Institute of Control and Computation Engineering

2006 Annual Report

Warsaw University of Technology
Faculty of Electronics and Information Technology
Institute of Control and Computation Engineering
Nowowiejska 15/19, 00-665 Warsaw, Poland
http://www.ia.pw.edu.pl, sekretariat@ia.pw.edu.pl

From the Director

The Institute of Control and Computation Engineering (ICCE – in Polish: Instytut Automatyki i Informatyki Stosowanej) was created in 1955 as the Chair of Automatic Control and Telemechanics by Professor Władysław Findeisen. It was reorganized in 1970 to become the Institute of Automatic Control. Rapid development of microprocessor technology and its impact on the field of control in recent years directed the interest of the staff and students towards computational and algorithmic aspects of control, decision support, man-machine interfaces, network communications, etc. This resulted in 1994 in the creation of new educational profiles offered by the institute and a change of its name to the present one. Professor Władysław Findeisen had been the Director of the institute until he was elected the Rector of Warsaw University of Technology in 1981. His achievements are recognized worldwide. He is Doctor Honoris Causa of the City University London, Technical University of Gdańsk, Technical University of Ilmenau and Warsaw University of Technology. This year we celebrated his 80th birthday. The institute offers courses in a broad area of information technology, concentrating on control and decision support systems, at three levels of education. At first two levels (equivalent to B.Eng. and M.Eng.) the degree programs combine courses from the areas of computer science and control.

We are also proud to offer interesting opportunities to our postgraduates so that they can continue their study and research towards a Ph.D. either in Computer Science or Control.

In 2006 the institute was involved in organizing three scientific events:

- IFIP Working Conference on Software Engineering Techniques — SET 2006: October 17–20, Warsaw, Poland,
- 16-th CISM-IFToMM Symposium on Robot Design, Dynamics, and Control ROMANSY 2006, June 20–24, 2006, Warsaw, Poland,
- 9-th National Conference on Evolutionary Algorithms and Global Optimization, 31 May–2 June, 2006, Murzasichle, Poland.

Prof. Mietek A. Brdyś, former member of our academic staff, together with the author of this note have been avarded a prize of Ministry of Science and Higher Education for the book 'Iterative Algorithms for Multilayer Optimizing Control'.

Research is a vital part of our activities, directly affecting both the institute's recognition in Poland and abroad, and the quality of teaching. Description of research programs conducted by the staff of the institute can be found in this report. I express my sincere appreciation to the faculty and staff of the institute for their efforts and contributions to our achievements in teaching and research.

I express my gratitude to all our partners, and in particular to our partners from abroad actively participating in international research programs. We would appreciate feedback concerning our activities. We shall be glad to answer any and all questions and we will be pleased to send reprints of our papers and reports upon request.

Piotr Tatjewski

Contents

Institute of Control and Computation Engineering
Faculty of Electronics and Information Technology
Warsaw University of Technology
Nowowiejska 15/19, 00-665 Warsaw, Poland
http://www.ia.pw.edu.pl, sekretariat@ia.pw.edu.pl

Main Office, room 521
tel.: +48 22 825 09 95, +48 22 234 73 97, fax: +48 22 825 37 19

Students Office, room 22/23
tel.: +48 22 234 7750, tel.: +48 22 825 52 80

1 General Information

The following information about organization of the Institute reflects the situation on December 31, 2006.

1.1 Directors

Professor Piotr Tatjewski, Director
Professor Cezary Zieliński, Deputy Director for Research
Dr. Tomasz Traczyk, Deputy Director for Academic Affairs

1.2 Organization of the Institute

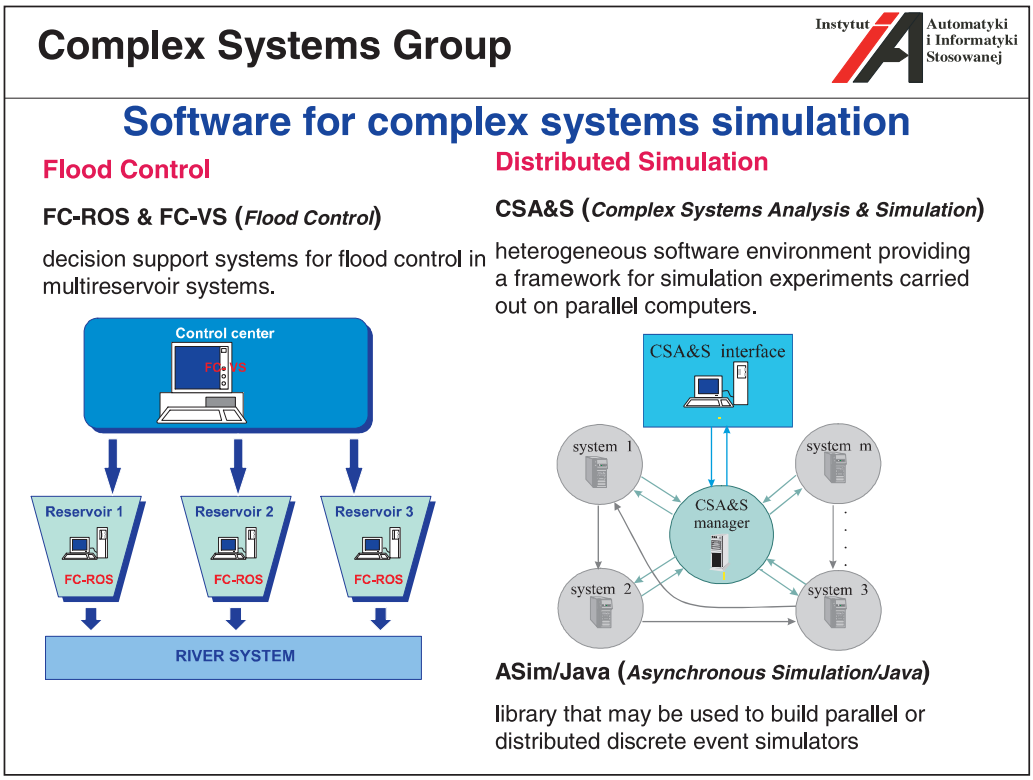
Systems Control Division

Division Head:	Professor Krzysztof Malinowski
Professors:	Włodzimierz Kasprzak, Krzysztof Malinowski, Andrzej Pacut, Cezary Zieliński
Professors, retired:	Władysław Findeisen, Radosław Ładziński, Jacek Szymanowski
Assistant Professors:	Piotr Arabas, Adam Czajka, Mariusz Kamola, Andrzej Karbowski, Tomasz J. Kruk, Bartłomiej Kubica, Ewa Niewiadomska-Szynkiewicz, Wojciech Szynkiewicz, Paweł Wawrzyński, Adam Woźniak
Assistants:	Adam Kozakiewicz, Tomasz Winiarski
Senior Lecturer:	Andrzej Rydzewski, Michał Warchoł
Ph.D. Students:	Bartłomiej Anszperger, Jacek Błaszczyk, Marcin Chochowski, Małgorzata Gadomska, Andrzej Igielski, Michał Karpowicz, Tomasz Kornuta, Michał Kudelski, Piotr Kwaśniewski, Marek Majchrowski, Roman Bartosz Nowicki, Fumio Adam Okazaki, Michał Pawluk, Joanna Putz-Leszczyńska, Andrzej Sikora, Maciej Staniak, Łukasz Stasiak, Przemysław Strzelczyk, Piotr Trojanek, Rafał Wardziński, Artur Wilkowski, Tomasz Winiarski

Research of the division is conducted in 3 research groups:

Complex Systems Group (**E. Niewiadomska-Szynkiewicz**, K. Malinowski, P. Arabas, M. Kamola, A. Karbowski, T. J. Kruk, B. Kubica, A. Woźniak, M. Warchoł, A. Kozakiewicz, B. Anszperger, J. Błaszczyk, M. Karpowicz, A. Sikora, P. Kwaśniewski)

The main area of interest is the theory and methodology of model-based predictive repetitive control and hierarchical control structures for non-linear systems under uncertainty, methods for solving continuous and discrete time optimization problems, and software for computer aided analysis and design of complex systems. Particular attention is given to distributed and parallel, synchronous and asynchronous, computations as well as to analysis and design of control algorithms and pricing techniques for computer networks. Also, important work is concerned with development of techniques for information systems security.



Complex Systems Group

Instytut Automatyki i Informatyki Stosowanej

Traffic control in TCP/IP networks

Family of price-based control algorithms for IP networks

Congestion control:
- New algorithm proposed
- Verified through simulations

Joint traffic engineering / bandwidth allocation methodology - designed to improve effectiveness (under investigation).

Simulation Tools

TcpSim – a fast TCP/IP simulator:
- calculation of transmission times for bulk data transfers
- flow-based - much faster than packet-level simulators
- original method of traffic modeling
- implemented in Java.

BrokerSim – a C++ pricing simulation package for OPNET:
- traffic generator for user profiles
- short-term traffic demand approximator
- broker module: pricing decisions and traffic shaping
- router pricing module augmenting OPNET's router model

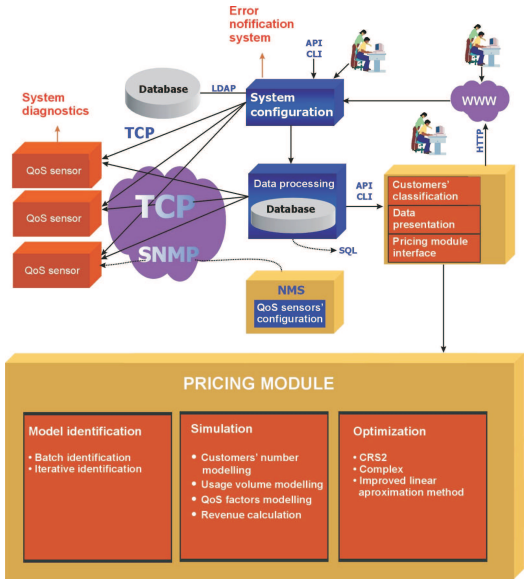
Complex Systems Group

Instytut Automatyki i Informatyki Stosowanej

QOSIPS System

Participation in QOSIPS (Quality of Service and Pricing Differentiation for IP Services) project of 5FP

QOSIPS goals:
- Differentiation of IP services
- Quality of service
- Pricing support
- Integration with NSP operation systems



Complex Systems Group

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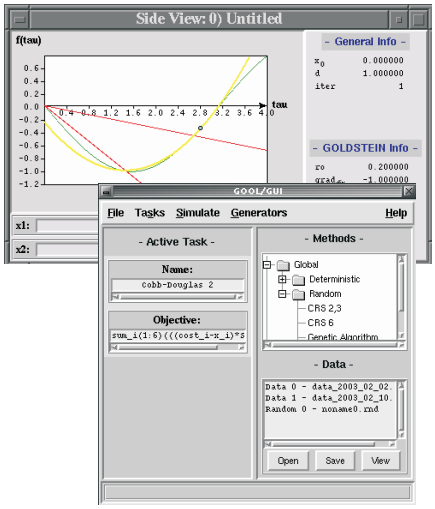
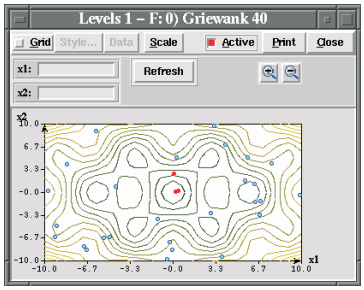
Global optimization

GOOL - Global Optimization Object–Oriented Library





GOOL

library of random search generators and optimization algorithms for convex and nonconvex, unconstrained and constrained problems

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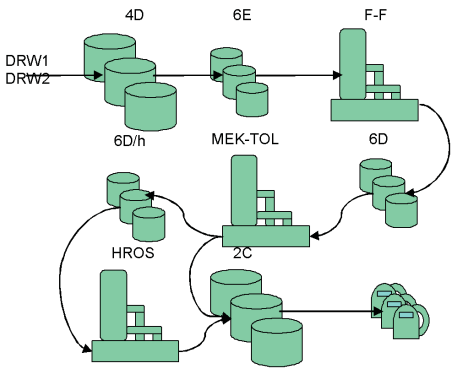
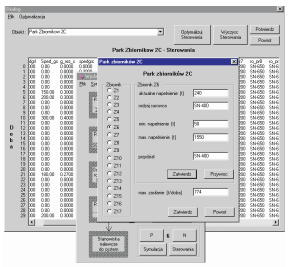
Operations scheduling using Constraint Programming

Solution of a scheduling problem in an Oil Refinery Division



Oil Refinery Division



Simulation and optimization system

Goals:

- Simulation of an Oil Refinery Division
- Finding all feasible solutions
- Meeting all technical requirements
- Constraint scheduling methods
- Very fast computations

Complex Systems Group

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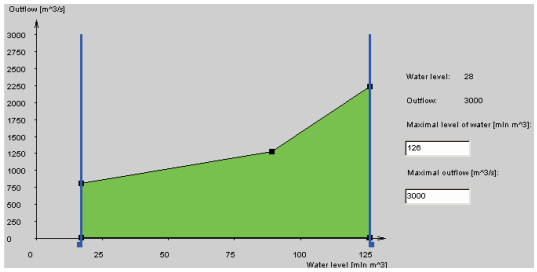
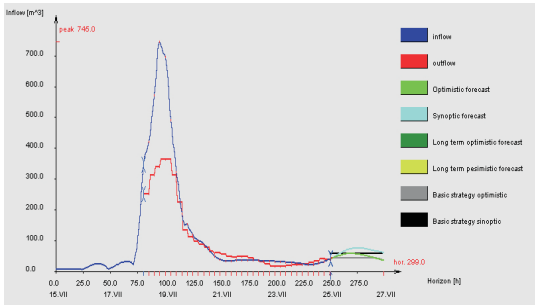
Optimal control and closed-loop design

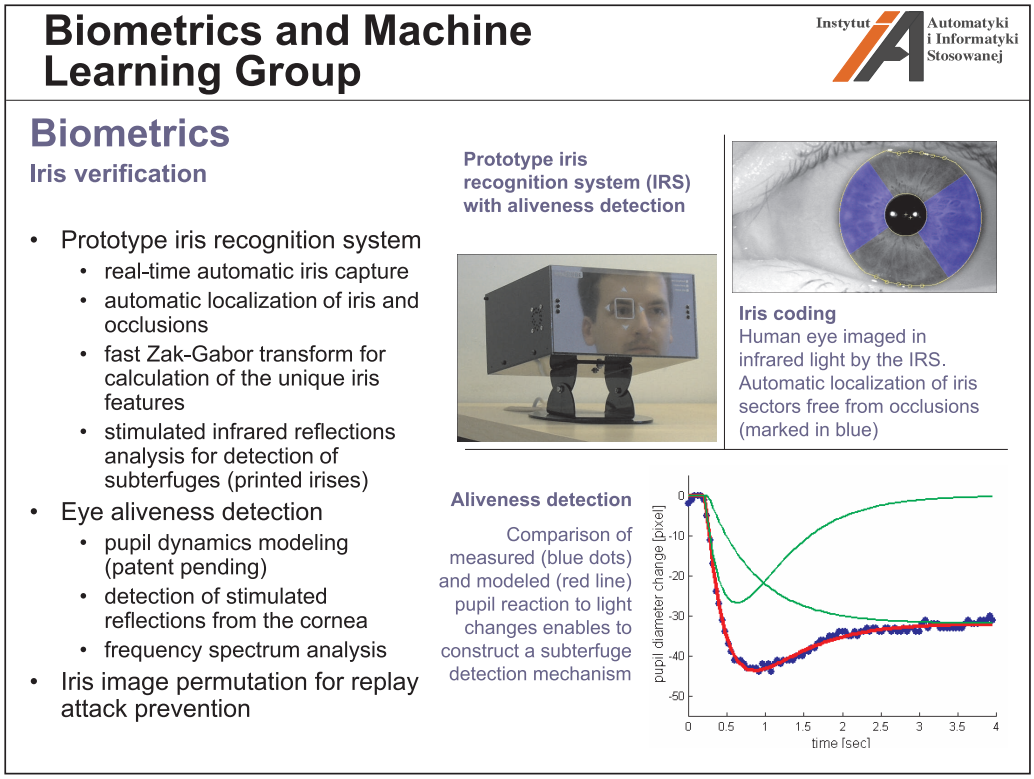
- development of OO libraries for calculation of optimal control in general nonlinear deterministic problems with constraints
- development of OO libraries for calculation of optimal closed-loop policies in general stochastic problems
- development of Decision Support Systems for flood control in single and multireservoir systems
- theoretical studies on optimal control in various conditions eg. with stochastic scenarios, fuzzy systems, worst-case, different risk measures, etc.
- theoretical and simulation studies on real-time control in computer networks at different levels





Biometrics and Machine Learning Group (**Andrzej Pacut**, A. Czajka, P. Wawrzyński, M. Chochowski, M. Gadomska, A. Igielski, M. Kudelski, R. B. Nowicki, J. Putz-Leszczyńska, Ł. Stasiak, P. Strzelczyk, R. Wardziński)

The research is centered on biologically inspired control and information technology, including biometrics, machine learning, uncertainty modeling, and biological modeling. Biometrics consists in using personal characteristics for identity authentication. Our research in biometrics includes pattern recognition for iris, hand-written signature, hand shape and lines, etc. Also, safety of biometric data storage and exchange, biometrics intelligent cards, and data encryption using biometrics are investigated. Machine learning research is focused on reinforcement learning, and in particular, learning algorithms, adaptive control, and multi-agent systems. Also, learning in neural networks and modeling granularity is investigated.



Biometrics and Machine Learning Group

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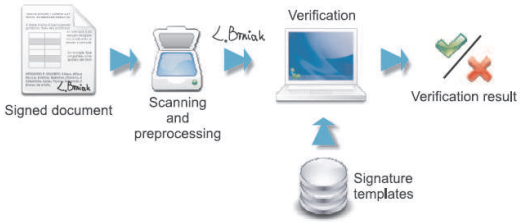
Biometrics

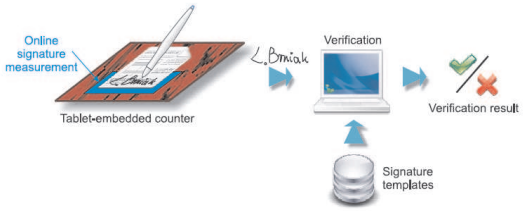
Handwritten signature-based identity verification



Verification of scanned signatures

- Integration of several independent methods of verification
- use of statistics, neural networks and Hidden Markov Models for signature features extraction
- Our solution give false acceptance rate of 12.5% with false rejection rate of 14.5%

Verification of on-line signatures



- signature as a multidimensional curve
- recognition based on handwriting dynamics, rather than paper image
- the use of neural networks, dynamic programming and time warping for classification purposes
- Our solution give false acceptance rate of 1% with false rejection rate of 1.9%

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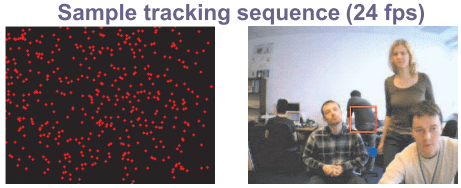
Biometrics

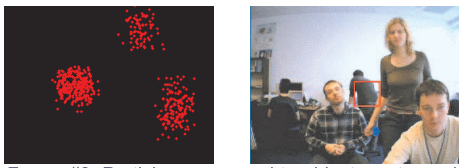
Particle filter-based face tracking and identification

- reference object is stored as hue-saturation histogram in the HSV color space
- application of Condensation Tracking framework
- Bhattacharyya coefficient-based distance measure used to weight particles
- automatic detection of the number of objects by Modified X-Means algorithm
- work in progress on gradual information collection for the purpose of identification with increasing confidence level

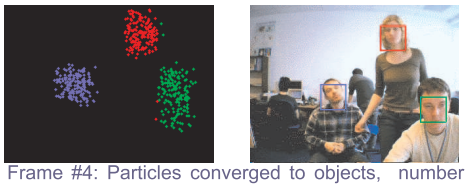
Sample tracking sequence (24 fps)



Frame #0: Particles spread all over the image (left: particle space, right: the image space)



Frame #3: Particles converged to objects, yet number of objects detected incorrectly



Frame #4: Particles converged to objects, number of objects detected correctly

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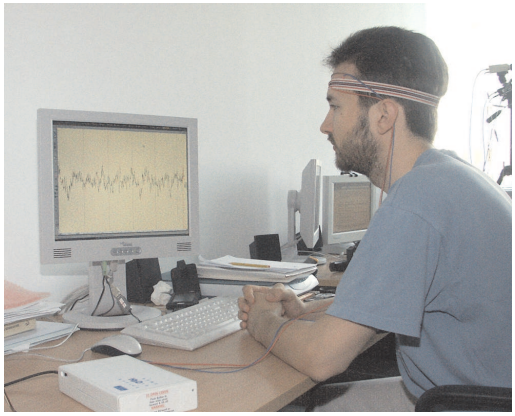
Biometrics

EEG-based identity verification

- Comparison of EEG signals distant in time
  - Short-term variability of EEG
  - Long-term variability of EEG
- Variability of EEG models in different recording conditions
- Linear modeling of EEG signal
- Nonlinear modeling of EEG
  - GARCH - Generalized Autoregressive Conditional Heteroskedasticity model



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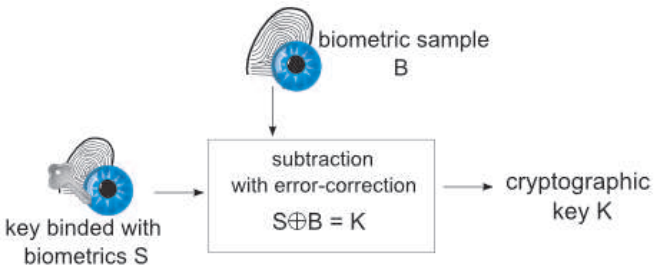
Biometrics

Biometric cryptography



- Hiding information within biometric data
  - analysis of information capacity for different biometric modalities
  - implementation of cryptographic primitives for iris biometrics
  - developing cryptographic schemes for secure biometric authentication
- Hardware implementations
  - implementation for smart-cards
  - implementation for USB-tokens

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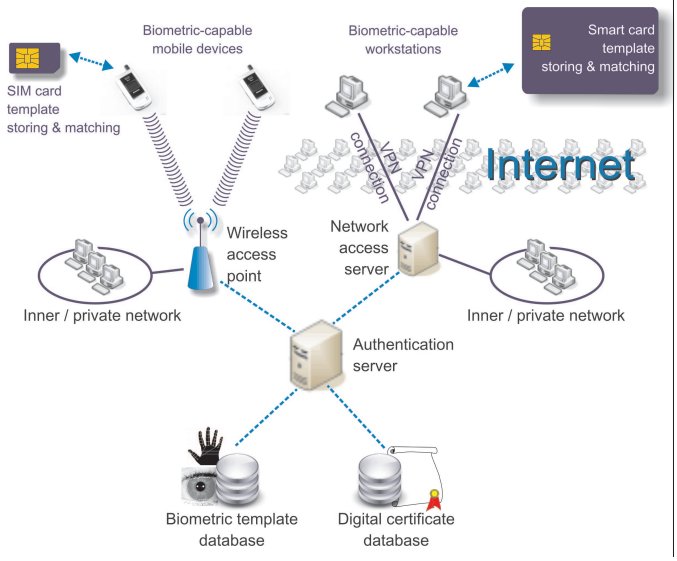
Biometrics

Biometric authentication for secure remote access



- Novel authentication protocols and techniques employing biometrics
- VPN & wireless networks applications
- Development of biometric capable mobile devices and workstations
- Smartcards and SIM cards application for distributed template storage and processing (match-on-token)
- Central template database design and management
- Multiple biometrics (iris, fingerprint and others)

Biometrics and Machine Learning Group

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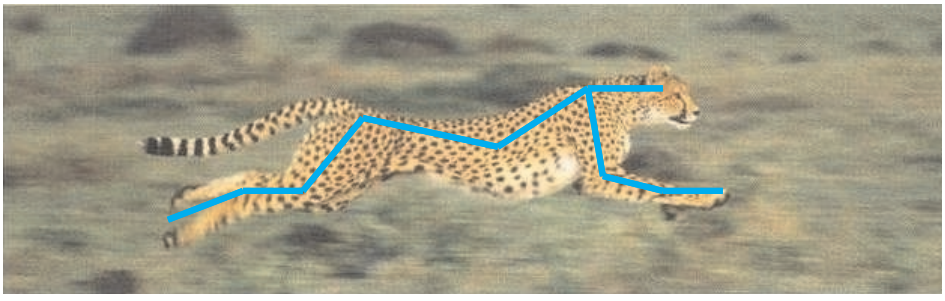
Machine Learning

Model-free on-line adaptive control based on reinforcement learning

Typical Reinforcement Learning methods are far too slow to be used in adaptive control. Our solution is based on a combination of **Actor-Critic methods** and **experience replay**. Simulations show more than **hundredfold increase** of control adaptation learning speed.

Reinforcement Learning algorithms usually behave poorly when time discretization increases. As a remedy we propose **piecewise non-Markov policies**. We tested this approach using a simulated planar model of cheetah.



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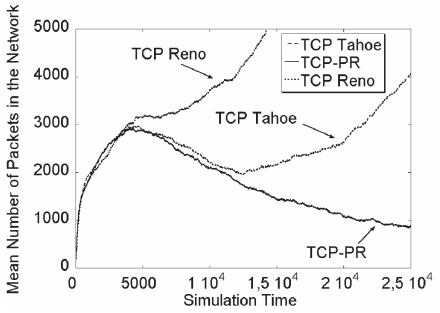
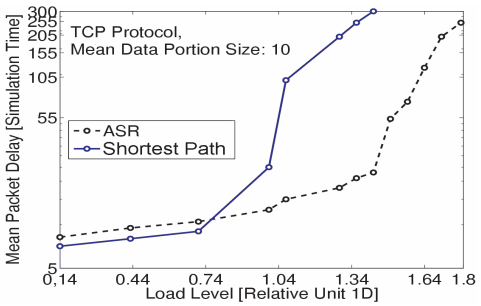
Machine Learning

Ant Routing (AR) is typically considered under UDP in the transport layer. We **extended AR to work under TCP**

- demands on theAR adaptation are higher
- range of load levels for AR is higher that for non-adaptive policies (Fig. below)
- statistics-based modifications of AR better use ant-collected information
- TCP versions more robust to packet reordering improve AR convergence (Fig. left below)





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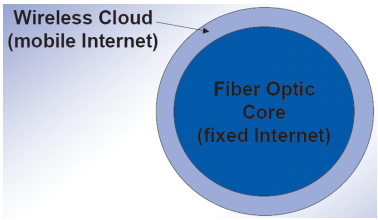
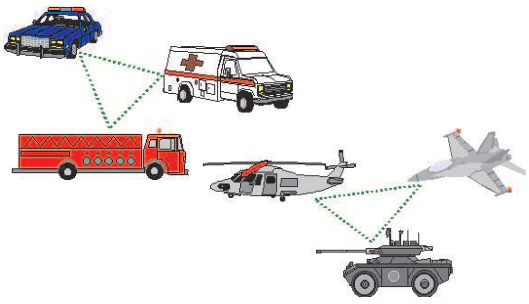
Instytut Automatyki i Informatyki Stosowanej

Machine Learning

Reinforcement Learning and SWARM Intelligence in ad-hoc networks

- Highly dynamic enviroment
- Strong need for adaptive mechanisms to solve routing problems, topology control, QoS provisioning, etc.
- We propose a novel network information management together with Reinforcement Learning and Swarm based algorithms
- NS2 network simulator is used in experiments

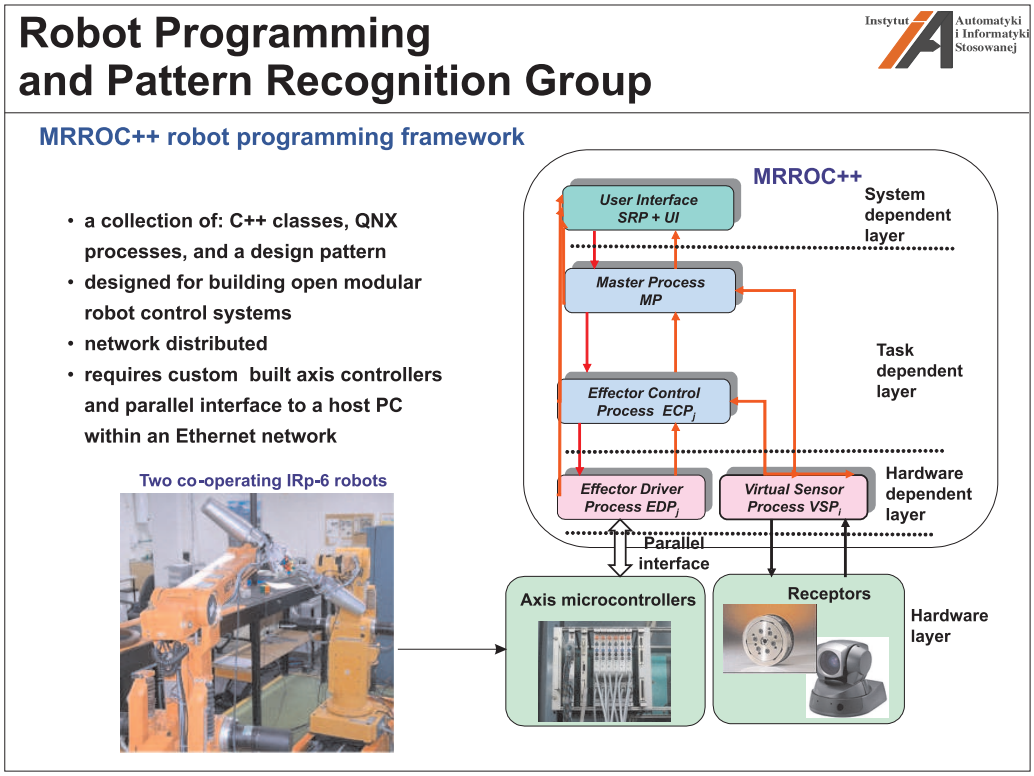




Wide area of ad-hoc networks applications

Robot Programming and Pattern Recognition Group (**C. Zieliński**, W. Kasprzak, W. Szynkiewicz, A. Rydzewski, T. Winiarski, T. Kornuta, A. F. Okazaki, M. Pawluk, M. Staniak. M. Majchrowski, P. Trojanek, A. Wilkowski)

Research of the group is concerned with robot motion planning and control systems, autonomous mobile robot localization and navigation, robot programming methods, computer vision systems and speach recognition systems. In the robot control systems area research is focused on new motion and force/position control algorithms for multi-robot systems. Special emphasis is given to the sensor-based motion planning and control of the single and multiple articulated or mobile robots. In the computer vision and signal processing (speech analysis) area the research is concentrated on autonomous navigation, transportation and security relevant environments. All of this research is centered around service robots, i.e. two-handed devices using visual servoing, force control, and speech recognition to fulfill tasks that humans usually execute.



Robot Programming and Pattern Recognition Group

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RNT and POLYCRANK prototype robots

- **RNT robot:** high stifness, large workspace, serial-parallel kinematic structure – well suited to milling and polishing tasks
- **POLYCRANK robot:** capable of very fast motions, has no joint limits, direct drive – well suited to palletization tasks

RNT robot:

Control systems based on MRROC++ programming framework

POLYCRANK robot

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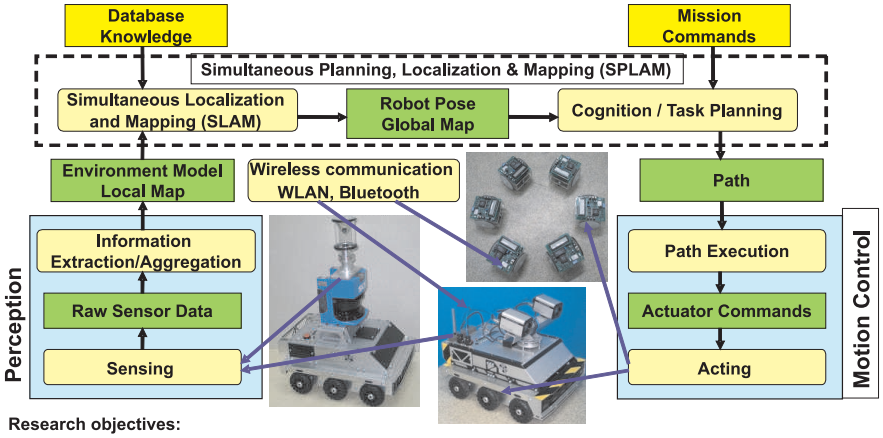
Control architecture for autonomous mobile robot teams



Research objectives:

- To develop the perceptual, representation, reasoning, learning and communication capabilities of autonomous mobile robot systems in human-oriented real-life environments
- To develop and implement a complete, effective, and reusable software for autonomous robot systems that incorporates both programming (manual coding) and learning-derived (automated coding) software composition to increase the ability of autonomous robots to function in unpredictable, dynamic environments
- To study the human-robot interaction (multi-modal interfaces)

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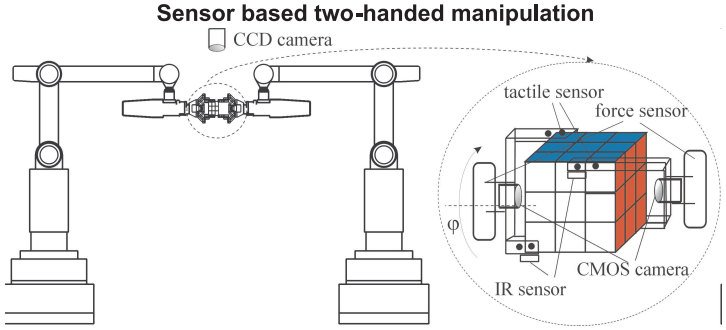
Sensor based two-handed manipulation



Rubik's cube puzzle as a benchmark task for service robots

Solution of the benchmark task requires:

- **Two-handed manipulation skill to efficiently turn the faces of the cube**
- **Visual sensing capability to locate the cube and identification of its initial state**
- **Visual servomechanism to approach the cube and to get hold of it**
- **Using tactile and force sensors to avoid jamming of the cube while rotating the faces**
- **Capacity for using tactile and force stimulus in manipulation**
- **Fusion of deliberative and behavioural control to work out the plan of motions solving the puzzle and to adapt quickly to sudden changes in the environment (e.g., jamming)**
- **Ability to recognize spoken commands and to synthesize replies and queries**

Robot Programming and Pattern Recognition Group

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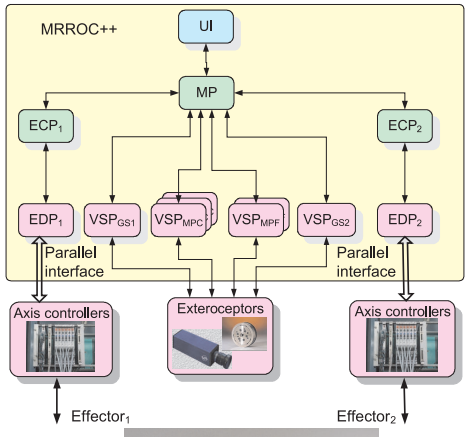
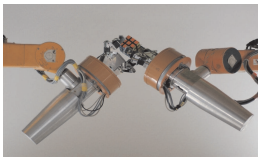
Two-handed Service Robot Controller Capable of Solving a Rubik's Cube Puzzle





Components:

MP – Master Process (produces the solution of the puzzle and generates the nominal motion trajectories for the two arms)

ECP – Effector Control Process (transmits the macro-steps generated by the MP to the EDP)

VSP – Virtual Sensor Process (aggregates data from sensors, i.e. cameras, enabling the localisation of the cube and identification of its state)

EDP – Effector Driver Process (divides the macro-step into steps and executes each step using the Task Frame Formalism for position-force control)

UI – User Interface (operator console and status and error reporting)

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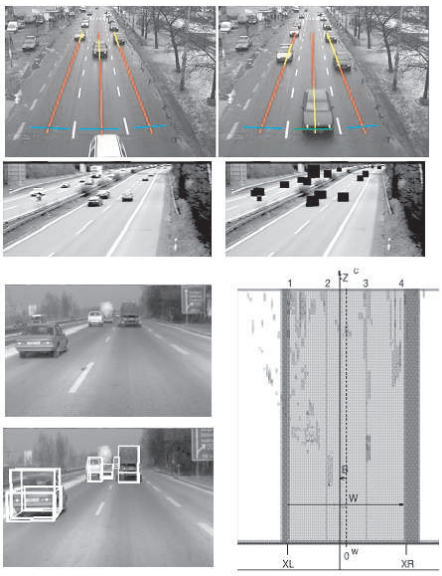
Road traffic analysis. Autonomous navigation.

•Supported by the project IST-11250 **OMNI** ("*Open Model For Network-wide Heterogeneous Intersection-based Transport Management*", 2000-2003) an „intelligent" visual sensor system was developed that performs queue length measurement and car counting – for every road lane in the image.

•Computer-vision based car driver assistance – road tracking and obstacle detection.



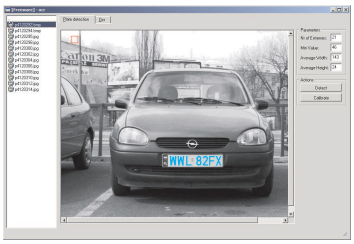
Robot Programming and Pattern Recognition Group

Instytut Automatyki i Informatyki Stosowanej

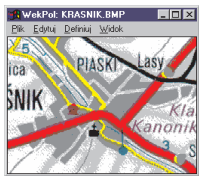
2-D object recognition in digital images

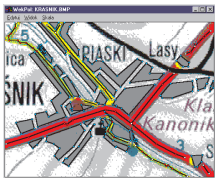
Car's license plate recognition :

- Automatic image region detection;
- Single symbol detection.
- Symbol classification.



Various 2-D object recognition:
i.e. fingerprint images, cartographic objects.





Robot Programming and Pattern Recognition Group

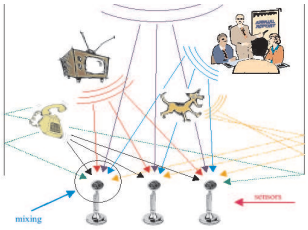
Instytut Automatyki i Informatyki Stosowanej

Blind separation of mixed signals

The „cocktail party" problem:

•Only mixtures of source signals can be acquired,

•The goal is to separate the original sources.



•Illustration of deconvolving 2-D image mixtures:

•Three convolved mixtures of three sources at the system's input.

•Three deconvolved images at the output.

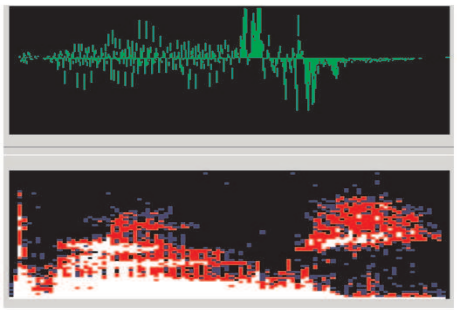
Robot Programming and Pattern Recognition Group

Instytut Automatyki i Informatyki Stosowanej

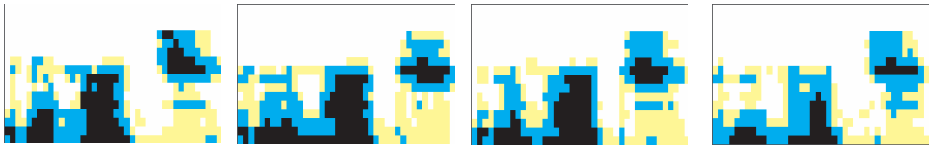
The recognition of Polish speech

The automatic recognition of Polish spoken words:

- Spectral analysis,
- Feature detection in signal frames,
- Sub-phoneme modeling,
- Frame classification,
- Model-based word recognition.



Example: low resolution spectral images acquired for four different expressions of the word „koniec".



Control and Software Engineering Division

Division Head:	Professor Piotr Tatjewski
Professors:	Piotr Tatjewski, Krzysztof Sacha
Assistant Professors:	Rafał Cegieła, Paweł Domański, Maciej Ławryńczuk, Piotr Marusak, Marcin Szlenk, Andrzej Zalewski
Senior Lecturers:	Jerzy Gustowski, Zygmunt Komor, Urszula Kręglewska
Senior Engineer:	Włodzimierz Macewicz
Ph.D. Students:	Ali Mhammed Benniran, Anna Felkner, P. Górczyński, Maciej Grula, Radosław Kacperczyk, Piotr Kaczyński, Andrzej Ratkowski, Marek Strzelczyk, Krzysztof Sztyber

Research of the division is conducted in 2 research groups:

Control Engineering Group (**P. Tatjewski**, P. Domański, Z. Komor, M. Ławryńczuk, P. Marusak, J. Gustowski, U. Kręglewska, P. Kaczyński, M. Strzelczyk, K. Sztyber)

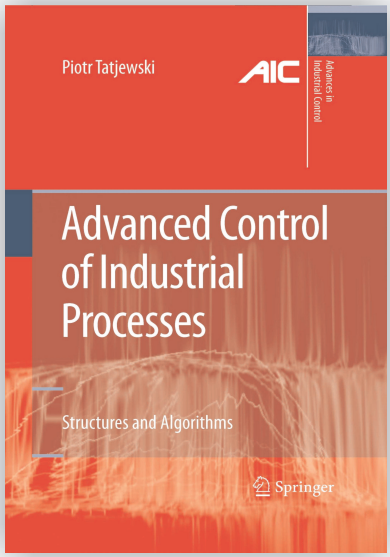
Research of the group encompasses control engineering techniques, in particular industrial process control. The focus is on predictive and fuzzy control algorithms, multilayer optimizing and supervisory control, and non-linear system control and analysis. Model-based predictive control algorithms for linear and nonlinear process modeling are developed and investigated. Soft computing methods for design and tuning of control systems are used, based on fuzzy systems, neural nets, and genetic algorithms. Theoretical considerations are combined with simulation analysis and investigations. Computer Control Systems Laboratory features laboratory-scale processes and is equipped with programmable controllers, industrial computers and workstations with software tools, including Matlab with Toolboxes and professional SCADA systems.

Control Engineering Group

Instytut Automatyki i Informatyki Stosowanej

Advanced control of industrial processes

- The multilayer control structure for industrial processes
- Non-linear process modeling using fuzzy techniques and neural networks
- Fuzzy control algorithms of Takagi-Sugeno type
- Algorithms and structures of model predictive control with linear and nonlinear process models (control laws, optimization-based algorithms)
- Software for development and testing of advanced process control algorithms



Springer, London, 2007

Control Engineering Group

Instytut Automatyki i Informatyki Stosowanej

Optimization of industrial processes and large-scale systems

- Procedures for steady-state optimization of industrial processes
- Structures and algorithms for on-line measurement-based set-point optimization under uncertainty
- Hierarchical (multilevel) optimization methods for large-scale systems
- Multilevel algorithms for on-line set-point optimization of interconnected processes under uncertainty

Imperial College Press/ World Scientific, 2005

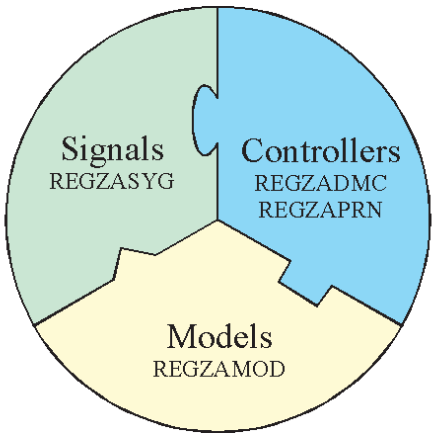
Control Engineering Group

Instytut Automatyki i Informatyki Stosowanej

REGZA - Algorithms and software environment for modeling and advanced control of industrial processes

Software Package:

- **REGZASYG** – programs and interface for signal processing
- **REGZAMOD** – programs and interface for process modeling
- **REGZADMC** – interface and model predictive control algorithms: linear DMC and nonlinear with fuzzy process models
- **REGZAPRN** – interface and model predictive control algorithms: linear GPC and nonlinear with neural network process models



Control Engineering Group

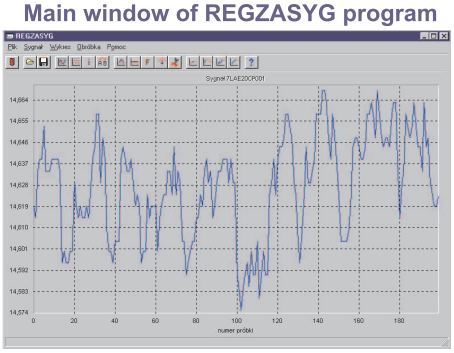
Instytut Automatyki i Informatyki Stosowanej

REGZA - Algorithms and software environment for modeling and advanced control of industrial processes

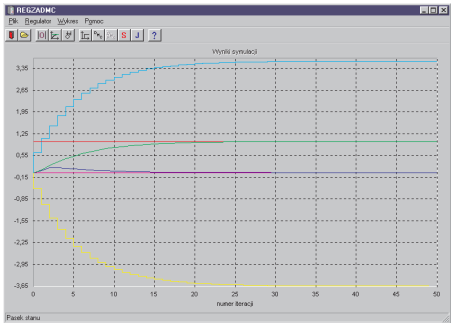
Nonlinear predictive control structures based on fuzzy and neural models

- Algorithms with successive linearization
- Algorithms with nonlinear prediction and linearization
- Algorithms with iteratively updated nonlinear prediction and linearization
- Algorithm with nonlinear optimization

Main window of REGZASYG program



Main window of REGZADMC program

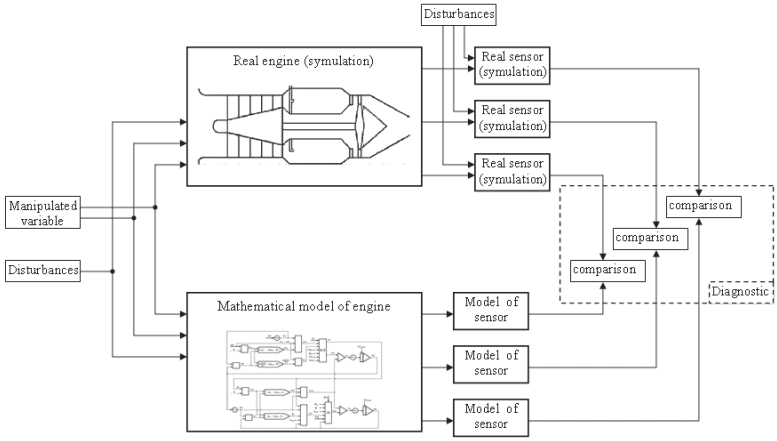


Control Engineering Group

Instytut Automatyki i Informatyki Stosowanej

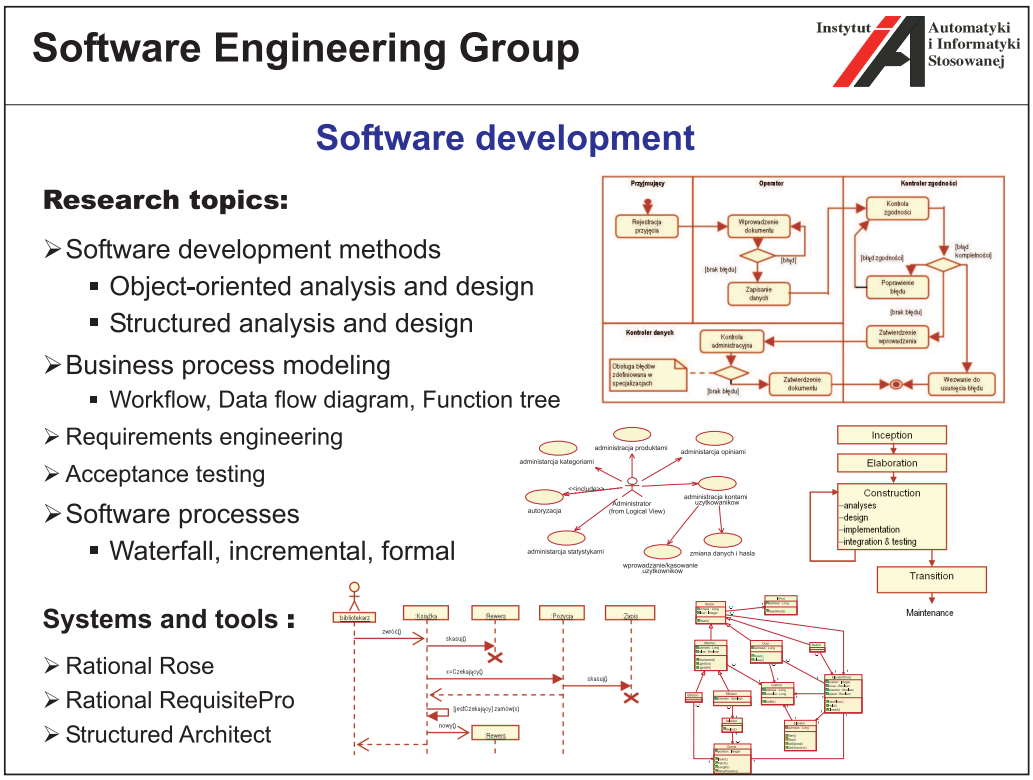
Sensors diagnostic system

mathematical modeling and simulation of a gas turbine engine and sensors, sensors diagnostic system design based on neural networks



Software Engineering Group (**K. Sacha**, R. Cegieła, A. Zalewski, W. Macewicz, M. Szlenk, A. Felkner, P. Górczyński, M. Grula, R. Kacperczyk, A. Ratkowski)

The main area of interest is the development and quality evaluation of software. Topics include software processes, analysis, design and quality evaluation methods, and software audit. Apart of the research activity, we have been working on a number of commercial projects related to the development and evaluation of huge software systems for public organizations and for the industry. The scope of those projects included business process modeling, requirements analysis, strategic planning, conducting the testing process, and software audit.



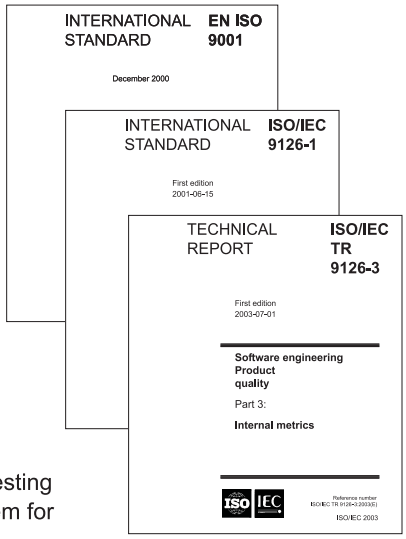
Software Engineering Group

Instytut Automatyki i Informatyki Stosowanej

Evaluation of the software quality

Research topics:

- Quality of the software process
- Quality of the software products
- Evaluation method:
  - Defining the set of quality criteria
  - Defining the set of questions
  - Evaluation and ranking
  - Threats and recommendations



Sample projects:

- Evaluation of the expected quality of software developed for IACS (support system for EU Common Agriculture Policy in Poland)
- Supervision and evaluation of the acceptance testing of the integrated management and control system for the post delivery service in Poland

Software Engineering Group

Instytut Automatyki i Informatyki Stosowanej

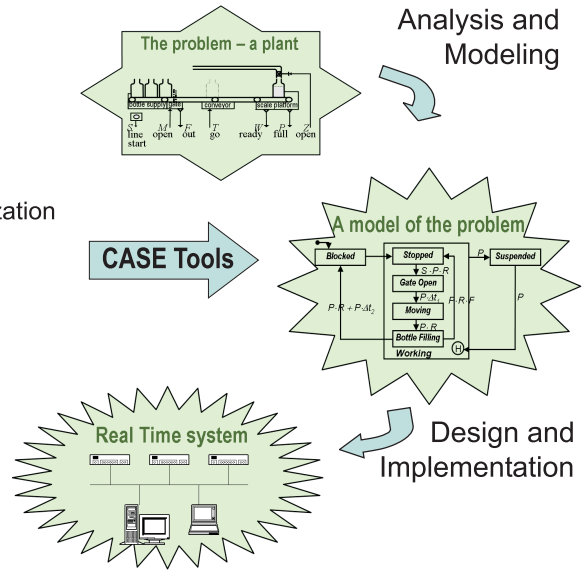
Real time systems

Research topics:

- System analysis and design
- System and software architecture
- Real time operating system
  - Task scheduling
  - Communication and synchronization
- Industrial networks
  - Devicebuses
  - Fieldbuses
- PLC controllers
  - Automatic program generation

Systems and tools:

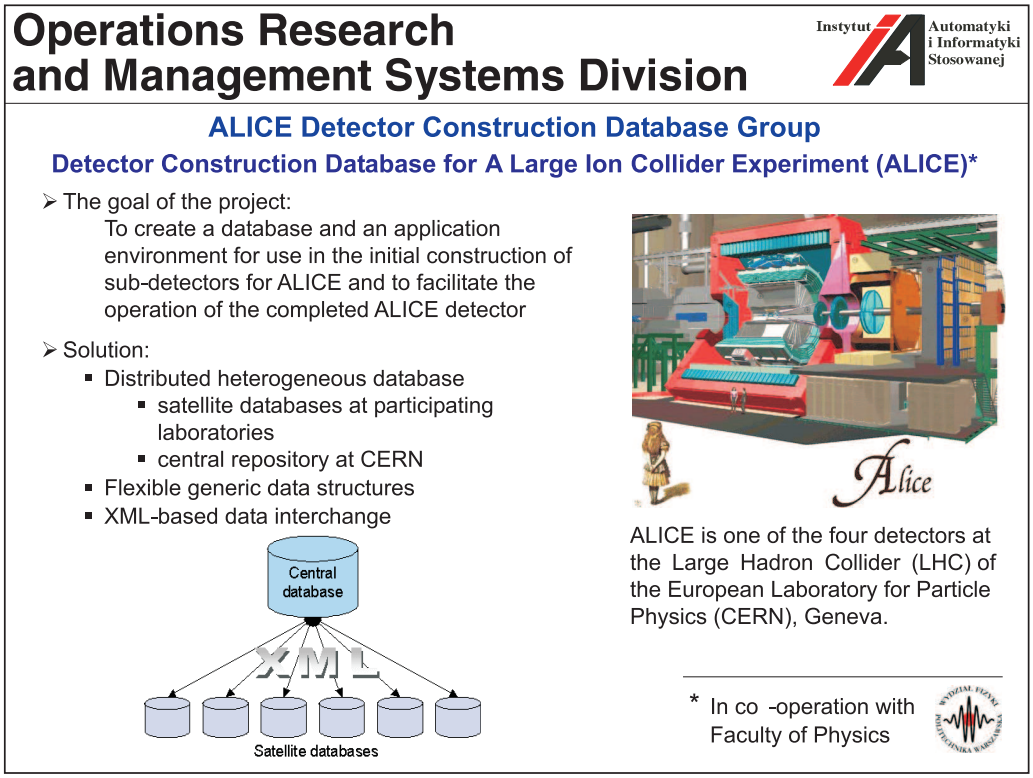
- QNX, OS/9
- Profibus
- Siemens Step 7

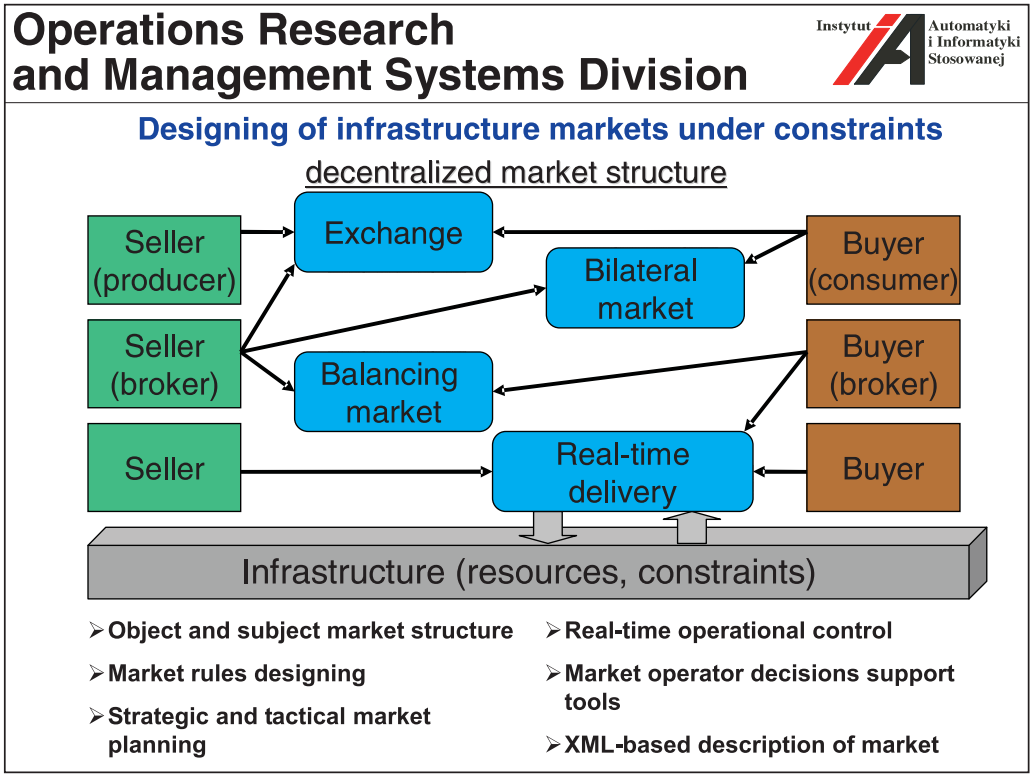


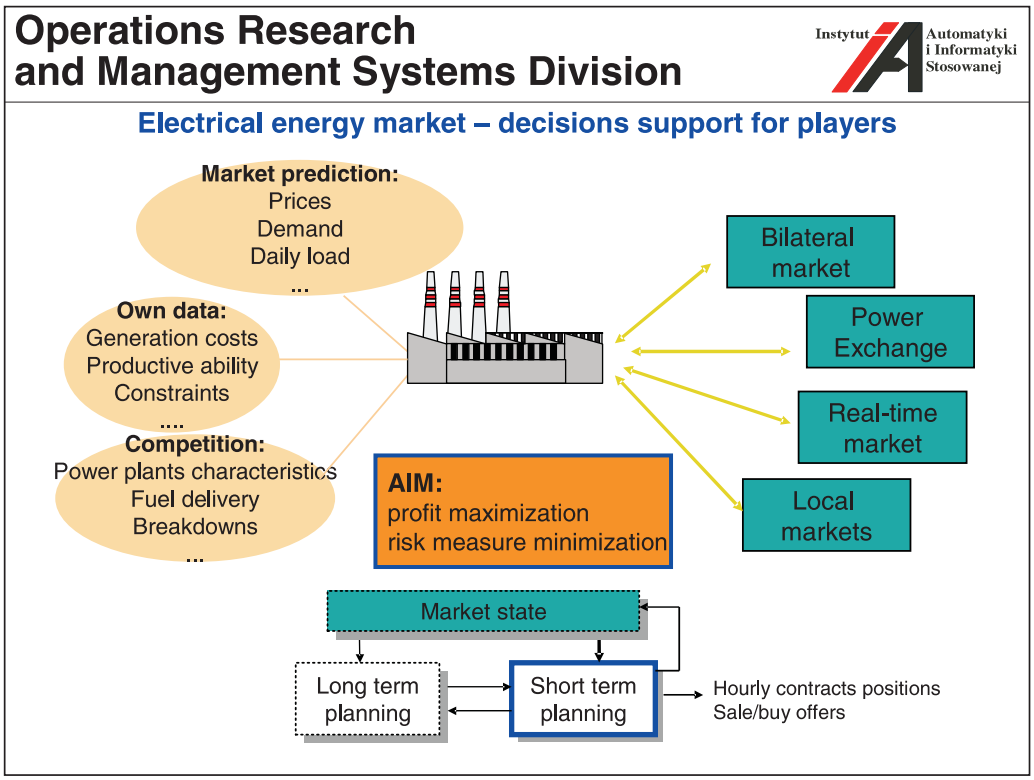
Operations Research and Management Systems Division

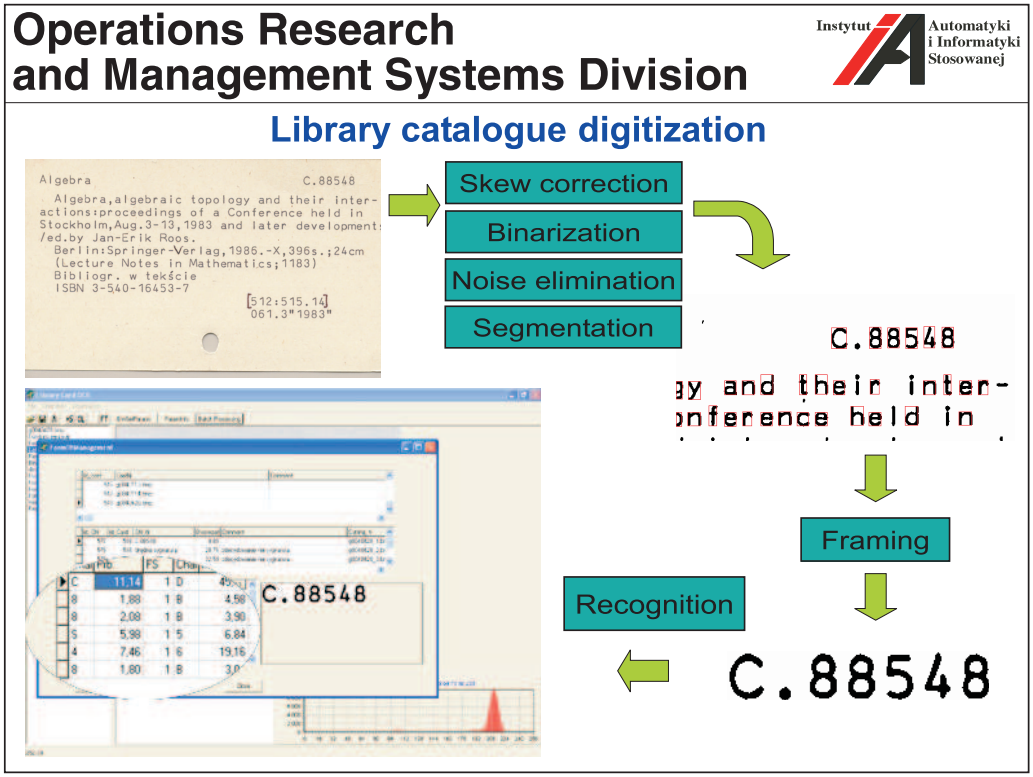
Division Head:	Professor Eugeniusz Toczyłowski
Professor:	Eugeniusz Toczyłowski
Assistant Professors:	Krzysztof Fleszar, Mariusz Kaleta, Krzysztof Pieńkosz, Grzegorz Płoszajski, Tomasz Traczyk
Assistant:	Izabela Żółtowska
Ph.D. Students:	Zdzisław Dybikowski, Przemysław Kacprzak, Andrzej Midera, Piotr Pałka, Mariusz Rogulski, Kamil Smolira

Research of the division is concerned with operation research and structural discrete optimization methods for control and management of discrete processes, including applications in the deregulated electric power industry, computer integrated manufacturing and educational systems. The research is focused on market and auctions design, scheduling techniques, efficient structural-based optimization algorithms, time-table generation, strategic and tactical planning, detailed scheduling, and real-time operational control. Also, the object oriented and relational database management systems and CASE methods are investigated to design of the distributed multi-functional heterogeneous information systems.




Operations Research
and Management Systems Division
Instytut Automatyki i Informatyki Stosowanej
Designing of infrastructure markets under constraints
decentralized market structure
Seller (producer)
Seller (broker)
Seller
Exchange
Bilateral market
Balancing market
Real-time delivery
Buyer (consumer)
Buyer (broker)
Buyer
Infrastructure (resources, constraints)
Object and subject market structure
Market rules designing
Strategic and tactical market planning
Real-time operational control
Market operator decisions support tools
XML-based description of market

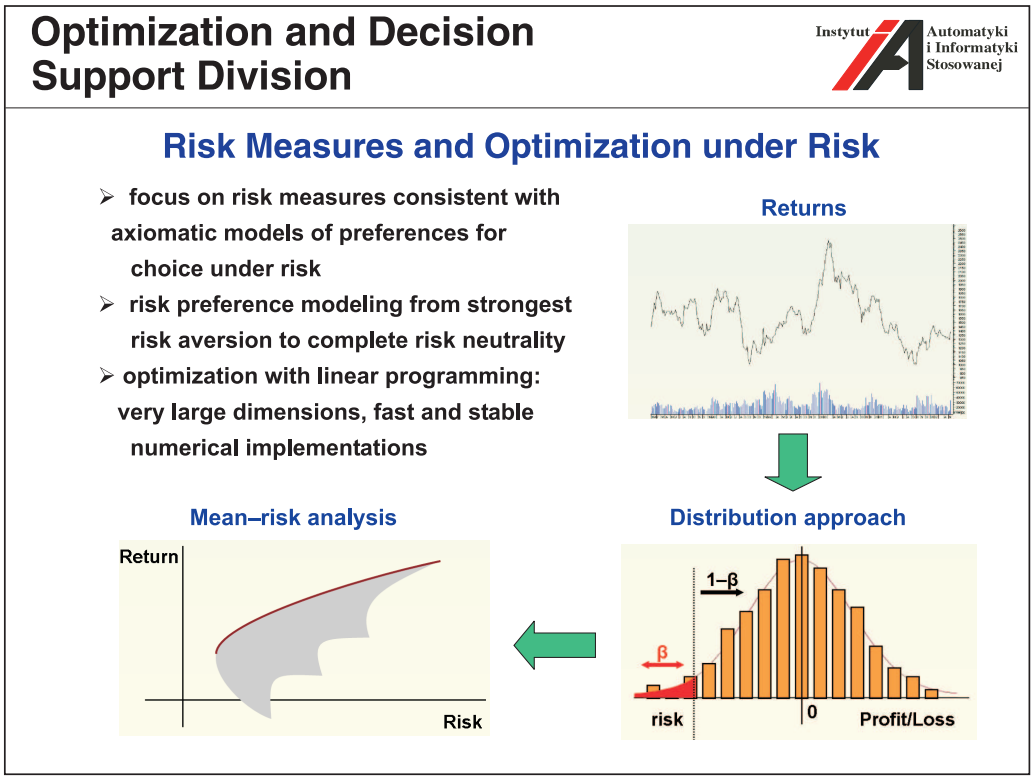

Operations Research
and Management Systems Division
Instytut Automatyki i Informatyki Stosowanej
Electrical energy market – decisions support for players
Market prediction:
Prices
Demand
Daily load
...
Own data:
Generation costs
Productive ability
Constraints
....
Competition:
Power plants characteristics
Fuel delivery
Breakdowns
...
AIM:
profit maximization
risk measure minimization
Bilateral market
Power Exchange
Real-time market
Local markets
Market state
Long term planning
Short term planning
Hourly contracts positions
Sale/buy offers


Operations Research
and Management Systems Division
Instytut Automatyki i Informatyki Stosowanej
Library catalogue digitization
Algebra C.88548
Algebra,algebraic topology and their inter-
actions:proceedings of a Conference held in
Stockholm,Aug.3-13,1983 and later development
/ed.by Jan-Erik Roos.
Berlin:Springer-Verlag,1986.-X,396s.;24cm
(Lecture Notes in Mathematics;1183)
Bibliogr. w tekście
ISBN 3-540-16453-7
[512:515.14]
061.3"1983"
Skew correction
Binarization
Noise elimination
Segmentation
C.88548
gy and their inter-
onference held in
Framing
Recognition
C.88548

Optimization and Decision Support Division

Division Head:	Professor Włodzimierz Ogryczak
Professors:	Włodzimierz Ogryczak, Wiesław Traczyk
Assistant Professors:	Janusz Granat, Jerzy Paczyński, Andrzej Stachurski
Senior Lecturers:	Tadeusz Rogowski, Jerzy Sobczyk
Lecturer:	Grzegorz Wójcik
Assistant:	Tomasz Śliwiński
Ph.D. Students:	Krzysztof Bareja, Cezary Chudzian, Piotr Górczyński, Bartosz Kozłowski, Adam Krzemienowski, Piotr Rzepakowski, Tomasz Strąbski

Research of the division is focused on the theory of distributed and parallel computational methods, and software for optimization. The theory covers a whole area of linear and non-linear, dynamic, stochastic and multiple criteria problems, and deals with such topics as the sensitivity aspects and the parametric aspects. Another area covers the decision theory, including the multi-person decisions and the game theory, and deals with software building for decision support and organization and management of computer networks. Also, research is carried on the methods of reasoning in knowledge based systems.

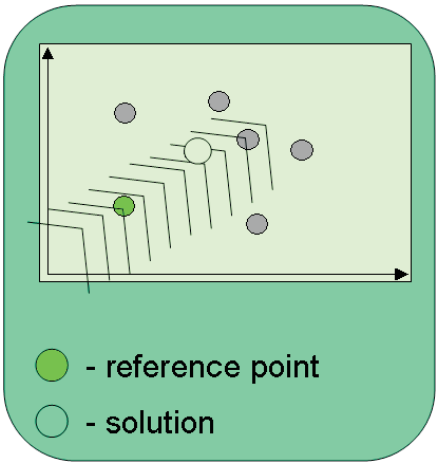


Optimization and Decision Support Division

Instytut Automatyki i Informatyki Stosowanej

Reference Point Method

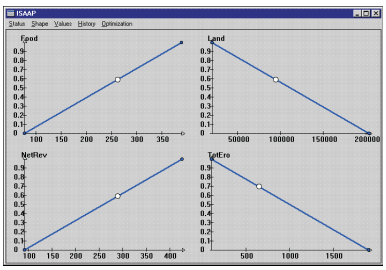
- interactive method for multicriteria model analysis
- guiding information by specification of the reference points
- a Pareto-optimal solution is selected for a given reference point

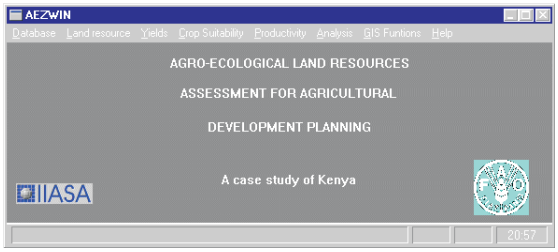


Optimization and Decision Support Division

Instytut Automatyki i Informatyki Stosowanej

Application of the reference point method to land resource assessment





1.3 Statistical Data

FACULTY and STAFF	2004		2005		2006	
	persons	FTE	persons	FTE	persons	FTE
Academic Staff	42(+1)	35.90(+1.5)	44(+2)	37.48(+2)	43(+2)	37.5(+2)
by titles/degrees						
Professors	4	4	4	4	4	4
D.Sc.-s	4	4	5	5	6	6
Ph.D.-s	22(+1)	20(+1)	24(+2)	21(+2)	24(+2)	21(+2)
M.Sc.-s	12	7.9	11	7.48	9	6.5
by positions						
Professors	8	8	9	9	9	9
Assistant Professors	21(+1)	19(+1)	21(+2)	19(+2)	22(+2)	20(+2)
Senior Lecturers	6	5	6	5	7	5.5
Lecturers	1	0.5	1	0.5	1	0.5
Assistants	6	3.4	7	3.98	4	2.5
Ph.D. Students	34		36		37	
Technical Staff	4	3	3	2.5	3	2.5
Administrative Staff	6	5.5	6	5.5	6	5.5

FTE – Full Time Employment units,
\+ – corrections due to persons on long-term leave of absence

ACTIVITIES	2004	2005	2006
Teaching activities			
standard teaching potential, hours	9 467	8 212	8 327.25
# hours taught	13 030	15 914.5	15 341.51
Degrees awarded			
D.Sc.	0	0	1
Ph.D.	3	5	5
M.Sc.	47	47	51
B.Sc.	53	40	53
Research projects			
granted by WUT	9	11	3
granted by State institutions	3	5	7
granted by international institutions	1	1	1
other	3	4	0
Reviewed publications			
monographs (authored or edited)	0	2	2
chapters in books	7	18	31
papers in journals	24	15	32
papers in conference proceedings	27	55	44
Reports, abstracts and other papers	16	14	28
Conferences			
participation (# of conferences)	23	33	40
participation (# of part. from ICCE)	43	52	73

RESOURCES	2003	2004	2005	2006
Space (sq.m.)				
laboratories	585	585	585	585
library + seminar room	74	74	74	74
faculty offices	724	724	724	724
Computers				
workstations*	14	14	9	15
personal computers*	245	245	165	269
Library resources				
books	4601	4683	4732	4814
booklets	1570	1684	1779	1885
journals subscribed	7	7	6	6

* Classification into workstations and personal computers changes due to modification of technical standards.

2 Faculty and Staff

Presentation of our faculty starts with Professors Emeriti and continues with Senior Faculty, Supporting Faculty, Ph.D. Students, and Administrative Staff. Senior Faculty includes Professors, Associate Professors, Assistant Professors, and Senior Lecturers. By Supporting Faculty we understand Lecturers, Assistants, and Research Associates, as well as Technical Staff. The personal information below regards the period of January 1 – December 31, 2006.

2.1 Professors Emeriti

Władysław Findeisen Professor (retired July 1999)

Systems Control Division, Complex Systems Group
room 524, tel. 660 7397 and 825 0995
W.Findeisen@ia.pw.edu.pl

M.Sc. 1949, Ph.D. 1954. Full Professor since 1962.

Founder and Director of ICCE (1955–1981), elected and re-elected Rector of WUT (1981–1985). Member of Polish Academy of Sciences (PAN) since 1971. Doctor Honoris Causa of The City University in London (1984), Warsaw University of Technology (1996), Gdańsk University of Technology (1997), Technische Universität Ilmenau (1998). Chairman of the Social Council to the Primate of Poland (1986–90), Vice-President of the Polish Academy of Sciences (PAN)(1990–1992), Senator of the Republic of Poland (1989–93), President of "Kasa Mianowskiego" (a foundation which sponsors foreign scientists in Poland) (since 1991), Vice-President of the Polish Committee for UNESCO (since 1999).

Radosław Ładziński Professor (retired January 1998)

Systems Control Division, Complex Systems Group
room 570, tel. 660 7648
R.Ladzinski@ia.pw.edu.pl

Born 1927, M.Sc. 1952, Ph.D. 1957 from WUT; the title of Professor of Technical Sciences awarded in 1968.

With WUT since 1949. Vice-Dean of the Faculty of Electronics, (1964–1969), head of the Ph.D. Program in Control Engineering and Computer Science (1977–1981), chairman of the Electronics and Information Technology Committee for Ph.D. Degree in Control and Computer Engineering (1991–1996). Parallel working with Institute of Electrical Engineering of Polish Academy of Sciences (PAN) (1955–1962), and with Institute of Automatic Control of PAN (1963–1968). Post-Doctoral Scholar, Royal Institute of Technology, Stockholm, Sweden (1957), British Council Scholar, University of Cambridge, England (1959–60), Visiting Lecturer, Department of Mathematics, University of Ghana, Accra, Ghana (1962–63), Professor of Engineering Science, University of Mosul, Iraq (1970–74), Professor of Engineering Mathematics, Rivers State University of Science and Technology, Port Harcourt, Nigeria (1981–87), Member of Magdalene College, University of Cambridge, England.

Interests: Dynamic systems, control theory, and applied mathematics.

Jerzy Pułaczewski Senior Engineer (retired since October 2003)

Systems Control Division, Robot Programming and Pattern Recognition Group
room 570, tel. 660 7648
J.Pulaczewski@ia.pw.edu.pl

M.Sc. 1958, Ph.D. 1965 from WUT.

With WUT since 1956, Deputy Director of ICCE (1972–80 and 1993–96), Deputy Dean of the Faculty of Electronics (1981–87), Chairman of the Departmental Curriculum Committee (1981–90), member of the Senate of Warsaw University of Technology (1987–90). Scholarship in Moscow Electroenergy University (1958–59), the British Council scholarship at Cambridge University, UK (1965–66), visiting researcher at Minneapolis University, Minneapolis, MN (1980–81).

Interests: Digital control algorithms, process modeling and simulation, process control.

Jacek Szymanowski Professor (retired January 2000)

Systems Control Division, Complex Systems Group
room 530, tel. 660 7922
J.Szymanowski@ia.pw.edu.pl

M.Sc. 1962, Ph.D. 1966, D.Sc. 1983 from WUT.

With WUT since 1968. Visiting Professor, Laboratoire d'Automatique de Nantes, Ecole Centrale de Nantes, France, 1992, 1994, 1995, 1996, 1997. Retired since January 1999.

Interests: Simulation of control systems, linear and nonlinear programming, control applications of optimization techniques, operating systems.

Andrzej P. Wierzbicki Professor (retired March 2004)

Optimization and Decision Support Division
room 24, tel. 6607750, 8255280
A.Wierzbicki@ia.pw.edu.pl

M.Sc. 1960, Ph.D. 1964, D.Sc. 1968 from WUT, titles of Professor of Optimization and Decision Theory awarded in 1975 and 1992.

With WUT since 1961, half time since March 1997. Deputy Director of the ICCE (1971-1975), Deputy Dean (1971-1972) and then Dean of FEIT (1975-1978) member of the Senate (1975-1978), member or chairman of many university commissions.

Since 1978 working with the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria and served (1979-1984) as the chairman of the Systems and Decision Sciences Program. Visiting prof. at the University of Minnesota, Minneapolis, MN, Brown University, Providence, RI (1970–1971), Kyoto University, Japan (1989-1990), Fernuniversitaet Hagen (1985) and Japan Advanced Institute of Science and Technology (2004-).

Director of the National Institute of Telecommunications in Poland (1996-2004). Chairman of the Commission of Applied Research of the State Committee for Scientific Research (KBN) (1991–1994). Chairman of the Consulting Panel for Promotion and Policy of Science of State Committee for Scientific Research (KBN) (1994-2000), Member of the Consulting Panel for Computer Infrastructure of Science KBN (1994-2000), Chairman of the Consulting Panel for International Scientific Cooperation of State Committee for Scientific Research (KBN) (2000-2004). Chairman of the Scientific Council of the Industrial Institute for Automation and Measurements (PIAP) (1991-2004), chairman of the Scientific Council of Scientific and Academic Computer Network NASK (1994-2004), and member of

the Scientific Council of Institute of System Research (IBS PAN) (since 1992). Member of the Committee of Automation and Robotics of Polish Academy of Sciences (PAN) (since 1970). Member of the Committee for Future Studies "Poland 2000+" PAN (since 1986, deputy chairman since 2000). Member and deputy chairman of the Panel for Cooperation with IIASA of PAN.

Member of the Polish Association for the Club of Rome. Member of Polish Mathematical Society (PTM) (since 1975) and of Society of Polish Electrical Engineers (SEP) (since 1970). Member of the Information Society Technology Advisory Group (ISTAG) of the European Commission (2000-2002). Recipient of George Cantor Award of the Int. Soc. of Multi-Criteria Decision Making for his results in multi-criteria optimization theory and decision support methodology (1992). Recipient of Tomasz Hofmokl Award of NASK for the promotion of informational society, 2005. Recipient of Best Paper Award at the Hawaii International Conference of Systems Science, 2005 for the paper: "Knowledge Creation and Integration: Creative Space and Creative Environments".

Interests: Optimization theory and algorithms, decision theory, decision support systems, negotiation methods and experiences, applications in telecommunication, information society issues, knowledge creation.

2.2 Senior Faculty

Piotr Arabas Assistant Professor (part-time)

Systems Control Division, Complex Systems Group
room 573, tel. 22 234 7126
P.Arabas@elka.pw.edu.pl

M.Sc 1996, Ph.D. 2004 from WUT

With WUT since 2002.

Interests: Hierarchical systems, predictive control, management of telecommunication services.

Rafał Cegieła Assistant Professor (on leave since September 2006)

Control and Software Engineering Division, Software Engineering Group
room 555, tel. 22 234 7997
R.Cegiela@ia.pw.edu.pl, www.ia.pw.edu.pl/~rcegiela

M.Sc. 1996, Ph.D. 2001 from WUT.

With WUT since 2001. Member of Information Systems Audit and Control Association (ISACA)

Interests: Software engineering, formal methods, IT project management and system audit.

Adam Czajka Assistant Professor (since April 2006, part-time)

Systems Control Division, Biometrics and Machine Learning Group
room 573, tel. 22 234 7126
A.Czajka@ia.pw.edu.pl, www.ia.pw.edu.pl/~aczajka

M.Sc. 2000, Ph.D. 2005 from WUT

With WUT since 2003. Assistant Professor at NASK Biometric Laboratories (2002–). Member of NASK Science Council (2006–). Member of IEEE (2002–). Secretary of the IEEE Poland Section (2006–)

Interests: Biometrics, pattern recognition, systems security.

Paweł Domański Assistant Professor (part-time)

Control and Software Engineering Division, Control Engineering Group
room 571, tel. 22 234 7861
P.Domanski@ia.pw.edu.pl

M.Sc. 1991, Ph.D. 1996 from WUT.

With WUT since 1991, half time since 1997.

Interests: Adaptive control, intelligent control, fuzzy logic.

Krzysztof Fleszar Assistant Professor (on leave since October 2005)

Operations Research and Management Systems Division
room 561, tel. 22 234 7123
K.Fleszar@ia.pw.edu.pl, www.ia.pw.edu.pl/~kfleszar

M.Sc. 2000, Ph.D. 2004 from WUT.

With WUT since 2003.

Interests: Combinatorial optimisation, scheduling and allocation, combinatorial auctions decision support, multi-dimensional optimisation.

Janusz Granat Assistant Professor

Optimization and Decision Support Division
room 25A, tel. 22 234 7640
J.Granat@ia.pw.edu.pl, www.ia.pw.edu.pl/~janusz

M.Sc. 1986, Ph.D. 1997 from WUT.

With WUT since 1987, chairmen of IFIP Working Group TC 7.6, Optimization-Based Computer Modeling and Design

Interests: Decision support systems, multicriteria decision analysis, data warehouses, decision support in telecommunication industry.

Jerzy Gustowski Senior Lecturer

Control and Software Engineering Division, Control Engineering Group
room 525, tel. 22 234 7699
J.Gustowski@ia.pw.edu.pl

M.Sc. 1979 from WUT.

With WUT since 1979.

Interests: Low level software for computer control, interfacing, single-chip microcomputers, PLC controllers.

Mariusz Kaleta Assistant Professor

Operations Research and Management Systems Division
room 561, tel. 22 234 7123
M.Kaleta@ia.pw.edu.pl

M.Sc. 2000, Ph.D. 2005, from WUT

With WUT since 2003.

Interests: Discrete optimization, operations research and management, decision support in energy market.

Mariusz Kamola Assistant Professor (part-time)

Systems Control Division, Complex Systems Group
room 573, tel. 22 234 7126
M.Kamola@ia.pw.edu.pl, www.ia.pw.edu.pl/~mkamola

M.Sc. 1997, Ph.D. 2004 from WUT.

With WUT since 2002.

Interests: Modeling and simulation, optimization, parallel computation, IP networks.

Andrzej Karbowski Assistant Professor

Systems Control Division, Complex Systems Group
room 572, tel. 22 234 7632
A.Karbowski@ia.pw.edu.pl, www.ia.pw.edu.pl/~karbowsk

M.Sc. 1983, Ph.D. 1990 from WUT.

With WUT since 1983. Research visitor, Politecnico di Milano and Universita di Genova, 1992, Edinburgh Parallel Computing Centre, 2000. Member of IEEE.

Interests: Large scale systems, distributed computations, optimal control and management in risk conditions, decision support systems, neural networks, environmental systems management, control and decision problems in computer networks.

Włodzimierz Kasprzak Professor

Systems Control Division, Robot Programming and Pattern Recognition Group
room 554, tel. 22 234 7866
W.Kasprzak@ia.pw.edu.pl, www.ia.pw.edu.pl/~wkasprza

M.Sc. 1981, Ph.D. 1987 from WUT, Dr-Ing. 1997 from Univ. of Erlangen-Nuremberg, D.Sc. 2001 from WUT.

With WUT since 1997. Member of Polish Section of IAPR.

Interests: Computer vision, speech recognition, pattern classification, signal analysis, artificial intelligence.

Zygmunt Komor Senior Lecturer

Control and Software Engineering Division, Control Engineering Group
room 571, tel. 22 234 7861
Z.Komor@ia.pw.edu.pl

M.Sc. 1964, Ph.D. 1976 from WUT.

With WUT since 1964.

Interests: Automatic control, control instrumentation design and implementation.

Urszula Kręglewska Senior Lecturer

Control and Software Engineering Division, Control Engineering Group
room 553, tel. 22 234 7121
U.Kreglewska@ia.pw.edu.pl, www.ia.pw.edu.pl/~ukreglew

M.Sc. 1973 from WUT.

With WUT in 1973–1993 and from 1994 to present, with Digital Equipment Poland 1993–1994.

Interests: Computer interfaces design.

Tomasz J. Kruk Assistant Professor

Systems Control Division, Complex Systems Group
room 530, tel. 22 234 7922
T.Kruk@ia.pw.edu.pl, www.ia.pw.edu.pl/~tkruk

M.Sc. 1994 from Technical University of Gdańsk. Ph.D. 1999 from WUT.

With WUT since 1999.

Interests: Operating systems, computer and network security, distributed systems.

Bartłomiej Kubica Assistant Professor (since September 2006)

Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
bkubica@elka.pw.edu.pl

M.Sc. 2001, Ph.D. 2006 from WUT.

With WUT since 2005.

Interests: Interval mathematics, optimization, numerical computations, queueing systems, probability, network management

Maciej Ławryńczuk Assistant Professor

Control and Software Engineering Division, Control Engineering Group
room 567, tel. 22 234 7673
M.Lawrynczuk@ia.pw.edu.pl

M.Sc. 1998, Ph.D. 2003 from WUT.

With WUT since 2003. Winner of "Gold chalk" ("Złota kreda") award

Interests: Process control and optimization, predictive control, neural networks, modelling.

Krzysztof Malinowski Professor (Head of Division)

Systems Control Division, Complex Systems Group
room 517, tel. 22 234 7397 and 8250995
K.Malinowski@ia.pw.edu.pl, www.ia.pw.edu.pl/~malinows

M.Sc. 1971, Ph.D. 1974, D.Sc. 1978, the title of Professor of Technical Sciences awarded in 1989, appointed to ordinary professorship in 1994.

With WUT since 1971. Director of ICCE (1984–1996), Dean of the FEIT (1996–1999), Director of the Center for Control and Information-Decision Technology (1993–2003). Member of the Senate of the Warsaw University of Technology (1993–2002), Chairman of the Senate Committee on Academic Staff (1993–1996 and 1999–2002), Chairman of Senate

Committee on Research (1996–1999), Director of the University Priority Research Program in Control, Information Technology, and Automation (PATIA) (1994–1999). Correspondent Member of the Polish Academy of Sciences (PAN) (since 1998), Member of the Warsaw Scientific Society (TNW), Member of Technical Sciences Group of the Ministry of National Education Expert Committee, Member of the Committee of Automation and Robotics of Polish Academy of Sciences (PAN), Vice Director (Research) of the Research and Academic Computer Network Institute (NASK), Chairman of the Scientific Council of the Industrial Institute for Automation and Measurements (PIAP), Member of the IFAC Technical Committees on Optimal Control and on Large Scale Systems.

Interests: Hierarchical control, model-based predictive control of nonlinear systems, applications of optimization, management and control of computer networks.

Piotr Marusak Assistant Professor
Control and Software Engineering Division, Control Engineering Group
room 567, tel. 22 234 7673
P.Marusak@ia.pw.edu.pl, www.ia.pw.edu.pl/~pmarusak

M.Sc. 1997, Ph.D. 2003 from WUT.

With WUT since 2002.

Interests: Predictive control of nonlinear systems, digital control algorithms, process modeling and simulation.

Ewa Niewiadomska-Szynkiewicz Assistant Professor (Leader of the Group)
Systems Control Division, Complex Systems Group
room 572, tel. 22 234 7632
E.Niewiadomska@ia.pw.edu.pl, www.ia.pw.edu.pl/~ens

M.Sc. 1986, Ph.D. 1995, D.Sc. 2005 from WUT.

Research Assistant at the Institute of Geophysics of Polish Academy of Sciences in (1987–1988), with WUT since 1988, NASK since 2001, IEEE Member.

Interests: Large scale systems, hierarchical control, computer simulation, computer aided control systems design, environmental systems management, decision support systems, distributed computations, global optimization, telecommunication systems.

Włodzimierz Ogryczak Professor (Head of Division)
Optimization and Decision Support Division
room 24, tel. 22 234 7750, 8255280
W.Ogryczak@ia.pw.edu.pl, www.ia.pw.edu.pl/~wogrycza

M.Sc. 1973, Ph.D. 1983 in Mathematics from Warsaw University, D.Sc. 1997 in Computer Science from PAN.

With Warsaw University, Institute of Informatics 1973–2000, with WUT since 2000. H.P. Kizer Eminent Scholar Chair in Computer Science at Marshall University, USA (1989-1992), visiting professor at Service de Mathématique de la Gestion of Université Libre de Bruxelles, Brussels, Belgium (1994-1995). Member of INFORMS, International Society of MCDM, GARP, Expert of The State Accreditation Committee.

Interests: Computer solutions and interdisciplinary applications in the area of operations research, optimization and decision making with the main stress on: multiple criteria analysis and decision support, decision making under risk, linear, network and discrete programming, location and distribution problems.

Andrzej Pacut Professor (Leader of the Group)

Systems Control Division, Biometrics and Machine Learning Group
room 522, tel. 22 234 7733
A.Pacut@ia.pw.edu.pl, www.ia.pw.edu.pl/~pacut

M.Sc. 1969, Ph.D. 1975, D.Sc. 2000 from WUT.

With Warsaw University of Technology since 1969, first with the Institute of Mathematics (until 1978) then with ICCE. Visiting Assistant Prof. at Lefschetz Center for Dynamical Systems of Brown University, Providence, RI (1980–1981), Visiting Associate Prof. at Oregon State University, Corvallis, OR (1984 and 1986–1991). Deputy Director of ICCE 1985–1986 and 1993–2005. Senior Member of IEEE, member of INNS (Int. Neural Networks Society). Vice Chairman (2001–2005) and Chairman (2006–) of the IEEE Poland Section. Member, Tech. Committee 182 of Polish Normalization Committee (PKN) (2003–), Head of the NASK Biometric Laboratories (2003–), member of NASK Science Council.

Interests: Learning systems, system identification, biometrics, neural modeling, neural networks.

Jerzy Paczyński Assistant Professor

Optimization and Decision Support Division
room 26, tel. 22 234 7862
J.Paczynski@elka.pw.edu.pl, www.ia.pw.edu.pl/~paczynsk

M.Sc. 1963 from WUT, M.Sc. in Mathematics 1973 from Warsaw University, Ph.D. 1974 from WUT.

With WUT since 1963. Deputy Director for Academic Affairs (1996–2005).

Interests: Modeling, modeling languages, transformations of formal languages — tools and applications, application of computer algebra and logic programming to systems theory and optimization.

Krzysztof Pieńkosz Assistant Professor

Operations Research and Management Systems Division
room 560a, tel. 22 234 7864
K.Pienkosz@ia.pw.edu.pl

M.Sc. 1984, Ph.D. 1992 from WUT.

With the Research Institute of Polish Gas and Oil Company 1984–1986, with WUT since 1986.

Interests: Operations research in particular discrete optimization, combinatorial algorithms, production planning and scheduling in manufacturing systems.

Grzegorz Płoszajski Assistant Professor

Operations Research and Management Systems Division
room 560a, tel. 22 234 7864
G.Ploszajski@ia.pw.edu.pl

M.Sc. 1968 from WUT, M.Sc. in Mathematics 1974 from Warsaw University, Ph.D. 1974 from WUT.

With WUT since 1969. Deputy Director for Information of the Main Library of WUT since 1996. Committee Member of 'Kasa Mianowskiego' since 2004.

Interests: Control and simulation of discrete production systems, production management, quality management, library automation, text algorithms, information retrieval.

Tadeusz Rogowski Senior Lecturer (part-time)

Optimization and Decision Support Division
room 530, tel. 22 234 7922
T.Rogowski@ia.pw.edu.pl

M.Sc. 1972 from WUT.

With WUT since 1972, Director of University Computer Center (1989-2002).

Interests: Computer network, programming languages, operating systems.

Andrzej Rydzewski Senior Lecturer

Systems Control Division, Robot Programming and Pattern Recognition Group
room 566, tel. 22 234 7649
A.Rydzewski@ia.pw.edu.pl

M.Sc. 1974 from WUT.

With WUT since 1974.

Interests: Design of digital systems and microprocessor-based control and measurement systems.

Krzysztof Sacha Professor (Leader of the Group)

Control and Software Engineering Division, Software Engineering Group
room 562, tel. 22 234 7756
K.Sacha@ia.pw.edu.pl, www.ia.pw.edu.pl/~sacha

M.Sc. (1973), Ph.D. (1976), D.Sc. (1996) from WUT.

With Minicomputer Research and Development Center ERA (1973), with WUT since 1976. Software Engineering Consultant for Industrial Automation Enterprize PNEFAL (1987–90), University of Groningen (1991–1992). Member of IEEE Computer Society and Section of Software Engineering of Polish Academy of Sciences (PAN). Member of the Senate of High School of Economy and Information Technology, Warsaw, Poland.

Interests: Software engineering, software quality evaluation, real-time systems, software specification and design methods.

Jerzy Sobczyk Senior Lecturer (part-time)

Optimization and Decision Support Division
room 519, tel. 22 234 7863
J.Sobczyk@ia.pw.edu.pl, www.ia.pw.edu.pl/~jurek

M.Sc. 1985 from WUT.

With WUT since 1984. FEIT Network Administrator.

Interests: Computer networks, programming languages, parallel and distributed programming, multi-criteria optimization.

Andrzej Stachurski Assistant Professor

Optimization and Decision Support Division
room 25a, tel. 22 234 7640
A.Stachurski@ia.pw.edu.pl, www.ia.pw.edu.pl/~stachurs

M.Sc. 1976, Ph.D. 1980 from WUT.

Senior Assistant (1979–80) and then Assistant Professor (1980–92) at the Institute of System Research (IBS PAN), with WUT since 1992. Visiting Professor at the Calabria University, Italy, 1984, Äbo Swedish Academy in Turku, 1987, Jyväskylä University, Finland, 1988, JSPS invitee at the Department of Control Engineering, Osaka University, Japan, 1988–89. Member of Polish Society of Operations and Systems Research. Author and co-author of many scientific papers and reports on optimization algorithms, identification, applications of optimizations in macro-economy modeling and optimal design problems in structural engineering. Co-author of a textbook "Podstawy optymalizacji" ("Foundations of Optimization") published in 1999. Reviewer of Control&Cybernetics, Optimization, Archives of Control Science, SIAM J. on Optimization, IEEE Concurrency.

Interests: Interests: nonlinear programming, large-scale optimization, applications to the optimal design problems in structural engineering, parallel and distributed calculations in Mathematical Programming.

Marcin Szlenk Assistant Professor (since July 2006)

Control and Software Engineering Division, Software Engineering Group
room 555, tel. 22 234 7997
M.Szlenk@ia.pw.edu.pl

M.Sc. 2000, Ph.D. 2006 from WUT

With WUT since 2005

Interests: Software modelling and verification, formal methods in software engineering.

Cezary Szwed Assistant Professor (until September 2006)

Operations Research and Management Systems Division
room 561, tel. 22 234 7123
C.Szwed@ia.pw.edu.pl

M.Sc. 1993 from WUT. Ph.D. 1999 from WUT.

With WUT since 1999. Member of Polish Electricity Association since 2004.

Interests: Operation research, timetabling, discrete optimization, combinatorial algorithms.

Wojciech Szynkiewicz Assistant Professor

Systems Control Division, Robot Programming and Pattern Recognition Group
room 554, tel. 22 234 7866
W.Szynkiewicz@ia.pw.edu.pl

M.Sc. 1985, Ph.D. 1996 from WUT.

With WUT since 1985. Deputy Director of the Research Center for Control and Information-Decision Technology (1999–2003).

Interests: Robotics, multiple robots coordination, robot sensor-based manipulation and motion planning, autonomous navigation, real-time systems.

Piotr Tatjewski Professor (Director of the Institute, Head of Division)

Control and Software Engineering Division, Control Engineering Group
room 521, tel. 22 234 7397 and 825 0995
P.Tatjewski@ia.pw.edu.pl, www.ia.pw.edu.pl/~tatjewsk

M.Sc. 1972, Ph.D. 1976, D.Sc. 1988, the title of Professor of Technical Sciences awarded in 2003

With Warsaw University of Technology since 1972. Head of Process Control Group since 1991, Deputy Director of ICCE for Academic Affairs (1987–1991), Director of ICCE since 1996. Head of the Undergraduate Degree Program in Computer Control Systems (1994-1996). DAAD scholarship in 1978 (TU Hanover), SERC research fellow at the City University, London (1986), visiting professor at the University of Birmingham (1992/1993). Member of Committee of Control and Robotics of Polish Academy of Sciences, Member of the Control and Robotics Section of the Scientific Research Council (KBN) 1997–2004. Member of Programme Committee of the Journal PAK, Expert of Ministry of Education and Science for Educational Standards

Interests: Multi-layer control systems, process control and optimization, predictive control, decomposition methods in optimization and control, soft computing methods.

Eugeniusz Toczyłowski Professor (Head of Division)

Operations Research and Management Systems Division
room 516, tel. 22 234 7950
E.Toczylowski@ia.pw.edu.pl

M.Sc. 1973, Ph.D. 1976, D.Sc. 1989 from WUT, the title of Professor of Technical Sciences awarded in 2004.

With WUT since 1973. Head of Operations Research and Management Systems Division, Vice-Dean of the Faculty of Electronics at WUT (1990–1993), chairman of the Rector's Committee for University Computerization (1993–1999), Advisor to the Dean on Strategic Planning (1993–1996). Head of the Undergraduate Program in Information Systems for Decision Support. Member of the Section on Decision Support (since 1992) and the Section on Knowledge Engineering and Operations Research (2003–) of the Committee of Automation and Robotics of Polish Academy of Sciences, Member of the Scientific Council of the Systems Research Institute (IBS PAN) (since 2002), Member of Consulting Council EnergoProject S.A. (2003–), Member of Steering Committee of the Energy Market (2003–).

Interests: Structural approaches to discrete optimization, operations research and management, management information systems, auction theory, competitive market design under constraints.

Tomasz Traczyk Assistant Professor (Deputy Director of the Institute since August 2005)

Operations Research and Management Systems Division
room 22/23, tel. 22 234 7750, 22 825 5280
T.Traczyk@ia.pw.edu.pl, www.ia.pw.edu.pl/~ttraczyk

M.Sc. 1984, Ph.D. 1992 from WUT.

With WUT since 1984.

Interests: Database management systems (DBMS), applications of DBMS in management and control, fourth generation languages, CASE methods, information systems, Web-based and distributed systems, XML language and its applications, variant configuration, software configuration management.

Wiesław Traczyk Professor

Optimization and Decision Support Division
room 523, tel. 22 234 7791
W.Traczyk@ia.pw.edu.pl

M.Sc. 1959, Ph.D. 1964, D.Sc. 1969 from WUT, the title of Professor awarded 1983.

With WUT since 1957, Vice-Dean of the Faculty of Electronics (1971–1975), Deputy Director (1975–1981) and Director of ICCE (1981–1984). Member of the Senate of Warsaw University of Technology (1981-1984), Chairman of the Senate Committee of Finances (1981-84). Professor of the University in Port Harcourt, Nigeria (1984-1987), Professor of the Institute of Telecommunications since 1997. Chairman of FEIT Committee for Ph.D. Degrees in Automatic Control and Computer Sciences (1990–2005). Head of ICCE Optimization and Decision Support Division (1997-2002).

Interests: Knowledge engineering, expert systems, artificial intelligence.

Michał Warchoł Senior Lecturer, part-time

Systems Control Division, Complex Systems Group
room 560, tel. 22 234 7665
M.Warchol@ia.pw.edu.pl, www.ia.pw.edu.pl/~warchol

M.Sc. 1991, Ph.D. 2002 from WUT.

With WUT since 1991.

Interests: Predictive control, synthesis of control systems, symbolic calculations, operating systems.

Paweł Wawrzyński Assistant Professor

Systems Control Division, Biometrics and Machine Learning Group
room 572a, tel. 22 234 7120
pP.Wawrzynski@elka.pw.edu.pl, www.ia.pw.edu.pl/~pwawrzyn

M.Sc. 2001 from WUT and 2004 from Warsaw University. Ph.D. 2005 from WUT.

With WUT since 2005.

Interests: Reinforcement learning, neural networks; modeling of memory, consciousness, and perception; adaptive control, learning robots.

Adam Woźniak Assistant Professor

Systems Control Division, Complex Systems Group
room 560, tel. 22 234 7665
A.Wozniak@ia.pw.edu.pl, www.ia.pw.edu.pl/~wozniak

M.Sc. 1970, Ph.D. 1975 from WUT.

With WUT since 1970. Advisor to the Dean of Faculty for Departmental Libraries (1987–1993 and 1999–2002), Member of WUT Library Council (since 1999), Member of WUT Committee for Student Admissions (2001-2002), Dean's Coordinator for Second-level Distance Learning (2005-).

Interests: Control of complex systems, servomechanisms, robot control, multi-criteria optimization, game theory, multiagent systems, decision support systems.

Andrzej Zalewski Assistant Professor

Control and Software Engineering Division, Software Engineering Group
room 555, tel. 22 234 7997
A.Zalewski@ia.pw.edu.pl

M.Sc. 1997, Ph.D. 2003 from WUT.

With WUT since 2002. Member of Information Systems Audit and Control Association (ISACA)

Interests: Software engineering, real-time systems, timing requirements, concurrent systems, performance analysis for computer systems, IT project economics.

Cezary Zieliński Professor (Deputy Director of the Institute since September 2006, Leader of the Group)

Systems Control Division, Robot Programming and Pattern Recognition Group
room 565, tel. 22 234 5102, 8255280
C.Zielinski@ia.pw.edu.pl, www.ia.pw.edu.pl/~zielinsk

M.Sc. 1982, Ph.D. 1988, D.Sc. 1996 from WUT.

With WUT since 1985. Research visitor at Loughborough University of Technology, UK (1990, 1992), Senior Fellow at Nanyang Technological University, Singapore (1999-2001), Secretary of Priority Research Program in Control, Information Technology, and Automation (PATIA) (1994-1999). Member of the Editorial Board of International Journal of Intelligent Mechatronics: Design and Production, Program Committee Member of PAK (Pomiary, Automatyka, Kontrola). Member of the Forecast Committee of the Polish Academy of Sciences: Poland 2000 Plus (2003–). Senior Member of IEEE (2002-). Vice Dean for Research and International Cooperation FEIT (2002–2005), Head of the Auditing Team of the Technological University Acreditation Committee (2003–), Head of ICCE Robot Programming and Pattern Recognition Group since 1996. Member of the board of EURON (European Robotics Network of Excellence). Deputy Director of ICCE for Research (2005–).

Interests: Robot programming methods, open-structure robot controllers, behavioral control, digital and microprocessor systems.

2.3 Supporting Faculty and Staff

Adam Czajka Assistant (until March 2006, part-time)

Systems Control Division, Biometrics and Machine Learning Group
room 573, tel. 22 234 7126
A.Czajka@ia.pw.edu.pl, www.ia.pw.edu.pl/~aczajka

(*for CV see p. 33*)

Adam Kozakiewicz Assistant (since December 2006, part-time)

Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
akozakie@ia.pw.edu.pl

M.Sc. 2001 from WUT.

With WUT since 2006.

Interests: Computer networks, distributed computation, network and systems security.

Włodzimierz Macewicz Senior Software Engineer

Control and Software Engineering Division, Software Engineering Group
room 525, tel. 22 234 7699
W.Macewicz@ia.pw.edu.pl, www.ia.pw.edu.pl/~wujek

M.Sc. 1983 from WUT.

With WUT since 1983.

Interests: Computer networks, data bases, operating systems, programming languages, text processing.

Marcin Szlenk Assistant (part-time, until July 2006)

Control and Software Engineering Division, Software Engineering Group
room 556, tel. 22 234 7124
M.Szlenk@ia.pw.edu.pl

M.Sc. 2000, Ph.D. 2006 from WUT

With WUT since 2005

Interests: Software modelling and verification, formal methods in software engineering.

Tomasz Śliwiński Assistant (part-time)

Optimization and Decision Support Division
room 26, tel. 22 234 7862
T.Sliwinski@ia.pw.edu.pl

M.Sc. 2000 from WUT

With WUT since 2004

Interests: Discrete optimisation, operations research, decision support.

Tomasz Winiarski Assistant (part-time)

Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
T.Winiarski.ia.pw.edu.pl

M.Sc. 2— from WUT

With WUT since 2004

Interests: Robot control systems, artificial intelligence.

Grzegorz Wójcik Lecturer (part-time)

Optimization and Decision Support Division
room 519, tel. 22 234 7863
G.Wojcik@ia.pw.edu.pl, www.ia.pw.edu.pl/~grzesio

M.Sc. 1994 from WUT.

With WUT since 1994, part-time since Feb. 1998.

Interests: Computer networks management, information systems.

Izabela Żółtowska Assistant (part-time)

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
I.Zoltowska@elka.pw.edu.pl, home.elka.pw.edu.pl/~imilenko

M.Sc. 2000 from WUT.

With WUT since 2005.

Interests: Operations, planning and economics of electric energy systems, optimization theory and its applications.

2.4 Ph.D. Students

Bartłomiej Anszperger Ph.D. Student (until March 2006)

Systems Control Division, Complex Systems Group

Supervisor: Krzysztof Malinowski

Krzysztof Bareja Ph.D. Student (since October 2006)

Optimization and Decision Support Division
room 556, tel. 22 234 7124
K.Bareja@elka.pw.edu.pl

Supervisor: Włodzimierz Ogryczak

Jacek Błaszczyk Ph.D. Student

Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
J.Blaszczyk@ia.pw.edu.pl

Supervisor: Krzysztof Malinowski

Marcin Chochowski Ph.D. Student

Systems Control Division, Biometrics and Machine Learning Group
room 518a, tel. 22 234 7805
mchochow@elka.pw.edu.pl, www.ia.pw.edu.pl/~mchochow

Supervisor: Andrzej Pacut

Cezary Chudzian Ph.D. Student

Optimization and Decision Support Division
C.Chudzian@elka.pw.edu.pl

Supervisor: Wiesław Traczyk

Zdzisław Dybikowski Ph.D. Student

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
Z.Dybikowski@elka.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Anna Felkner Ph.D. Student
Control and Software Engineering Division, Software Engineering Group
room 556, tel. 22 234 7124
A.Felkner@elka.pw.edu.pl

Supervisor: Krzysztof Sacha

Małgorzata Gadomska Ph.D. Student
Systems Control Division, Biometrics and Machine Learning Group
room 572a, tel. 22 234 7120
M.Gadomska@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Piotr Górczyński Ph.D. Student
Optimization and Decision Support Division
room 556, tel. 22 234 7124
P.Gorczynski@ia.pw.edu.pl

Supervisor: Andrzej P. Wierzbicki

Maciej Grula Ph.D. Student (since October 2006)
Control and Software Engineering Division, Software Engineering Group
room 556, tel. 22 234 7124
M.Grula@elka.pw.edu.pl

Supervisor: Krzysztof Sacha

Andrzej Igielski Ph.D. Student
Systems Control Division, Biometrics and Machine Learning Group
room 572a, tel. 22 234 7120
A.Igielski@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Radosław Kacperczyk Ph.D. Student (until February 2006)
Control and Software Engineering Division, Software Engineering Group
room 556, tel. 22 234 7124
R.Kacperczyk@ia.pw.edu.pl, untilMarch2006

Supervisor: Krzysztof Sacha

Przemysław Kacprzak Ph.D. Student
Operations Research and Management Systems Division
room 526, tel. 22 234 7125
P.Kacprzak@ia.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Piotr Kaczyński Ph.D. Student (since October 2006)
Control and Software Engineering Division, Control Engineering Group
room 567, tel. 22 234 7673
P.Kaczynski@elka.pw.edu.pl

Supervisor: Piotr Tatjewski

Michał Karpowicz Ph.D. Student

Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
M.Karpowicz@ia.pw.edu.pl

Supervisor: Krzysztof Malinowski

Tomasz Kornuta Ph.D. Student
Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
T.Kornuta@elka.pw.edu.pl

Supervisor: Cezary Zieliński

Adam Kozakiewicz Ph.D. Student (until February 2006)
Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
akozakie@ia.pw.edu.pl

Supervisor: Krzysztof Malinowski

Bartosz Kozłowski Ph.D. Student
Optimization and Decision Support Division
room 556, tel. 22 234 7124

Supervisor: Włodzimierz Ogryczak

Adam Krzemienowski Ph.D. Student (until February 2006)
Optimization and Decision Support Division
room 556, tel. 22 234 7124
akrzemie@ia.pw.edu.pl

Supervisor: Włodzimierz Ogryczak

Michał Kudelski Ph.D. Student
Systems Control Division, Biometrics and Machine Learning Group
room 572a, tel. 22 234 7120
M.Kudelski@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Piotr Kwaśniewski Ph.D. Student (since October 2006)
Systems Control Division, Complex Systems Group
room 573a, tel. 22 234 7860
P.Kwasniewski@elka.pw.edu.pl

Supervisor: Krzysztof Malinowski

Marek Majchrowski Ph.D. Student (since October 2006)
Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
M.Majchrowski@elka.pw.edu.pl

Supervisor: Cezary Zieliński

Andrzej Midera Ph.D. Student

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
A.Midera@ia.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Roman Bartosz Nowicki Ph.D. Student

Systems Control Division, Biometrics and Machine Learning Group
room 572a, tel. 22 234 7120

Supervisor: Andrzej Pacut

Fumio Adam Okazaki Ph.D. Student

Systems Control Division, Robot Programming and Pattern Recognition Group
room 556, tel. 22 234 7124
A.Okazaki@elka.pw.edu.pl

Supervisor: Włodzimierz Kasprzak

Piotr Pałka Ph.D. Student

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
P.Palka@ia.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Michał Pawluk Ph.D. Student

Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
mpawluk@elka.pw.edu.pl, www.ia.pw.edu.pl/~robotyka

Supervisor: Cezary Zieliński

Joanna Putz-Leszczyńska Ph.D. Student

Systems Control Division, Biometrics and Machine Learning Group
room 518a, tel. 22 234 7805
jputz@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Andrzej Ratkowski Ph.D. Student

Control and Software Engineering Division, Software Engineering Group
A.Ratkowski@elka.pw.edu.pl

Supervisor: Krzysztof Sacha

Mariusz Rogulski Ph.D. Student (until September 2006)

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
M.Rogulski@ia.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Piotr Rzepakowski Ph.D. Student (since October 2006)

Optimization and Decision Support Division
room 556, tel. 22 234 7124
P.Rzepakowski@elka.pw.edu.pl

Supervisor: Włodzimierz Ogryczak

Andrzej Sikora Ph.D. Student

Systems Control Division, Complex Systems Group
room 573, tel. 22 234 7126
A.Sikora@ia.pw.edu.pl

Supervisor: Krzysztof Malinowski

Kamil Smolira Ph.D. Student

Operations Research and Management Systems Division
room 526, tel. 22 234 7125
K.Smolira@elka.pw.edu.pl

Supervisor: Eugeniusz Toczyłowski

Maciej Staniak Ph.D. Student

Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
M.Staniak@ia.pw.edu.pl

Supervisor: Cezary Zieliński

Łukasz Stasiak Ph.D. Student

Systems Control Division, Biometrics and Machine Learning Group
room 518a, tel. 22 234 7805
lstasiak@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Tomasz Strąbski Ph.D. Student

Optimization and Decision Support Division

Supervisor: Włodzimierz Ogryczak

Marek Strzelczyk Ph.D. Student (until September 2006)

Control and Software Engineering Division, Control Engineering Group
room 567, tel. 22 234 7673
M.Strzelczyk@elka.pw.edu.pl

Supervisor: Piotr Tatjewski

Przemysław Strzelczyk Ph.D. Student

Systems Control Division, Biometrics and Machine Learning Group
room 518a, tel. 22 234 7805
pstrzelc@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Krzysztof Sztyber Ph.D. Student
Control and Software Engineering Division, Control Engineering Group
room 567, tel. 22 234 7673
K.Sztyber@ia.pw.edu.pl

Supervisor: Piotr Tatjewski

Piotr Trojanek Ph.D. Student (since October 2006)
Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
P.Trojanek@elka.pw.edu.pl

Supervisor: Cezary Zieliński

Rafał Wardziński Ph.D. Student
Systems Control Division, Biometrics and Machine Learning Group
room 518a, tel. 22 234 7805
rafal@elka.pw.edu.pl

Supervisor: Andrzej Pacut

Artur Wilkowski Ph.D. Student
Systems Control Division, Robot Programming and Pattern Recognition Group
room 556, tel. 22 234 7124
A.Wilkowski@elka.pw.edu.pl

Supervisor: Włodzimierz Kasprzak

Tomasz Winiarski Ph.D. Student
Systems Control Division, Robot Programming and Pattern Recognition Group
room 012, tel. 22 234 7117
T.Winiarski@ia.pw.edu.pl

Supervisor: Cezary Zieliński

2.5 Administrative and Technical Staff

Elżbieta Głowacka Secretary, Student affairs.
room 23, tel. 22 234 7750, 22 825 5280
E.Glowacka@ia.pw.edu.pl

Maria Graszka Office support.
room 23, tel. 22 234 7750, 22 825 5280
M.Graszka@ia.pw.edu.pl

Małgorzata Jaworska Finances support (until March 2006, part-time).
room 563, tel. 22 234 7122
M.Jaworska@ia.pw.edu.pl

M.Sc. 2001 from Łódź University.

Elżbieta Matyjasiak Secretary, Main office.
room 521, tel. 22 234 7397, 22 825 0995
E.Matyjasiak@ia.pw.edu.pl

M.Sc. 2002 from Warsaw School of Management and Marketing.

Jolanta Niedbało Office support (part-time).

room 527, tel. 22 234 7865
J.Niedbalo@ia.pw.edu.pl

Jadwiga Osowska Manager, Finances.

room 563, tel. 22 234 7122
J.Osowska@ia.pw.edu.pl

M.Sc. 1975 from WUT.

Agnieszka Paprocka Finances Support (since October 2006, part-time).

room 563, tel. 22 234 7122
A.Paprocka@ia.pw.edu.pl

Ryszard Tchórz Technical support.

room 559, tel. 22 234 7698

Beata Woźniak Manager, Administration.

room 521a, tel. 22 234 7397
B.Wozniak@ia.pw.edu.pl

M.Sc. 1993 from Warsaw University.

3 Teaching Activities – Academic Year 2005/2006

Course Title	**Course code**	**Hours per week**	**Class**	**Lecturer**
Administration of UNIX and TCP/IP	ASU	2 – 2 –	OSK, OT	J. Sobczyk
Algorithms and Data Structures	AISD1	2 – 1 –	sem. 3	A. Zalewski (spring)
Commercial Data Bases 2	KBD2	2 – – 2	BDSI, OT	T. Traczyk (spring)
Computer Networks	ECONE	2 1 1 –	ANGL, OT	J. Sobczyk (spring)
Computer Networks (I)	SKM	2 – 1 1	SKOR, OT	J. Sobczyk (fall)
Control	ECONT	2 1 1 –	ANGL, OT	R. Ładziński (spring)
Data Bases 2	BD2	2 – – 1	BDSI, OT	T. Traczyk
Decision Support	WDEC	2 – 2 –	MKPWD, OT, PP-SID	J. Granat
Decisions Under Competition Circumstances	DWW	2 – – 1	MKPWD, OT, PZ, PZ-I, PZ-SID	A. Woźniak (spring)
Decision Support Under Risk Conditions	WDWR	2 – – 1	PZ-I, OT	W. Ogryczak (spring)
Digital Circuits	EDC1	2 – 2 –	ANGL	C. Zieliński (spring)
Discrete and Network Optimisation	ODS	2 – – 1	PZ-I, PZ-A, PZ-O, OT	E. Toczyłowski (fall)
Distributed Operating Systems	RSO	2 – 1 –	PZ, OT, PZ-I, PZ-SID, PZ-ISI	T. Kruk (spring)
Dynamic Systems	EDYSY	2 – 2 –	ANGL, OT	R. Ładziński (fall)
Event programming (I)	PROZ	2 – – 1	ATP, OT	W. Kasprzak (fall)
Fundamentals of Control Systems	PSTE	2 – 1 –	sem. 4	P. Tatjewski (spring) K. Malinowski (fall)
Fundamentals of Digital Technology	PTCY	2 – 2 –	sem. 2	C. Zieliński (fall)
Fundamentals of Operation Research	POBO	2 – 1 –	sem. 4	K. Pieńkosz (spring) G. Płoszajski (fall)
Fundamentals of Optimization	POPTY	2 – 2 –	MKPWD, OT	A. Stachurski
Fundamentals of Parallel Computation	PORR	2 – – 2	SKOR, PZ-A, PZ-I	A. Karbowski
Fundamentals of Programming	PRI	2 1 2 –	sem. 1	J. Paczyński (spring)
Image and Speech Recognition	EIASR	2 1 – 1	ANGL., OT	W. Kasprzak (fall)
Image and Speech Recognition	ROSM	2 – – 1	PZ-P, ISO, OT, MUS	W. Kasprzak (fall)
Information Project Management	ZPI	2 – – 1	BDSI, OT	K. Pieńkosz
Intelligent Robot Systems	ISR	2 – 1 –	MUS, PZ-A, PZ-SID, OT	C. Zieliński (spring)
Introduction to Robotics	WR	2 – 2 –	MUS, SCRJC,OT	W. Szynkiewicz
Knowledge Engineering	IW	2 – – 1	ISO, OT	W. Traczyk
Methods of Artificial Inteligence	MSI	2 – – 1	ISO, PZ-P, PZ-O	C. Zieliński, A.Pacut W. Kasprzak (spring)
Numerical Methods (J)	MNUM	2 – – 1	PSTER, OT	P. Tatjewski
Numerical Methods	ENUME	2 – 2 –	ANGL, OT	P. Tatjewski (spring)
Object Oriented Programming	PROBE	2 – 2 –	sem. 2	W. Kasprzak (fall)
Operating System	EOPSY	2 1 1 –	ANGL, OT	T. Kruk (fall)
Software Engineering	IOP	2 – 1 –	OSK, OT	K. Sacha
Software Specification and Design	SPOP	2 – 1 –	OSK, PZ-SID, PZ-I, OT	K. Sacha
Management IT Systems	SIZ	2 – – 2	MKPWD, OT	J. Granat
Microcomputer Systems	SMK	2 – 1 –	SYK, OT	A. Rydzewski (spring)
Neural Networks	SNR	2 – – 1	ISO, PZ, PZ-I, PZ-SID, OT	A. Pacut (spring)

Course Title	Course code	Hours per week	Class	Lecturer
Operating Systems	SOI	2 – 2 –	OSK, OT	T. Kruk (fall)
Optimization and Decision Support	OWD	2 – – 1	PZ-A, PZ-I, OT	W. Ogryczak (spring)
Parallel Numerical Methods	EPNM	2 – – 2	ANGL., OT	A. Stachurski (fall)
Principles of Computer Science	EPCOS	2 – – –	ANGL, OT	W. Kasprzak (fall)
Process Automatization Techniques	TAP	2 – 1 –	MUS, PZ-A, OT	P. Tatjewski (fall)
Process Control	STP	2 1 – 1	PSTER, OT, SCRJC	P. Tatjewski
Process Management and Scheduling	ZAH	2 – 2 –	MKPWD, OT, MUS, PP-SID	E. Toczyłowski (spring)
Programmable Controllers	SP	2 – 1 –	MUS, OT	J. Gustowski (spring)
Programming 1	EPRO1	2 1 1 –	ANGL, OT	J. Paczyński (fall)
Programming 2	EPRO2	2 – 2 –	ANGL, OT	A. Stachurski (spring)
Real-time Systems	SCZR	2 – 2 –	PSTER, OT	K. Sacha
Synthesis of Decision Rules	SRD	2 – 2 –	MKPWD, MUS, OT, PP-SID	K. Malinowski (spring)
Theory of Optimization	TOP	2 – – 1	MKPWD, PZ-P, OT	W. Ogryczak (fall)
Uncertainty, Modeling, and Prediction	POZ	2 – – 1	MUS, OT, PP-SID	A. Pacut (fall)

Table explanations

Hours per week

The digits in a four-digit code denote number of hours per week of, consecutively: lectures, tutorials, laboratory hours and project hours (for instance, `[2 -1 1]` corresponds to two hours of lectures, no tutorials, one hour of laboratory and one hour of project per week).

Semester

symbol	level	description
OT	all levels	free electives
ANGL	all levels	taught in English
MUS	B.Sc.	specialization in Control Systems and Methods
MKPWD	B.Sc.	specialization in Computer Methods of Decision Support
BDSI	B.Sc.	specialization in Databases and Information Systems
OSK	B.Sc.	specialization in Computer System Programming
ISO	B.Sc.	specialization in Intelligent Computation Systems
PSTER	B.Sc.	specialization in Control
SKOR	B.Sc.	specialization in Computer Networks and Distributed Computations
ATP	B.Sc.	specialization in Programming Algorithms
SYK	B.Sc.	specialization in Computer Systems
SCRJC	B.Sc., M.Sc.	specialization in Control Systems
PZ-P	M. Sc., Ph.D.	advanced classes, fundamental
PZ-A	M. Sc., Ph.D.	advanced classes, control
PZ-I	M. Sc., Ph.D.	advanced classes, informatics
PZ-SID	M.Sc., Ph.D.	advanced classes, Decision and Information Systems
PP-SID	M.Sc., Ph.D.	fundamental classes, Decision and Information Systems

4 Projects

[PR1] Network of Excellence within EU FP6 IST FET 507728 **European Robotics Research Network of Excellence**, granting period: 01.05.2004 – 31.05.2008. Principal investigator from WUT: Cezary Zieliński. EURON II is the continuation of EURON I within FP6.

The objective of EURON (European Robotics Network) is the implementation and maintenance of a network of excellence within the 6th Framework Programme that enables the coordination of research and education, fosters the collaboration between academic and industrial institutions, encourages publications and conferences in the area of robotics. The aim is to provide the foundation that allows Europe to remain at the forefront of robotics both in terms of research and industrial products.

[PR2] Rector's grant 503R0040006 **Four legged walking robot**, granting period: 22.05.2006 -– 31.12.2006, Coordinator: ICCE. Principal investigator: Wojciech Szynkiewicz, Investigators: Michał Walęcki, Bartosz Markocki, Piotr Trojanek, Marek Majchrowski, Marcin Hamada.

The primary goal of this project was to develop a prototype version of a four-legged walking machine. The robot was design and assembled from readily available components. The mechanical part – comprised of a central body and four legs – was constructed out of aluminium for the strength to weight ratio of the material. Each leg has three degrees of freedom actuated by three servo motors, thus the total degrees of freedom of the robot is twelve. The robot controller hardware is based mainly on FPGA modules and a single-board RISC microcontroller. This prototype has progressed through the design and fabrication stages of development, and is currently in the early stages of testing.

[PR3] Deans's Grant 503G0042006 **Polish speech coders in speech analysis and synthesis**, granting period: 4.07.2006 -— 31.12.2006. Principal Investigator: Kasprzak Włodzimierz. Investigators from ICCE: Kasprzak Włodzimierz, Wilkowski Artur, Staniak Maciej, Investigators from ITele: Przemysław Dymarski, Artur Janicki, Sławomir Kula, Sebastian Wydra.

The research project was jointly performed by two research groups - one from the Institute of Control and Computation Engineering (ICCE) and one from the Institute of Telecommunications (ITele). The main motivation of this project was to equip robot agents with intelligent speech sensor and actuator capabilities. Our group from ICCE was engaged in the subject „Speech feature detection and coding in speech analysis". The group from ITele elaborated the subject: "Corpus speech synthesis of polish speech". We decided to apply the so called "mel cepstral coefficients" (MFCC) as the basis for our speech features. The feature vector consists of 26 coefficients, with 12 MFCC coefficients, one energy coefficients and 13 corresponding gradient coefficients. We have tested different combinations of MFCC -, energy- and gradients features to find the optimum set, by comparing command recognition qualities if applying different feature vectors. The next task was to make the features nearly speaker-independent. We studied the dependence of different phonemes from basic speaker frequency, so called F0. An appropriate feature normalisation scheme was proposed. Finally, a two-step clustering and vector quantization algorithm was proposed. In the first step the feature set is clustered into an exhaustive set of acoustic classes (corresponding to tri-phones), and their representatives are detected. In the second step, an integration of phonetic descriptions of speech samples, made by a human expert, with these acoustic classes is performed. Both speech

synthesis and speech analysis algorithms have been implemented in a C++ programming environment and they have been installed in the robot programming environment MRROC++ at ICCE.

[PR4] Dean's grant 503G0041006 **Object library of algorithms for dynamic optimization**, granting period: 04.07.2006 – 31.12.2006. Principal investigator: Krzysztof Malinowski. Investigator: Jacek Błaszczyk.

The aim of the project was to continue research on algorithms for dynamic optimization of large-scale problems supporting completion of advanced PhD thesis. In particular, method of sequential quadratic programming (SQP) with many replaceable modules (different quadratic programing solvers, matrix solvers and Hessian approximations) and method of nonlinear interior point based on utilisation of general purpose open source nonlinear programming (NLP) solver IPOPT were implemented in object oriented C++ library for solution of discrete-time optimal control problems, called OCT (Optimal Control Toolbox). The effectiveness and robustness of both mentioned algorithms have been carefully tested and compared using performance profiles methodology on significant set of optimal control test problems with large number of decision variables.

[PR5] MNiI grant 3 T11C 030 28 **Column Generation Technique in structural scheduling and decision support algorithms**, granting period: 24.05.2005 – 23.05.2006. Principal investigator: Eugeniusz Toczyłowski. Investigators: Tomasz Śliwiński.

The goal of the project was to develop models and algorithms for a group of difficult discrete optimization problems. The approach is based on a structural analysis of the problems towards application of Danzig-Wolfe decomposition and column generation scheme together with other optimisation algorithms. Effective solution procedures were found for such problems as: solving linear programs with the ordered weighted averaging objective, resource allocation with max-min fairness for mulicomodity network flows, unit commitment for power generation, scheduling multiple items of different types on a single flexible flow line and preemptive jobs scheduling on parallel machines with setup times and renewable resources.

[PR6] MNiI grant 3 T11A 005 28 **Multipurpose predictive control algorithms**, granting period: 17.05.2005 – 16.11.2007. Principal investigator: Piotr Tatjewski. Investigators: Paweł Domański, Maciej Ławryńczuk, Piotr Marusak.

The goal of the research is to develop structures and algorithms of multipurpose predictive control, in particular concerning optimizing predictive control and control in reconfigurable structures. The first topic concerns a case when dynamics of disturbances (uncontrolled process inputs) is comparable with dynamics of the controlled process, thus making classical multilayer approach not efficient. Closer cooperation or even integration of regulatory control and current set-point optimization is the subject of the research. The second topic is to develop design procedures leading to multipurpose reconfigurable predictive control, when both structure and parameters of the controller can be on-line adopted to the changes in control targets and/or external influences. The hierarchical approach is considered, with an intelligent supervisory unit. Related practically important case is when reconfiguration is triggered by occurrence of faults, leading to the design of fault-tolerant control systems. Versatility in formulation of predictive control algorithms makes on-line changes in their structure and parameters possible, adopting to the current process situation.

[PR7] MNiI grant no 4 T11A 003 25: **Control of Multirobot systems performing service tasks**, granting period: 15.11.2003 – 14.11.2006. Principal investigator: Cezary Zieliński. Investigators: Włodzimierz Kasprzak, Wojciech Szynkiewicz, Adam Woźniak,

Andrzej Rydzewski, Tomasz Winiarski, Maciej Staniak, Fumio Adam Okazaki, Krzysztof Mianowski (IAEAM), Marek Wojtyra (IAEAM), Witold Czajewski (ISEP).

The general objective of the grant was to create a service robot. Unlike industrial robots that operate in factories, hence in very structured environments and with very little interaction with human beings, service robots will have to operate in unstructured and to a certain extent unpredictable human ambient, moreover frequently interacting with people. To operate efficiently in such conditions service robots will have to posses similar capabilities that human beings have. Their sensing capabilities will have to include: vision, touch, feeling of exerted force and hearing. They must have that ability of two-handed dexterous manipulation. Last but not least, they must be highly reactive to sudden changes in the environment and be capable of reasoning, i.e. creation of action plans leading to the execution of the task at hand. Integration of all of the above components into a single complex system requires both adequate programming tools (e.g. a robot programming framework) and theoretical investigations showing what should be the proper structure of such a system. The operation of the constructed system was validated on the task of solving a Rubik's cube handed over by an operator.

[PR8] MNiI grant no 3T11C 005 27 **Models and algorithms for efficient and fair resource allocation in complex systems**, granting period: 20.10.2004 – 19.10.2007. Coordinator: ICCE. Principal investigators: Włodzimierz Ogryczak, Michał Pióro (IT), Eugeniusz Toczyłowski. Investigators: Krzysztof Pieńkosz, Krzysztof Fleszar, Mariusz Kaleta, Adam Krzemienowski, Tomasz Śliwiński.

The goal of the research is to develop theory and techniques concerned with quantitative analysis and decision support at the strategic, tactical and operational level of fair resource (or cost) allocation in various systems. Techniques for inequality measurement and equitable optimization algorithms as well as their use in decision support process represent the main algorithmic focus while the fairness of costs or profits allocation procedures within complex systems is major modeling issue of the research within ICCE. Fairness problems related to the telecommunication network design are analyzed by researchers from IT.

[PR9] MNiI grant no 1523/t11/2005/29 **Decision support optimization models for generation companies in energy market**, grant period: 05.12.2005 – 06.12.2006. Principal investigator:Eugeniusz Toczyłowski. Investigator: Izabela Żółtowska

The research provides optimization models that support thermal units scheduling and generation planning for energy producers operating in an electricity spot market. The models take into consideration possibility of submitting hourly block bids in a sequence of auctions that constitute the spot market, the uncertain energy prices and the thermal units production costs and technical constrains, as well as the financial and physical contracted obligations. Several multicriteria stochastic optimization models that consider producer's risk aversion degree were formulated: thermal units scheduling model, generation bidding model, aggregated scheduling model. Also a new model for determining the social welfare distribution for the multiperiod auction in the context of solving the unit commitment problems is formulated.

[PR10] MNiI grant no PBZ-MIN/011/013/2004 **Models of threats in the urban agglomeration within Crisis Management System, dedicated for Warsaw**, granting period: 29.06.2006 -– 29.06.2009. 11 research institutions. Coordinator Military University of Technology, Faculty of Cybernetics. Principal investigators from ICCE: Ewa Niewiadomska-Szynkiewicz, Krzysztof Malinowski. Investigators: Michał Karpowicz, Andrzej Sikora.

The general objective of the grant is to develop and implement the Crisis Management System (CMS) dedicated for urban agglomeration of Warsaw. The Expected results are: a set of threat models (e.g. predictive) and algorithms covering threats defined in the catalogue of urban threat, a demonstrable distributed software components of CMS for threat analyses supporting. A real urban threat is described by: a type of threat, a source of threat, critical infrastructures, possible losses, methods of counteractions, etc. The following type of threads are considered: military, chemical, biological, radiological, fire, flood, network infrastructures (service), terrorist, environmental catastrophes. The focus is on the synergy effect of complex threats. Due to the complexity of the system the distributed software environment is proposed as a simulation framework. The general idea of CMS software system is as follows: it will consist of autonomy of simulators in a wide and heterogeneous „open architecture" network, the event-driven, continues and astronomical time management will be considered. coherent simulation – same time and events for all software applications and users, reusability of simulators and other components. The simulator will be used to predict states or factors values for next periods and simulate the course and effects of terrorist action. The goal of ICCE team is to realize 18th task of the project: Prediction and simulation of floods of the Vistula river and crisis management in Warsaw during flood. The expected final result of this task is the component of CMS for flood modelling, simulation, prediction and decision support concerned with flood management in the agglomeration of Warsaw.

[PR11] MNiI grant 0290/t02/2006/30 **Analysis of integrated multi-product trade models in the distributed systems with area differentiated prices of goods and services based on the energy market**, granting period: 31,05.2006–30.05.2007. Principal investigator: Eugeniusz Toczyłowski. Investigator: Mariusz Rogulski.

The purpose of the project is to consider a security constrained balancing problem for joint balancing of the electric power and regulation reserves under presence of the security constraints, where the detailed requirements for transmission reserves in the distributed power network are directly taken into account. There are developed approximate optimization methods that provide efficient and fast solutions for this security constrained balancing problem.

[PR12] Statutory grant 504G036300: **Development of methodology of control, decision support and production management**, granting period 1.10.2005 – 31.12.2006 and 15.07.2006 – 31.12.2007. Principal investigators: Andrzej Pacut, Krzysztof Malinowski, Włodzimierz Ogryczak, Krzysztof Sacha, Piotr Tatjewski, Eugeniusz Toczyłowski, Cezary Zieliński.

5 Degrees Awarded

5.1 D.Sc. Degrees

Ewa Niewiadomska-Szynkiewicz
Symulacja komputerowa w analizie i projektowaniu złożonych systemów sterowania
Degree awarded on June 26, 2006

5.2 Ph.D. Degrees

Advisor: **Eugeniusz Toczyłowski**

Izabela Żółtowska
Modele optymalizacyjne wspomagania decyzji wytwórców na rynku energii elektrycznej
Degree awarded on December 19, 2006 (with honors)

Advisor: **Andrzej P. Wierzbicki**

Sylwester Laskowski
Wspomaganie procesu ustalania cen detalicznych i negocjacji stawek rozliczeniowych na konkurencyjnym rynku usług telekomunikacyjnych
Degree awarded on June 27, 2006

Advisor: **Piotr Tatjewski**

Sebastian Plamowski
Wdrażanie zaawansowanych układów regulacji w strukturze przełączanej
Degree awarded on June 27, 2006

Advisor: **Krzysztof Malinowski**

Bartłomiej Kubica
Optimization of Admission Control for Systems with Uncertain Parameters
Degree awarded on April 25, 2006

Advisor: **Krzysztof Sacha**

Marcin Szlenk
Formalna semantyka i wnioskowanie o pojęciowym diagramie klas w UML
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