, 2006, pp. 339-350.

[10] Sladký, K., Sitař, M.: Necessary and sufficient optimality conditions in multichain semi-Markov decision processes. In: Prague Stochastics 2006 (M. Hušková a M. Janžura, eds.), Matfyzpress, Prague 2006, pp.633-643, CD-ROM

[11] Sladký, K.: Some remarks on risk-sensitive optimality criteria in Markov decision processes. Proc. Internat. Conf. Quantitative Methods in Economics (Multiple Criteria Decision Making XIII, J. Pekár, ed.), University of Economics, Bratislava 2006, pp. 165–173.

[12] Sladký, K.: Approximation in stochastic growth models. Proc. 24 Internat. Conf. Mathematical Methods in Economics 2006, Plzeň, pp.465-470. CD-ROM

[13] Šmíd, M.: Behavior of a Risk Averse EMH-believer at a Limit Order Market, proceedings of WEHIA 2006, International Conference on Economic Sciences with Heterogeneous Interacting Agents. WEHIA 2006, Bologna, IT

[14] Šmíd, M.: Optimal Strategies at a Limit Order Market, Proceedings of the 24th International Conference Mathematical Methods in Economics 2006, Eds: Lukáš L., Plzeň, pp. 471-474, CD-ROM.

[15] Šmíd, M.: On Markov Properties of Limit Order Markets, Prague Stochastics 2006, Eds: Hušková M., Janžura M., Prague, pp. 633-643, CD-ROM.

[16] Vácha, L., Vošvrda, M.: Wavelet Applications to Heterogeneous Agents Model, Prague Economic Papers, 16 (2007), 1, 38-54, ISSN 1210-0455.

[17] Vácha, L., Vošvrda, M.: Wavelet Applications to Heterogeneous Agents Model, Working Paper 21, FSV UK, 2006

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Rafael Redondo – Inst. of Optics, Madrid, Spain

Eva Ocelíková – Faculty of Electrotechnics and Informatics, Technical University Košice, Slovak Republic

Jaroslav Kautský – Flinders University of South Australia, Adelaide, Australia

Esa Rahtu – University of Oulu, Finsko

Profile:

Research Topics:

The Department is involved in basic research in image processing and pictorial pattern recognition. Major application areas are biomedicine, remote sensing, astronomy, and art conservation.

a) Recognition of distorted images and patterns by invariant descriptors regardless of their actual position in the scene

b) Registration and fusion of several images of the same scene taken at different times, by different sensors and/or from different viewpoints in order to obtain information of higher quality

c) Theory of moment invariants, namely of rotation invariants, affine invariants and invariants to convolution.

d) Restoration of degraded images, namely multichannel blind deconvolution, edge-preserving denoising, local contrast enhancement, and color transformations

International Cooperation:

Members of the Department participate in joint research with their colleagues from:

Flinders University of South Australia, Adelaide, Australia,

University of Dortmund, Germany,

CIC-IPN, Mexico City, Mexico

Institute of Optics, CSIC, Madrid, Spain,

Faculty of Electrotechnics and Informatics, Technical University Košice, Slovak Republic.

University Boards:

J. Flusser is a chairmen of the Scientific Board of the Institute of Information Theory and Automation.

J. Flusser is a member of the State Examination Committee at the Faculty of Nuclear Science and Physical Engineering.

J. Flusser and S. Saic are members of the Board of doctoral studies I2 "Software systems" at the Faculty of Mathematics and Physics.

Editorial Boards:

J. Flusser is a member of the Editorial Board of the journal *Kybernetika*

Recent Activities:

Grants and Projects:

"Digital image fusion in case of nonlinear imaging models", J. Flusser, supported by the Grant Agency of the Czech Republic No. 102/04/0155;

"Intelligent and information technology for information and control systems decision-making support", D. Klimešová, supported by the Ministry of education No. 69, jointly with the Faculty of Electrotechnics and Informatics, Technical University of Košice;

"New developments on multimodality image fusion", J. Flusser, jointly with the Institute of Optics, Madrid, Spain;

"Image processing in art conservation", B. Zitová, jointly with the Academy of Fine Art, Prague;

"Construction of knowledge system for decision support based on geodata", L. Soukup, jointly with the Research Institute of Geodesy, Topography and Cartography, grant of Ministry of Education No. 2C06028 (In-GeoCalc);

"Mathematical methods for superresolution of digital images", F. Šroubek

"Space resolved ballistic electron emission spectroscopy on individual InAs/GaAs dots embedded in AlGaAs barriers." F. Šroubek, supported by the Grant Agency of the Czech Republic No 202/05/0242

"Subcontract project under Person Identification in Mobile Decives and Video Surveillance (Person ID)", University of Oulu, J. Flusser

Teaching and Supervising Activities:

University Courses:

Digital Image Processing, J. Flusser, Faculty of Mathematics and Physics, Charles University, Prague

Image Processing and Pattern Recognition I, II, J. Flusser (lectures); B. Zitová, O. Horáček, and J. Kamenický (computer exercises), Faculty of Nuclear Science and Physical Engineering, CTU, Prague

Special Functions and Transformations in Image Analysis, J. Flusser and B. Zitová, Faculty of Mathematics and Physics, Charles University, Prague

Geographical Information Systems and Image Processing, D. Klimešová, Faculty of Economics and Management, Czech University of Agriculture, Prague

Applied Computer Science, S. Saic, Faculty of Science, Charles University, Prague

Adjustment of Geodetic Networks, L. Soukup, Faculty of Civil Engineering, CTU, Prague

Supervising:

In 2006, 11 Ph.D students and 13 diploma (master) students were supervised by the members of the Department. Three Ms. theses were successfully defended.

Conferences and International Contacts:

Conferences – Participation:

The members of the Department presented twenty two papers at international conferences.

Conferences – Organization:

J. Flusser was a member of the program committees of the Computer Vision Winter Workshop CVWW'06, Telc, Czech Republic, 18th Int'l. Conf. Pattern Recognition ICPR'06, Hong Kong, Conf. Advanced Concepts for Intelligent Vision Systems ACIVS'06, Antwerp, Belgium, Workshop on Information Optics, Toledo, Spain, Chairman of COMPSTAT'06 Invited Session on Image Analysis, Rome, Italy.

Filip Šroubek was a member of the program committee of the Workshop on Information Optics, Toledo, Spain.

International Contacts:

The Department has numerous contacts with universities and research institutes abroad (see International Cooperation section for details). This collaboration has led, among others, to two joint projects and several joint papers published or submitted in 2006.

Results:

A unified approach to superresolution and multichannel blind deconvolution

We have developed a new method for blind deconvolution and superresolution of multiple degraded low-resolution images. No prior information about the shape of degradation blurs is assumed. The proposed approach consists of building a regularized energy function and minimizing it with respect to the original image and blurs, where regularization is carried out in both the image and blur domains. The image regularization based on variational principles maintains stable performance under severe noise corruption. The blur regularization guarantees consistency of the solution by exploiting differences among the acquired low-resolution images. We have performed several experiments on synthetic and real data to illustrate robustness and utilization of the proposed technique in real applications [1,2].

Recognition of partially occluded objects

We introduce novel method for object description based on affine moment invariants. The description uses new kind of important points, doesn't need higher than first derivative and it is affine invariant. We demonstrated that our object description is suitable method for partially occluded object recognition [3].

Duplicated image regions detection based on moment invariants

Duplicated image regions or the copy-move forgery is a common type of digital image forgery. The method is based on moment blur invariants, which results in an advantage that the proposed method successfully detect duplicated regions even in presence of blur degradation, additional noise or contrast changes in the forged areas. The method is able to work successfully also when the tampered image is saved in a lossy format, such as JPEG. The proposed method tiles the image with overlapping blocks and uses blur invariants to represent them. The dimension of

the blocks representation is reduced by using the principal component transformation. Furthermore, to be able to do efficiently range queries in multidimensional data to analyze the block similarities, a K-d tree representation is used. The output of the algorithm is a duplicated image regions map [4].

Space-variant restoration of images degraded by camera motion blur

We were working on the problem of restoration of images degraded by camera motion blur with application in the reduction of camera shake. We considered multichannel case, when at least two images of the same scene are available.We have developed a restoration algorithm that can be applied if the camera moves in one plane perpendicular to optical axis without any rotations. Moreover, we have started investigation of the ways how the algorithm could be extended to general camera motion. The proposed algorithm belongs to the group of variational methods that estimate simultaneously sharp image and depth map, based on the minimization of a cost functional [5].

Electronic database of materials research of paintings

We have developed a comprehensive solution for processing and archiving information about artwork specimens used in the course of art restoration - Nephele. The information processing based on image data is used in the procedure of identification of pigment and binder present in the artwork, which is very important issue for restorers. Materials research is usually provided as a part of restoration process. The aim of the materials research of painting layers is to identify inorganic and organic compounds (pigments and binders) using microanalytical methods, and to describe stratigraphy and morphology of layers in light end electron microscopes. The results are used to interpret the painting technique of original paint and re-paints and to describe secondary changes of painting materials. The materials research report usually contains images, texts and analytical data. The Nephele system is the database for painting materials research reports, extended with the image preprocessing modules and the image retrieval facilities [6].

Publications:

Altogether one book chapter, 4 journal papers and 23 conference papers appeared in 2006.

List of Selected References:

1. Šroubek F., Flusser J. : "Resolution Enhancement via Probabilistic Deconvolution of Multiple Degraded Images", *Pattern Recognition Letters*, vol. 27, pp. 287-293, 2006

2. Šroubek F., Flusser J., Zitova B. : "Image Fusion: A Powerful Tool for Object Identification", in: *Imaging for Detection and Identification*, (Byrnes J. ed.), pp. 107-128, Springer, 2006

3. Krolupper F., Flusser J. : "Polygonal Shape Description for Recognition of Partially Occluded Objects", *Pattern Recognition Letters*, accepted in Dec 2006

4. Mahdian B., Saic S. : "Detection of copy-move forgery using a method based on blur moment invariants", *Forensic Science International*, accepted in Nov 2006

5. Šorel M., Flusser J. : "Simultaneous Recovery of Scene Structure and Blind Restoration of Defocused Images.", in: *Proc. Computer Vision Winter Workshop CVWW'06*, (Chum O., Franc V. eds.), pp. 40-45, Telč, Czech Republic, February 2006

6. Benes M., Zitova B., Flusser J., Hradilova J., Hradil D. : "The Image Processing System for Art Specimens: Nephele", in: *Proc. 14th European Signal Proc. Conf. EU-SIPCO'06*, Florence, Italy, Sept. 2006

7. Flusser J., Suk T. : "Rotation Moment Invariants for Recognition of Symmetric Objects", *IEEE Trans. Image Proc.*, vol. 15, pp. 3784-3790, 2006

Software Products

Three image processing software products, created by the Department members, have been upgraded and their new versions were released in 2006.

ZODOP – General-purpose image processing system for Windows (S. Saic, T. Suk)

IMARE – Matlab toolbox for image registration and matching (B. Zitová, J. Flusser)

BSR Tool – Matlab toolbox for blind deconvolution a superresolution (F.Šroubek, J. Flusser)

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Profile:

Research Topics:

The scope of the Department of Pattern Recognition activities covers statistical pattern recognition, with emphasis on model-based pattern recognition and application of finite mixtures, modelling of random fields for scene interpretation, probabilistic neural networks, statistical feature selection and applications in economics, car industry, architecture, medicine, and text document classification and processing. In all these areas the group members enjoy an international reputation expressed by scientific awards and memberships in governing bodies of international organizations.

International Cooperation:

Members of the Department co-operate in the field of statistical pattern recognition with several foreign Universities, especially with the University of Surrey, UK, (Prof. Kittler); University of Bonn, Germany, (Prof. R. Klein); Vienna University of Technology, Austria, (Prof. W. Purgathofer); University of Valencia, Spain, (Prof. F. Ferri); University of Hokkaido, Japan, (Prof. Mineichi Kudo, joint research project); University of Salzburg (Dr. H. Meier, joint research project); Max-Planck Institute for Informatics, Saarbrucken, Germany, (Prof. H. Seidel); Institute National de Recherche en Informatique et en Automatique, Montbonnot, Sophia Antipolis, France (Dr. C. Soler, Dr. J. Zerubia joint research project); Delft University of Technology, The Netherlands, (Prof. R.P.W. Duin, Dr. P. Paclik); Cambridge University, United Kingdom (Prof. R. Hanka); University of Auckland, New Zealand (Prof. G. Gimmelfarb) and others.

University Boards:

J.Novovičová is a member of the Field of Study Board of doctoral studies on the Faculty of Mathematics and Physics, Charles University, Prague. M. Haindl is a member of the Field of Study Board of doctoral studies on the Faculty of Electrical Engineering of the Czech Technical University in Prague and on the Faculty of Electrical Engineering and Communication Brno University of Technology, a member of State Doctoral Examination Committees at the Faculty of Mathematics and Physics, Charles University, Prague and the Faculty of Electrical Engineering of the Czech Technical University in Prague, and the Scientific Boards of the Institute of Information Theory and Automation and the Institute of Computer Science. .

Editorial Boards:

Michal Haindl - ERCIM News, IAPR Newsletter.

Representation in International Societies:

M. Haindl is the Chair of the IAPR Membership Committee, a member of the IAPR Publication and Publicity Committee, a member of the ERCIM - Editorial Board, a member of the ERCIM European Cooperation Task Force, a member of the ERCIM Human Resources Task Force and a member of the ERCIM WG Image Understanding. Pavel Pudil is an external PhD examiner for Cambridge University and a member of the IAPR Governing Board (representative of the Czech Republic). J.Grim, M.Haindl, J.Novovičová, P.Pudil and P.Somol are members of the Committee TC1 "Statistical Techniques in Pattern Recognition" of the International Association for Pattern Recognition.

Grants and Projects:

M. Haindl: "Multimedia Understanding through Semantics, Computation and Learning - MUSCLE, "
(EC Network of Excellence No. FP6-507752, 2005-2008)

M. Haindl: "Automatic Acquisition of Virtual Reality Models from Real World Scenes, "
(GAAV ČR IS 1ET400750407, 2004-2008)

M. Haindl: "ERCIM"
(Grant Agency of MŠMT, INGO No. LA147, 2002-2006)

M. Haindl: "Research Centre DAR - Data, Algorithms, Decision Making, "
(Grant Agency of MŠMT, 1M0572, 2005-2009)

J. Grim: "Recurrent Probabilistic Neural Networks, "
(Grant Agency of the Czech Republic, No. 102/07/1594, 2007-2010)

Teaching and Supervising Activities:

University Courses:

The following university courses are presented by the members of the department:
University of Economics - Faculty of Management: Fundamentals of Statistics, (P. Pudil); Applied artificial intelligence for management (P. Pudil)

Supervising:

Jiří Filip was awarded his PhD. Three diploma theses and 7 doctoral projects were supervised by the department members in 2006. Martin Hatka was awarded the first price (applied mathematics category) in the International SVOC competition, Bratislava for his diploma thesis.

Conferences and International Contacts:

Conferences – Participation:

Members of the department presented their contributions at the following international conferences:

J. Filip, M. Haindl: IWICPAS (International Workshop on Intelligent Computing in Pattern Analysis/Synthesis). Xian, China, August 2006,

J. Filip, J. Novovičová, P. Somol, P. Vácha: DAR workshop, Třešť, December 2006,

J. Grim, J. Novovičová, P. Somol: Joint IAPR International Workshops SSPR 2006 and SPR 2006. Hong Kong, China, August 2006,

M. Haindl, J. Filip: 5th MUSCLE workshop, February 2006, Istanbul, Turkey,

M. Haindl, J. Filip, J. Grim, S. Mikeš, J. Novovičová, P. Pudil, P. Somol, P. Vácha: 18th International Conference on Pattern Recognition. Hong-Kong, China, August 2006,

M. Haindl: 1st International Workshop on the European Network of Mechatronics Centres, Plzeň, June 2006,

M. Haindl, J. Novovičová, P. Pudil, P. Somol: 11th Iberoamerican Congress in Pattern Recognition, Cancun, Mexico, November 2006,

M. Haindl: International Conference Image Analysis and Inverse Problems, Eindhoven, The Netherlands, December 2006,

M. Haindl, P. Pudil, P. Somol: 2nd International Workshop on the European Network of Mechatronics Centres, Železná Ruda, December 2006

Conferences–Organization:

M. Haindl has been a member of the program committees of the 18th International Conference on Pattern Recognition, 2006 Hong Kong, China; International Conference on Image Analysis and Recognition, ICIAR 2006, Povoa de Varzim, Portugal; Workshop on Intelligent Computing in Pattern Analysis/Synthesis (IWICPAS 2006), Xi'an, China and 17th European Conference on Artificial Intelligence, Riva del Garda, Italy.

J. Novovičová has been a member of the Program Committee of the Joint IAPR International Workshops SSPR 2006 and SPR 2006, Hong Kong, China and the Iberoamerican Congress on Pattern Recognition CIARP 2006, Cancun, Mexico.

International Contacts:

The Department has extensive contacts with foreign research institutes and universities. This collaboration was formalised in solution of two international research projects and several joint publications. Professor R. Hanka from the Cambridge University, UK, Prof. Dmitris Ververidis from the Aristotle University of Thessaloniki, Greece, Prof. Dimitry Chetverikov and Dr Gabor Renner from SZTAKI Budapest, Hungary, Dr Hana Ševčíková from the University of Washington, Seattle, USA and Prof. Xiaoyi Jiang from the University of Münster, Münster, Germany were visiting researchers in the department.

Results:

Compression and Modelling of Bidirectional Texture Function

The highest fidelity representations of realistic real-world materials currently used comprise Bidirectional Texture Functions (BTF). The BTF is a six dimensional function depending on view and illumination directions as well as on planar texture coordinates. The huge size of such measurements, typically in the form of thousands of images covering all possible combinations of illumination and viewing angles, has prohibited their practical exploitation and obviously some compression and modelling method of these enormous BTF data spaces is inevitable. The proposed approach [3] combines BTF spatial clustering with cluster index modelling by means of an efficient Markov random field model. This method allows to generate seamless cluster index of arbitrary size to cover large virtual 3D objects surfaces. The method [3] represents original BTF data using a set of local spatially dependent Bidirectional Reflectance Distribution Function (BRDF) values which are combined according to synthesised cluster index and illumination / viewing directions. BTF data compression using this method is about 1 : 100 and their synthesis is very fast.

Dynamic Colour Texture Synthesis

Textural appearance of many real word materials is not static but often shows progress in time. If such a progress is spatially and temporally homogeneous these materials can be represented by means of dynamic textures (DT). DT modelling is a challenging problem which can add new quality into computer graphics applications. We have developed a novel hybrid method [1],[2] for colour DTs modelling. The method is based on eigen-analysis of DT images and subsequent pre-processing and modelling of temporal interpolation eigen-coefficients using a spatial causal auto-regressive model. The proposed method shows good performance [2] for most of the tested DTs, which depends mainly on the properties of the original sequence. Moreover, this method compresses significantly the original data and enables extremely fast synthesis of unlimited artificial sequence, which can be easily performed by means of contemporary graphics hardware. This work was developed as a part of EU NoE MUSCLE project in cooperation between three ERCIM members UTIA, SZTAKI, Hungary and CWI, Amsterdam hosting the experimental DT database.

Text Document Classification

The usability of the Oscillating Search algorithm for feature/word selection (FS) in text categorization was explored [12]. The multi-class Bhattacharyya distance for multinomial model as the global feature subset selection criterion for reducing the dimensionality of the bag of words vector document representation has been used. This criterion takes into consideration inter-feature relationships. Three subset selection procedures has been experimentally compared: the commonly used best individual feature selection based on information gain, the same based on individual Bhattacharyya distance, and the Oscillating Search to maximize Bhattacharyya distance on groups of features. The obtained feature subsets are then tested on the standard Reuters data with two classifiers: the multinomial Bayes and the linear SVM. The presented experimental results illustrate that using a non-trivial feature selection algorithm is not only computationally feasible, but it also brings substantial improvement in classification accuracy over traditional, individual feature evaluation based methods.

We also investigated the idea of modifying certain feature selection algorithms to enable prototype (keyword) search in documents. This led to definition of a flexible prototype-search framework [17] whose potential applicability is not restricted to document processing only.

Feature Selection

Among recent topics studied in context of feature selection the hybrid algorithms seem to receive particular attention. We proposed a new hybrid algorithm, the flexible hybrid floating sequential search algorithm, that combines both the filter and wrapper search principles [17]. The main benefit of the proposed algorithm is its ability to deal flexibly with the quality-of-result versus computational time trade-off and to enable wrapper based feature selection in problems of higher dimensionality than before. We show that it is possible to trade significant reduction of search time for negligible decrease of the classification accuracy. Experimental results are reported on two data sets, WAVEFORM data from the UCI repository and SPEECH data from British Telecom. Another method [10] based on mutual correlation was proposed for extensive feature spaces applications.

Multimodal Range Image Segmentation

A fast range image segmentation method [7] for scenes comprising general faced objects was proposed.

The range segmentation is based on a recursive adaptive probabilistic detection of step discontinuities which are present at object face borders in mutually registered range and intensity data. Detected face outlines guides the subsequent region growing step where the neighbouring face curves are grouped together. Region growing based on curve segments instead of pixels like in the classical approaches considerably speed up the algorithm. The exploitation of multimodal data significantly improves the segmentation quality .

Unsupervised Color Texture Segmentation

Recently we have proposed Gaussian mixtures as a local statistical model to synthesize artificial textures. In particular, we describe the statistical dependence of pixels of a movable window by multivariate Gaussian mixture of product components. As the mixture components correspond to different variants of image patches appearing in the window they can be used to identify different segments of the source color texture image. The segmentation can be obtained by means

of Bayes formula provided that a proper decomposition of the estimated Gaussian mixture into sub-mixtures is available. As shown in the paper [6] the mixture model can be decomposed by maximizing the mean probability of correct classification of pixels into segments. The algorithm takes into account the assumed consistency of final segmentation.

Another two color texture unsupervised segmentation algorithms [8],[15] were published. The algorithm [15], based on Markov tree models, processes independently the spectral and spatial information. The method [8] locally represents multispectral texture mosaics by four causal multispectral random field models recursively evaluated for each pixel and the segmentation algorithm is based on the underlying Gaussian mixture model. The performance of both methods was extensively tested on the Prague segmentation benchmark [11] and compares favourably with several alternative texture segmentation methods.

Trainable Similarity Measure for Image Classification

In object recognition problems a two-stage system is usually adopted composed of a fast and simple detector and a more complex classifier. A design of the second stage classifier based on the recently proposed trainable similarity measure which is specifically designed for supervised classification of images has been studied. Common global measures such as correlation suffer from uninformative pixels and occlusions. The proposed measure is based on local matches in a set of regions within an image which increases its robustness. The configuration of local regions is derived specifically for each prototype by a training procedure. The classifiers built using the trainable similarity have been experimentally compared to the state-of-the-art AdaBoost image classifier based on locally-extracted image features. The comparison has been carried out on a real-world pedestrian recognition problem. The result illustrates that for a given range of sample sizes the trainable similarity represents a better solution than the AdaBoost algorithm which requires significantly larger training sets [13].

Image Retrieval

Two fast illumination invariant image retrieval methods [9] for scenes comprising textured objects with variable illumination were developed. Both methods are based on texture gradient modelled by efficient set of random field models. We developed illumination insensitive measures for textured images representation and compared them favorably with steerable pyramid and Gabor features in the illumination invariant BTF texture recognition.

Publications:

Altogether 17 papers have been published in the last year.

List of Selected References:

1. Filip J., Haindl M., Chetverikov D.
   Fast synthesis of dynamic colour textures.
   ERCIM News, 66 (2006):53–54, 2006.

2. Filip J., Haindl M., Chetverikov D.
   Fast synthesis of dynamic colour textures.
   In Yeung D.S. Yan H. Lorette G. Tang Y.Y., Wang S.P., editor,
   Proceedings of ICPR 2006 - The 18th International Conference on Pattern
   Recognition, 2006.

3. Filip J., Haindl M.
   Btf modelling using brdf texels.
   Lecture Notes in Computer Science, 4153 (2006):475–484, 2006.

4. Grim J.
   EM cluster analysis for categorical data.
   Lecture Notes in Computer Science, 4109 (2006):640–648, 2006.

5. Grim J., Haindl M., Somol P. Pudil P.
   A subspace approach to texture modelling by using gaussian mixtures.
   In Ho T. K. Haralic B., editor, *Proceedings of the 18th*
   Conference on Pattern Recognition. ICPR 2006, 2006.

6. Grim J., Somol P., Haindl M. Pudil P.
   Color texture segmentation by decomposition of gaussian mixture
   model.
   Progress in Pattern Recognition, Image Analysis and
   Applications, 4225 (2006):287–296, 2006.

7. Haindl M., Žid P.

   Multimodal range image segmentation by curve grouping.

   In Yeung D.S. Yan H. Lorette G. Tang Y.Y., Wang S.P., editor,

   Proceedings of ICPR 2006 - The 18th International Conference on Pattern

   Recognition, 2006.

8. Haindl M., Mikeš S.

   Unsupervised texture segmentation using multispectral modelling approach.

   In Yeung D.S. Yan H. Lorette G. Tang Y.Y., Wang S.P., editor,

   Proceedings of ICPR 2006 - The 18th International Conference on Pattern

   Recognition, 2006.

9. Haindl M., Vácha P.

   Illumination invariant texture retrieval.

   In *Proceedings of ICPR 2006 - The 18th International Conference*

   on Pattern Recognition, 2006.

10. Haindl M., Somol P., Ververidis D. Kotropoulos C.

    Feature selection based on mutual correlation.

    Progress in Pattern Recognition, Image Analysis and

    Applications, 4225 (2006):569–577, 2006.

11. Mikeš S., Haindl M.

    Prague texture segmentation data generator and benchmark.

    ERCIM News, 64 (2006):67–68, 2006.

12. Novovičová J., Somol P., Pudil P.

    Oscillating feature subset search algorithm for text categorization.

Lecture Notes in Computer Science, 4225 (2006):578–587, 2006.

13. Paclík P., Novovičová J., Duin R.

    Building road-sign classifiers using a trainable similarity measure.

    IEEE Transactions on Intelligent Transportation Systems, 3

    (2006):309–321, 2006.

14. Paclík P., Novovičová J., Duin R.

    A trainable similarity measure for image classification.

    In *Proceedings of the 18th Conference on Pattern Recognition.*

    ICPR 2006, 2006.

15. Scarpa G. Haindl M.

    Unsupervised texture segmentation by spectral-spatial-independent.

    In *Proceedings of ICPR 2006 - The 18th International Conference*

    on Pattern Recognition, 2006.

16. Somol P., Pudil P.

    Multi-subset selection for keyword extraction and other prototype

    search tasks using feature selection algorithms.

    In *Proceedings of ICPR 2006 - The 18th International Conference*

    on Pattern Recognition, 2006.

17. Somol P., Novovičová J., Pudil P.

    Flexible-hybrid sequential floating search in statistical feature selection.

    Lecture Notes in Computer Science, 4109 (2006):623–639, 2006.

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Profile:

Research Topics:

The Department concentrates mainly on multi-disciplinary research in the field of VLSI signal processing applications, namely:

The department focuses on research, development and implementation of advanced digital signal processing algorithms, mainly in the fields of adaptive signal processing in communications, audio and image processing. Our aim is to use a multidisciplinary approach, building both on our experience with using statistics for system identification and modeling, relevant fields of linear algebra and on research in the field of embedded system architectures.

Our target platforms are Field Programmable Gate Arrays (FPGAs) and Digital Signal Processors (DSPs). We use Matlab/Simulink to specify, model and verify algorithms that we later convert to C (for the DSP implementation) or hardware description languages such as VHDL or Handel-C. Finally, we synthesize hardware configuration file for the FPGA device.

As such specialized solutions are likely to be used in embedded systems, we also research features that result in extremely fast execution, use small amount of memory, small chip area or low power consumption. We achieve this both through designing new or modifying existing DSP algorithms, and using architectural properties such as dynamic reconfiguration of FPGAs.

Our research areas are namely:

a) Theory of identification, algorithmic design and mapping on parallel processing arrays.

b) General applications of digital signal processing: prediction, noise cancellation, adaptive equalization.

c) Advanced signal processing in telecommunications, MIMO communication systems, OFDM systems, equalization, synchronization, adaptive algorithms.

d) Design methodology for dynamic reconfiguration of FPGAs, taking into account both high-level design specification and low-level chip placement and routing.

e) Novel FPGA architectures for future complex self-adaptive systems.

f) Fault-tolerant design for FPGAs and ASICs with special consideration of dynamic reconfiguration.

g) Hardware/Software codesign, hardware acceleration in embedded systems with applications in image processing.

h) Implementations based on rapid prototyping techniques for embedded systems with signal processors and FPGAs.

University Boards:

Jiří Kadlec and Martin Daněk are members of examination boards for defenses of master and doctoral theses at the Czech Technical University, Faculty of Electrical Engineering.

Representation in International Societies:

Jiří Kadlec — Czech delegate of the IST Programme Committee for the 6th Framework Programme EU (2002-2006); a member of the Czech Chapter of IFAC (Area: Modeling, Identification and Signal Processing); a member of the Council for Support of AS CR Participation in European Integration of Research and Development.

Martin Daněk — a member of the Program Committee of the International Conference on Field-Programmable Logic and Applications, a member of the Program Committee of the IEEE Workshop on Design and Diagnostics of Electronic Circuits and Systems (DDECS), a member of the Program Committee of the Southern Conference on Programmable Logic (SPL), a member of the Program Committee of the Euromicro Symposium on Digital System Design (DSD).

Jan Schier and Antonín Heřmánek — members of the Program Committee IASTED Signal and Image Processing 2007 Conference

Milan Tichý — a member of the Marie Curie Fellowship Association

Recent Activities:

Grants and Projects:

M. Daněk, J. Kadlec: "AETHER – self-Adaptive Embedded Technologies for Pervasive Computing Architectures" (No. FP6-IST-027611, 2006-2008)

J. Kadlec: "Centre of Applied Cybernetics" (No. 1M0567, 2005-2009, Ministry of Education, Youth and Sports of the CR)

M. Daněk: " Design of Highly Reliable Control Systems Built on Dynamically Reconfigurable FPGAs" (No. GA102/04/2137, Grant Agency of the CR)

A. Heřmánek: "Digital Video-Sensoric System of a Reconnaissance Robot" (No. 1ET100750408, 2004-2007, NPV TP2 Information Society)

R. Bartosinski: "Participation in the Evolution of the Standardization for Embedded Software for Automotive Industry" (No. 1ET400750406, 2004-2007, NPV TP2 Information Society)

J. Schier, A. Heřmánek: "Specification of Quantitative Criteria and Optimization of Resources for Broadband Access Network" (No. 1ET300750402, 2004-2007, NPV TP2 Information Society)

J. Schier: "Rapid Prototyping Tools for Development of HW-Accelerated Embedded Image and Video Processing" (No. 1ET400750408, 2004-2008, NPV TP2 Information Society)

M. Daněk: "Technology for Improving the Testability of Modern Digital Circuits" (No. 1QS108040510, 2005-2008, NPV PP2)

J. Kadlec: "VLAM - Virtual Laboratory of Microprocessor Technology Application" (No. 2C06008, 2006-2011, NPV 2 Information Society)

J. Kadlec: "COSINE - Co-ordinating Strategic Initiatives on Embedded Systems in the European Research Area" (No. FP6-IST-004225, 2005-2007)

J. Kadlec: "IST World - Knowledge Base for RTD competencies in IST" (No. FP6-IST-015823, 2005-2007)

J. Kadlec: "OKO IST Professional Contact Organization" (No. 1P04OK458, 2004-2007, Ministry of Education, Youth and Sports of the CR, Programme EUPRO)

M. Kadlecová: "Idealist34 - Partner Search Support for participants in IST Priority by European network of NCP for IST under the 6th Framework Programme" (No. FP6-IST-511355, 2004-2006)

M. Kadlecová: "Idealist7fp - Support for Participants in ICT Priority by Network for IST under the Transition to the 7th Framework Programme" (No. FP6-IST-045059, 2006-2008)

Teaching and Supervising Activities:

University Courses:

Eight courses on subjects related to the research field of the department were given:

Czech Technical University — Faculty of Electrical Engineering:
Microprocessor System Design (J. Kadlec, R. Bartosinski);
Adaptive Methods of Signal Processing (J. Kadlec);
Parallel Algorithms and Architectures (J. Kadlec)
Problems and Algorithms (M. Daněk);
Automated Design of Digital Systems (M. Daněk)
Logic Circuits (L. Kafka)
Czech Technical University — Faculty of Transportation Sciences:
Modeling of System and Processes (B. Kovář)
Mathematical Analysis (B. Kovář)

Supervising:

B. Kovář and M. Tichý have successfully defended their doctoral theses.

Six members of the department are still heading towards their PhD degree.

Five bachelor and five master students have been supervised by the department members in 2006. The bachelor theses (J. Svozil, J. Stejskal, T. Škarda, Karel Fatura, Pavel Kolín) and one master thesis (L. Kohout) were defended in 2006.

International Cooperation:

Conferences – Participations:

Members of the department presented their papers, posters or demonstrators at numerous international conferences and fairs such as

Innovation & Business LIVE – 8th International Conference on Entering Foreign Markets: ICT Trends & Strategies, co-funding from EU programmes – Prague, round table and invited presentation (Kadlec)

3rd Annual ARTEMIS International Conference – Austria, Graz, presentation of our R&D results at a stand (Kadlec)

IST 2006 Strategies for Leadership International Conference and Exhibition – Finland, Helsinki, presentation of our R&D at an exhibition booth "PicoNet - Implementing Floating-Point Digital Signal Processing" (Kadlec, Daněk, Bartosinski, Honzík, Kafka, Kohout)

ITEA2 Symposium – France, Paris, invited presentation (Kadlec)

FPGA 2006 – ACM/SIGDA 14th International Symposium on Field-Programmable Gate Arrays – USA, Hyatt Regency Monterey, poster presentation (Tichý)

DDECS 2006 – IEEE Workshop on Design and Diagnostics of Electronic Circuits and Systems – Prague, paper and poster presentation (Daněk, Kadlec, Kafka)

ARC 2006 – International Workshop on Applied Reconfigurable Computing – The Netherlands, Delft, poster presentation (Schier)

DATE 2006 – Design, Automation and Test in Europe – Germany, Munich, invited presentation at the Renaissance of FPGA-Based High Performance Computing workshop (Kadlec)

ISSPIT 2006 – The IEEE Symposium on Signal Processing and Information Technology – Canada, Vancouver, paper presentation, chairman of the section "DSP systems and implementations" (Heřmánek)

FPL 2006 – 16th International Conference on Field Programmable Logic and Applications – Spain, Madrid, poster presentation (Kuneš).

IWES 2006 – 5th International Workshop on Embedded Systems – Crete, Heraklion, invited presentation (Schier)

MAPLD 2006 – 9th Military and Aerospace Programmable Logic Devices international conference – Washington D.C., USA, paper presentation (Heřmánek, Bartosinski)

SiPS 2006 – IEEE 2006 Workshop on Signal Processing Systems – Canada, Calgary, paper and poster presentation (Schier)

DT 2006 – Digital Technologies 2006 – Slovakia, Žilina, paper presentation (Schier)

Conferences – Organization:

J. Kadlec — Workshop "Robotics in IST FP7", 7.11.2006, Technology Centre AS CR

J. Kadlec — Workshop and round table for FP6 project proposers from the Academy of Sciences, 14.11.2006, ÚTIA

M. Daněk — Member of the program committee of the International Conference on Field-Programmable Logic and Applications. Conf. FPL'2006 was held in Madrid, Spain, in August 2006.

International Cooperation and Contacts:

Department members are networked with European researchers and companies especially through EU IST projects:

Celoxica, Ltd., UK (Dr. P. Bishop)
ITIV Karlsruhe, DE (M. Huebner)
CEA, F (C. Gamrat)
Philips Research Eindhoven, NL (Dr. N. Benshop)
IMEC Leuven (Leoš Kafka – long term stay finished in summer 2006)

Results:

Research performed in frame of the Centre for Applied Cybernetics

Optimal scheduling of the FI-CMA algorithm for the library of pipelined logarithmic operations has been performed in cooperation with the group of Dr. Zdenek Hanzalek at CTU Prague. Result has been presented at the NASA MAPLD 2006 conference in Washington, DC and at the SiPS 2006 conference in Canada.

Reconfigurable HW has been designed for acceleration of computation of large cross ambiguity functions. This research has been performed in cooperation with ERA Pardubice.

In cooperation with the company Celoxica UK we have demonstrated the use of compact PicoBlaze controllers for the assembly of high performance and power efficient floating point DSP pipelines. We have decomposed floating point algorithm into a sequence of hardware processes using a PicoBlaze network to manage the operation sequence. This result has been published in the Xilinx Embedded Magazine.

Design of Highly Reliable Control Systems Built on dynamically Reconfigurable FPGAs

The goal of this longer term research is to design a new, advanced design methodology for reconfigurable circuits that will be based on the new technological possibilities and to make it accessible both to local small and medium-size enterprises and to education of students at universities. Our research is aimed at creating an integrated circuit with new qualities. The current trend in digital VLSI design is such that supply voltages decrease as well as feature sizes (which are now well under 100 nano meters) and chip sizes increase. These trends on the one hand enable to increase the computing power of the designed circuits, and at the same time to decrease the price per one transistor, but they also make the circuits more susceptible to errors, their behavior becomes more or less stochastic. These reasons change the meaning of individual circuit parame-

ters, it becomes acceptable to use a larger part of the circuit for service functions and it is often economically justifiable to back up function units so as to increase the reliability of the whole circuit. Research is performed together with Faculty of Mechatronics, TU Liberec, Faculty of Electrical Engineering, CTU. Work is partially supported by GA 102-04-2137 project.

Specification of Quantitative Criteria and Optimization of Resources for Broadband Access Networks – ADSL

The goal of this research is to contribute to the development of the broadband access networks in the public domain. It is focused on two related areas:

1. specification of qualitative criteria for typical services of broadband access network and optimization of this network to guarantee these services

2. optimization methods for filter design and research of adaptive equalization algorithms used in the digital subscriber line

The first task is being solved by using analysis and modeling of the traffic character for different types of services and their combinations and by simulating the network traffic under various conditions. The analytical design methods for the broadband digital filters are beeing optimized and their implementation will have to be considered. In the field of adaptive equalizers, we focus on advanced deconvolution methods, which are, due to their computational complexity, still seldom used in the industry. Research is performed together with Faculty of Electrical Engineering, CTU and it is partially supported by NPV-IT Project No.: 1ET300750402.

Digital Video-Sensoric System of Reconnaissance Robot – ORPHEUS

This research focuses on methods for a digital wireless transfer of video and other sensor data from the video-sensoric system of a reconnaissance robot and their visualization and integration in the user interface at the operator seat. The results of the project will be evaluated in a real-world environment using the platform of the reconnaissance robot Orpheus. Our goal is to improve the Orpheus platform so that it will be competitive with the future top-class reconnaissance robots used worldwide while adapting it to real operations. To reach this goal, new methods for robust digital wireless transfer of video

and other data and an innovative telepresentation user interface with the feature-extraction capabilities will be developed. Research is performed together with Faculty of Electrical Engineering and Communication, BUT. This work is partially supported by NPV-IT Project No.: 1ET100750408. http://www.orpheus-project.cz

Rapid Prototyping Tools for Development of HW-Accelerated Embedded Image and Video Processing Applications - RIPAC

This project is targetted in acceleration of computationally intensive image and video processing using combined DSP/FPGA system. The aim of the project is to develop tools allowing for easy prototyping and on-site adjustment for such system. Such environment, should, at the lower level, use relatively simple scripting language and, at the higher level, some rapid development tool. Included will be also libraries of hardware macros and DSP functions and their simulation equivalents.

In 2006, the accelerator support in the simulation environment Simulink has been improved. In the present time, an infrastructure for hardware implementation of the acceleration is being created. The project partner, Brno University of Technology, has finalized fast data communications between DSP and FPGA and has analyzed implementation possibilities for HW implementation of image classifiers.

The project is supported the Grant agency of the Czech Academy of Sciences, in the frame of the NPV-IT Project No. 1ET400750408. http://www.ripac.cz

Participation in the Evolution of the Standardization for Embedded Software for Automotive Industry – SESAP

The objective of this joint effort is to participate in an European–wide standardization of automotive software. Since 2005, participation of UTIA in the EU Embedded Technology Platform and membership of UNIS in the European standardization process Autosar has been achieved. One of the project aims is development of an integration between the Processor Expert tool and the Matlab environment. The integration supports automatic code generation of an embedded systems from their models. In 2005, the Processor Expert Embedded Real-time Target package has been developped and registred under the PEERT trademark for this reason. In 2006, the integration has been upgraded according to the Autosar

standard. Research is performed together with Faculty of Electrical Engineering CTU, and company UNIS Brno. Work is partially supported by NPV-IT Project No.: 1ET400750408.

Technology for Improving the Testability of Modern Digital Circuits - RETAC

The project aims at creating a new technology for diagnosing SoC-type digital circuits; project outputs will be a prototype and methodology. The method used for testing SoC circuits will be based on the so-called RESPIN architecture (IEEE 1500 compliant). The RESPIN architecture considers reconfiguration of each circuit core so that each core can be tested by the cores in its neighbourhood. Test vectors can be applied in a compressed form and the decompression can be done in the circuit using the neighbouring reconfigurable cores. The compressed test vectors for this architecture will be generated using the COMPAS tool designed and implemented by the applicant's team. The prototype will be implemented using the FPGA circuits from Atmel. To improve the testability of the designed circuits a tool will be created that will speed up fault simulation using circuit models implemented in dynamically reconfigurable FPGA circuits. The research is performed together with the Dept. of Computer Science and Engineering, Faculty of Electrical Engineering, CTU in Prague, and it is partially supported by NPV-PP2 Project No. 1QS108040510.

Partner Search Support for participants in IST Priority for IST under the 6th Framework Program

Our objective is to ease the process of finding partners for Czech organizations who wish to participate in the EU Information Society Technologies Programme IST. The Ideal-ist network has representatives in the all Member States, as well as the Associated States, including Israel, Malta, Turkey, Russia and Belarus, total 34 states. We maintain these portals
http://www.oko-ist.cz/
http://www.ideal-ist.cz/

This activity is beeing supported by EU FP6 IST support projects IDEALIST34, IST World, COSINE and by OKO-IST project granted by the Ministry of Education Youth and Sports of the Czech republic.

Pocket Braille Notebook with Synthetic Speech Output for the Blind Users – GIN

Long term research performed in the department resulted in an innovated version of pocket notebook equipped with Czech synthetic speech and the Braille keyboard. The notebook performs many tasks in several ways. It can serve as a notetaker. Users can make lists, search through them, remove or add items. They can ask for the time or date. There are also stop watch, alarm clock and count-down timer functions. The telephone directory makes it possible to store names, phone numbers and addresses. The diary maintains users appointments and reminders of important events.

User can connect the notebook to a computer and transfer data (a complete book). After the development made in 2005, wider range of MMC or SD memmory cards can be used (128MB — 2GB). Removable media serve as large capacity data storage for books, vocabularies, databases.

Publications in 2006:

4 journal papers, 13 conference papers, 2 theses, 3 technical reports and 3 electronic documents have been published during 2006.

Selected References:

1. Šůcha, P., Hanzálek, Z., Heřmánek, A., Schier, J.: Efficient FPGA Implementation of Equalizer for Finite Interval Constant Modulus Algorithm. In *Proceedings of the IEEE Symposium on Industrial Embedded Systems IES 2006*, Antibes Juan-Les-Pins, CNRS-ENS, Lyon, France, 2006, pp. 1–10. ISBN 1-4244-0777-X

2. Tichý, M., Schier, J., Gregg, D.: Efficient Floating-Point Implementation of High-Order (N)LMS Adaptive Filters in FPGA. In *Reconfigurable Computing: Architecures and Applications. Proceedings of the Second International Workshop ARC 2006*, Delft, The Netherlands, Springer Berlin, 2006, pp. 311–316. ISBN 3-540-36708-X. ISSN 0302-9743

3. Heřmánek, A., Kuneš, M., Kvasnička, M.: Comuputation of Long Time Cross Ambiguty function using reconfigurable HW. In: *Proceedings of the 6th IEEE International Symposium on Signal Processing and Information Technology ISSPIT'06*. Vancouver : IEEE, 2006, pp. 1–5. ISBN 0-7803-9754-1

4. Heřmánek, A., Kuneš, M., Kvasnička, M.: Using Reconfigurable HW for High Dimensional CAF Computation. In: *Proceedings of the International Conference on Field Programmable Logic and Applications*, Madrid, Spain, 2006. Institute of Electrical and Electronic Engineering, pp. 641–644. ISBN 1-4244-0312-X

5. Kadlec, J., Daněk, M.: Design and verification methodology for reconfigurable designs in Atmel FPSLIC. In *Proceedings of the IEEE Workshop on Design and Diagnostics of Electronic Circuits and Systems DDECS 2006*. Czech Technical University, Prague, 2006, pp. 79–80. ISBN 1-4244-0184-4

6. Kafka, L., Novák, O.: FPGA-based fault simulator. In *Proceedings of the IEEE Workshop on Design and Diagnostics of Electronic Circuits and Systems DDECS 2006*. Czech Technical University, Prague, 2006, pp. 274–278. ISBN 1-4244-0184-4

7. Tichý, M.: Efficient Floating-Point-Like Implementation of the (N)LMS and GS-FAP Algorithms in FPGA, Reserach Report 2165, ÚTIA AV ČR, 2006.

8. Tichý, M.: Floating-Point Arithmetic Library and the FAL Matlab Toolbox, Research Report - Software (CD-ROM), ÚTIA AV ČR, 2006.

9. Kadlec, J., Chappel, S.: Implementing floating-point DSP. In *Embedded Magazine*. Vol. 2, No. 3 (2006), pp. 12-14.

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Postgraduate Students:

David Kraus – theory of random point processes, event history analysis

Profile:

Research Topics:

The Department concentrates on mathematical research in the following areas.

a) Information in statistical experiments and optimal statistical decisions (estimation, testing, classification), with emphasis on maximum entropy, minimum divergence methods, and asymptotic theory.

b) Robust statistical procedures and their applications in various statistical environments, including adaptivity and self-organization. Regression analysis.

c) Statistical inference in random processes and random fields. Applications in stochastic optimization, change-point, optimum investment portfolios, and image and speech processing.

International Cooperation:

Members of the Department participate in joint research with their colleagues from Universities in: Augsburg, Germany (Prof. J. Heinrich); Aarhus, Denmark (Prof. E. B. Vedel–Jensen); Rostock, Germany (Prof. F. Liese); Madrid, Spain (Prof. L. Pardo); Leuven, Belgium (Prof. E. C. van der Meulen); Montpellier, France (Prof. A. Berlinet); Elche, Spain (Prof. D. Morales); Karlsruhe, Germany (Prof. W. Stummer); Waterloo, Canada (Prof. K. T. Wong); Helsinki, Finland (Prof. E. Oja); Baltimore, U. S. A. (Prof. J. Smid); Ilmenau, Germany (Prof. S. Vogel, Prof. C. Leibscher); Vilnius, Lithuania (Prof. V. Paulauskas, Prof. M. Bloznelis).

University Boards:

I. Vajda is a chairman of the State Examination Committee at the Faculty of Physical and Nuclear Engineering and vice-chairman of the Board of doctoral studies at the same faculty, J. Á. Víšek is a dean of the Faculty of Social Sciences, Charles University and member of Scientific Board.

Researchers of the Department are members of 3 different boards for defenses of doctoral theses at the Charles University, Faculty of Mathematics and Physics (Faculty of Social Sciences) and Czech Technical University.

Editorial Boards:

Marie Hušková — Journal of Statistical Planning and Inference, Statistics, Applications of Mathematics, Sequential Analysis,

Martin Janžura — Kybernetika, Statistical Inference for Stochastic Processes

Petr Tichavský — IEEE Transactions on Signal Processing Letters

Igor Vajda — Kybernetika, Test, Revista Matematica Complutense, Applications of Mathematics, Journal of Statistical Planning and Inference

Jan Ámos Víšek — Acta Universitatis Carolinae Oeconomica, Bulletin of the Czech Econometric Society.

Representation in International Societies:

Marie Hušková — The Institute of Mathematical Statistics, American Statistical Association (ASA), International Statistical Institute, Bernoulli Society (Programme coordinator)

Petr Lachout — member of American Mathematical Society

Petr Tichavský — Institute of Electrical and Electronics Engineering

Igor Vajda — member of International Committee European System Union, Institute of Electrical and Electronics Engineering, Institute of Mathematical Statistics

Jan Ámos Víšek — Bernoulli Society for Probability and Mathematical Statistics, International Association for Statistical Computing

Petr Volf — Bernoulli Society for Mathematical Statistics and Probability, European Network for Business and Industrial Statistics.

Recent Activities:

Grants and Projects:

M. Hušková: "Statistical models for structural changes and related problems III." (GA ČR, GA201/06/0186, 2006 – 2008).

M. Hušková: "Statistical dynamical models and their applications in economics, techniques and natural sciences" (GD 201/05/H007, 2005 – 2008).

M. Hušková: "Detecting changes in time series" (NATO, PST.EAP.CLG 980599, 2004 – 2006).

M. Janžura: "Probabilistic methods in the study of phase transitions of complex systems" (GA ČR, GA201/06/1323, 2006 – 2008)

I. Vajda: "New results in testing the goodness-of-fit based in Pearson-type statistics" (GAAV ČR, A 1075403, 2004 – 2006)

P. Volf: "Intelligent information system of maintenance management" (MO ČR, FI-IM3/036, 2006 – 2008)

P. Volf: "Spatial-temporal point processes and their applications" (GAAV ČR, IAA101120604, 2006 – 2012), (co-investigator, together with MFF UK Praha)

"Research Center for Quality and Reliability of Production" (MSM ČR, 1M06047, 2006 – 2009)

"Research Center Data, algorithms, decision making" (MSM ČR, 1M0572, 2006 – 2009)

Teaching and Supervising Activities:

University Courses:

36 courses on subjects related to the research field of the department were read.

University of Economics:
Probability theory and statistics (J. Á. Víšek); Advanced mathematical statistics (M. Hušková)

Charles University — Faculty of Mathematics and Physics:
Statistical seminar Bayesian methods, Probability and mathematical statistics, Sequential analysis, Sequential and Bayesian methods, Mathematical statistics, Design of experiments, Probability and statistics, Sequential and Bayesian methods, Selected chapters of stochastics (M. Hušková) Advanced econometrics optimization, Advanced optimization and convex analysis, Introduction to optimization, Invariance principles, Mathematical proseminar of the Department of Statistics (P. Lachout) Stochastic differential equations, Seminar on stochastic evolution equations, Markov processes (J. Seidler) Seminar on probability and statistics (J. Swart)

Charles University — Faculty of Social Sciences:
Probability and mathematical statistics, Econometrics, Mathematical tools for capital markets, Statistics, Statistical data analysis, Advanced parts of econometrics (J. Á. Víšek)

Charles University — Faculty of Science:
Information theory (T. Marek)

Czech Technical University — Faculty of Physical and Nuclear Engineering:
Stochastic systems (M. Janžura); Quality control, Random processes (J. Michálek); Information theory (I. Vajda)

Technical University Liberec:
Applied Mathematics (P. Volf)

The School of Professional Higher Education Chotěboř:
Elements of mathematical statistics (J. Michálek)

Conferences and International Contacts:

Conferences – Organization:

Prague Stochastics 2006
A joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague, August 21 – 25, 2006 (together with KPMS MFF UK, 169 participants, 130 abroad)

Conferences – Participations:

17 lectures, 3 of them invited, have been delivered at international conferences, including

Tomáš Marek, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Lucie Fajfrová, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Petr Volf, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Petr Volf, Annual Conference of ENBIS, Wroclaw

Igor Vajda, International Conference of France Statistical Society, Paris

Marie Hušková, EMS 2006, Torun, Poland

Marie Hušková, ROBUST 2006, Lhota nad Rohanovem

Marie Hušková, PROBASTAT 2006, Smolenice

Marie Hušková, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Petr Tichavský, Zbyněk Koldovský, IEEE Int. Conference on Acoustics, Speech and Signal Processing (ICASSP) Toulouse

Lucie Fajfrová, 2nd International Workshop on Data – Algorithms – Decision Making, Třešť

Tomáš Hobza, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

David Kraus, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Zbyněk Pawlas, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Jan Swart, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

Jan A. Víšek, Prague Stochastics 2006, a joint session of 7th Prague Symposium on Asymptotic Statistics and 15th Prague Conference on Information Theory, Statistical Decision Functions and Random Processes, Prague

International Contacts:

The results of international cooperation were summarized in 10 joint papers with foreign colleagues. The department members visited 7 universities and research instituted in abroad, the following scientists were guests in department in 2006: Márton Balázs (Budapest University of Technology and Economics, Hungary) Zdizsaw Brzeniak (University of York, UK) Erika Hausenblas (Universität Salzburg, AU) Hannelore Lisei (Universitatea Babe-Bolyai Cluj, Romania) Markus Riedle (Humboldt Universität zu Berlin, DE) Rongfeng Sun (Technische Universität Berlin, DE) prof. Dr. Wolfgang Stummer, (Universität Erlangen , DE) E. C. van der Meulen, (Catholic University of Leuven, BE).

Results:

Blind Source Separation

Blind Source Separation consists of recovering original signals from their mixtures when the mixing process is unknown. In biomedicine, namely in MEG and EEG signal processing, one of the most popular algorithms nowadays is SOBI (Second Order Blind Identification). We proposed a procedure for fast implementation of the Weights-Adjusted SOBI (WASOBI) algorithm for asymp-

totically optimal separation of Gaussian autoregressive (AR) sources. The procedure employs fast computation of the optimum weight matrix, as well as an elaborate scheme for minimization of the associated weighted Least-Squares criterion. The resultant complexity is $O(d^2 M^2 + d^3 M)$, where d is the number of sources and M is the required number of estimated correlation matrices. Our procedure allows separation of more than 100 sources in order of tens of seconds in Matlab. Simulations verify that the algorithm still attains the corresponding Cramér-Rao bound, even in these high dimensions.

Divergences and Informations in Statistics and Information Theory

Basic properties of f-divergences are proved in a new simpler manner. New relations to sufficiency and deficiency are established and new applications in estimation and testing are proposed. Statistical information of De Groot and the classical information of Shannon are shown to be extremal cases of a newly introduced class of so-called Arimoto informations.

Robustness of Median Estimator in Bernoulli Logistic Regression

The paper of T. Hobza and L. Pardo: On Robustness of Median Estimator in Bernoulli Logistic Regression published in the Proceedings of the Prague Stochastics 2006, presents generalized logistic regression models which include the classical model with binary responses governed by the Bernoulli law depending on the logistic regression function. The median estimator of the logistic regression parameters employing smoothed data in the discrete case, introduced in Hobza et al (2005), is considered. Sensitivity of this estimator to contaminations of the logistic regression data is studied by simulations and compared with the sensitivity of some robust estimators previously introduced to logistic regression. The median estimator is demonstrated to be more robust for higher levels of contamination.

Publications:

Proceedings of the Prague Stochastics 2006 and Book of Abstracts of the Prague Stochastics 2006, Eds.: Hušková Marie, Janžura Martin

List of Selected References:

1. Wong K. T., Tichavský Petr, Cheung S. K., Liao G.: A new pre-processing technique to enhance single-user-type DS-CDMA detectors in "blind" space-time rake receivers, IEEE Transactions on Wireless Communications vol. 10 (2006), 5, p. 2932–2944

2. Janžura Martin, Nielsen Jan: A simulated annealing-based method for learning Bayesian networks from statistical data, International Journal of Intelligent Systems vol. 3 (2006), 21, p. 335–348

3. Vajda Igor, Liese F., Morales D.: Asymptotically sufficient partitions and quantizations, IEEE Transactions on Information Theory vol. 12 (2006), 52, p. 5599–5606

4. Koldovský Zbyněk, Tichavský Petr, Oja E.: Efficient Variant of Algorithm FastICA for Independent Component Analysis Attaining the Cramer–Rao Lower Bound, IEEE Transactions on Neural Networks vol. 5 (2006), 17, p. 1265–1277

5. Lachout Petr: Epi-convergence almost surely, in probability and in distribution, Annals of Operations Research vol. 1 (2006), 142, p. 187–214

6. Hušková Marie, Meintanis S. G.: Change point analysis based on empirical characteristic functions, Metrika vol. 63 (2006), 2006, p. 145–168

7. Hušková Marie, Meintanis S. G.: Change-point analysis based on empirical characteristic functions of ranks, Sequential Analysis vol. 25 (2006), 2006, p. 1–16

8. Fajfrová Lucie: Infinite queueing system with tree structure, Kybernetika vol. 5 (2006), 42, p. 585–604

9. Kupsa Michal, Chaumoitre V.: k-limit laws of return and hitting times, Discrete and Continuous Dynamical Systems vol. 1 (2006), 15, p. 73–86

10. Berlinet A., Vajda Igor: On asymptotic sufficiency and optimality of quantizations, Journal of Statistical Planning and Inference vol. 12 (2006), 136, p. 4217–4237

11. Liese F., Vajda Igor: On divergences and informations in statistics and information theory, IEEE Transactions on Information Theory vol. 10 (2006), 52, p. 4394–4412

12. Vajda Igor, Morales D., Pardo L.: On efficient estimation in continuous models based

on finitely quantized observations, Communications in Statistics – Theory and Methods vol. 35 (2006), p. 1629–1653

13. Zvárová Jana, Vajda Igor: On Genetic Information, Diversity and Distance, Methods of Information in Medicine vol. 45 (2006), p. 173–179

14. Volf Petr: On statistical analysis of compound point process, Austrian Journal of Statistics vol. 35 (2006), p. 389–396

15. Tichavský Petr, Koldovský Zbyněk, Oja E.: Performance analysis of the FastICA algorithm and Cramér–Rao bounds for linear independent component analysis, IEEE Transactions on Signal Processing vol. 4

(2006), 54, p. 1189–1203

16. Swart Jan M., Fleischmann K.: Renormalization analysis of catalytic Wright-Fisher diffusions, Electronic Journal of Probability vol. 11 (2006), p. 585–654

17. Víšek Jan Ámos: The least trimmed squares. Part I: Consistency, Kybernetika vol. 1 (2006), 42, p. 1–36

18. Víšek Jan Ámos: The least trimmed squares. Part II: $\sqrt{n}$-consistency, Kybernetika vol. 2 (2006), 42, p. 181–202

19. Víšek Jan Ámos: The least trimmed squares. Part III: Asymptotic normality, Kybernetika vol. 2 (2006), 42, p. 203–224