Faculty of Computer and Information Science

University of Ljubljana

Survey of Activities in 2009

Contents

Prof. Dr. Franc Solina

Foreword

This booklet provides some basic information about the Faculty of Computer and Information Science of the University of Ljubljana. The Faculty is the leading institution in the field of Computer and Information Science in Slovenia. Since its first study program in computer science began in 1973, it has a lengthy roster of alumni, some of which achieved distinction in academic and business circles in Slovenia and abroad (Group "Alumni FRI" on www.linkedin. com). The Faculty has a number of active research groups that attract funding from various EU programs and bilateral state programs as well as funding from Slovenian and foreign industry.

Due to the high demand for graduates in the area of Computer and Information Science in Slovenia the Faculty has avoided the trend of declining enrolment as in some other engineering and science disciplines. The Faculty actively promotes the study of computer and information science by offering free summer workshops for high school students.

However, since the younger generations in Slovenia are smaller in size we have to attract promising students to our educational and research programs in the future from a larger geographical area. We offer new study programs designed according to the Bologna principles which enable a more interdisciplinary approach to computer science education and should help to make the exchange of students even easier.

In the age of globalization the Faculty faces increasing competition in all areas. In recent years we have expanded our research competence to a wider spectrum of promising technical areas by attracting experienced researchers and teachers. Further expansion will be possible only when the Faculty's most pressing problem will be solved – the shortage of space. The construction of the new Faculty building using European funds has already started in 2010 and is expected to be finished in 2013.

I hope that this booklet will forge new links to the international Computer Science community, which is a prerequisite for the Faculty to successfully continue its mission. I am inviting those readers who will find some interesting material in the booklet to establish contacts with our Faculty members.

Franc Solina
Dean and Professor of Computer and Information Science

About FRI

General Information

Dean **Prof. Dr. Franc Solina**
Associate Dean for Education **Prof. Dr.Radko Osredkar**
Associate Dean for Research **Doc. Dr. Janez Demšar**
Associate Dean for Development **Prof. Dr. Nikolaj Zimic**
Head of administration **Ivan Malešič, Nives Macerl** (from 1. 10. 2009)

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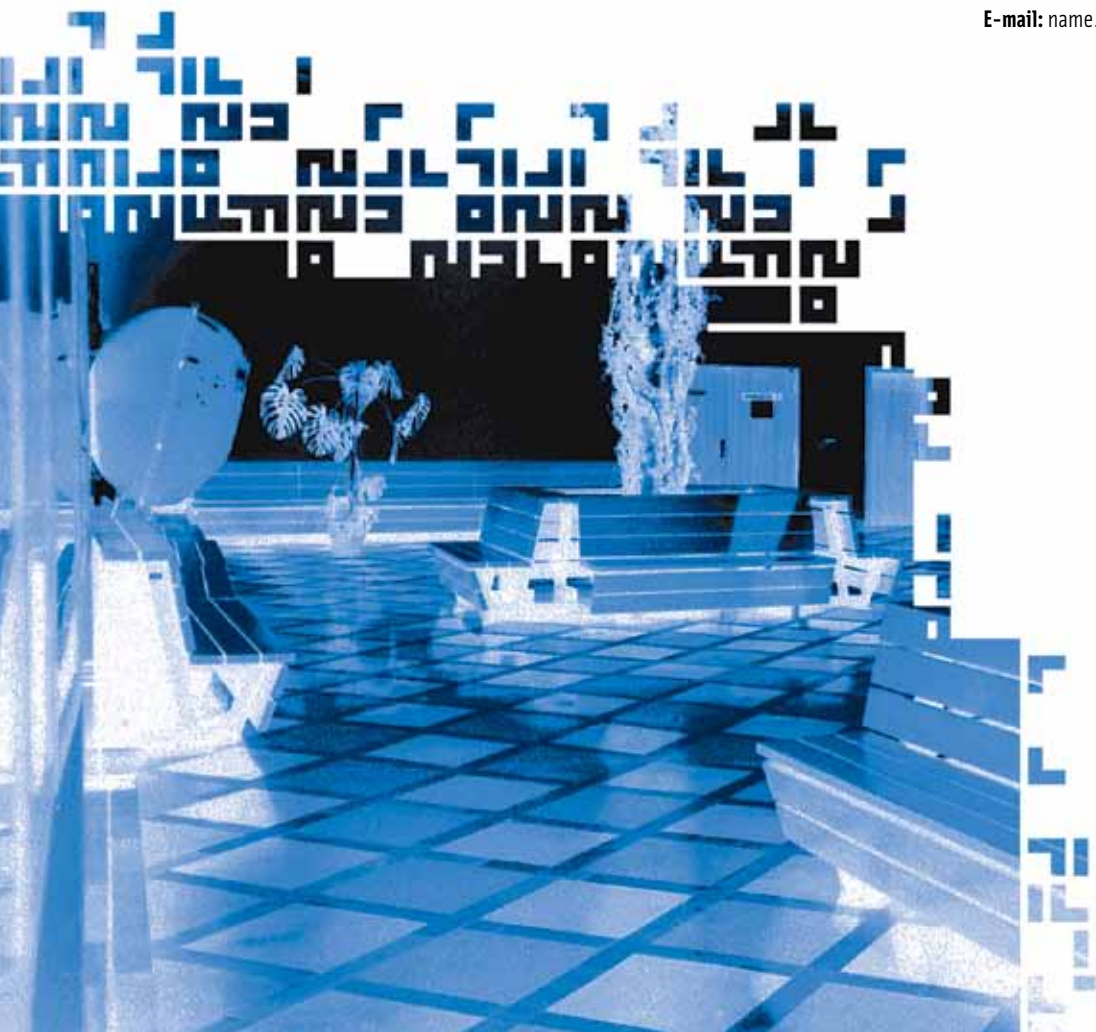Tržaška cesta 25
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FRI

The Faculty of Computer and Information Science was established in 1996 after the former Faculty of Electrical Engineering and Computer Science split up into two faculties. However, the undergraduate program in computer science at the University of Ljubljana was established in 1973, first as an elective program after the second year of electrical engineering study, and since 1982 as an independent four year program.

Up to now more than 1986 students have completed the undergraduate program in computer science and obtained university degree. At the graduate level more than 320 Master's degrees (M.Sc.) and 103 the Doctoral degrees (Ph.D.) in Computer and Information science have been awarded. Currently, there are about 1700 undergraduate and 120 graduate students at the Faculty. The Faculty has 137 employees, of which 120 are teaching and research staff.

The building which houses FRI is shared with the Faculty of Electrical Engineering. FRI has 7 teaching laboratories equipped with a total of about 135 networked personal computers and shares with the Faculty of Electrical Engineering 19 lecture halls. The research laboratories are equipped with about 530 personal computers or workstations. The Faculty's central computer serves as the main e-mail and web server. The Faculty's local network is connected to the Internet through the University of Ljubljana network, "Metulj" (Butterfly), and the Academic Research Network of Slovenia (ARNES). Practically all classrooms are covered by wireless network. The Faculty has a joint library with the Faculty of Electrical Engineering. It houses a large collection of books, textbooks and journals and offers access to several on-line services and databases. Both faculties also share a publishing department which is engaged primarily in publishing textbooks for students in the Slovenian language (original and translated).

How to Reach Ljubljana

BY AIR

The Ljubljana airport at Brnik is about 20 km North-West from the center of Ljubljana (see Figure 2). It has fairly good connections with other European airports (Frankfurt, Munich, London, Zurich, Copenhagen, Paris, etc.) and is by Adria, the national Slovenian air carrier, as well as number of other major European airlines.

BY PASSENGER CAR

Ljubljana is connected to all neighbouring countries with a good road system and visitors should not encounter problems on their trip.

BY AIR AND RAIL

Via Austria: By plane to Vienna, Graz or Klagenfurt airport and by train or car to Ljubljana (direct trains go twice daily on weekdays)

Via Germany: By plane to Munich and by train or car to Ljubljana (a direct train goes once every day)

Via Croatia: By plane to Zagreb and by train or car to Ljubljana

Via Italy: By plane to Venice or Trieste and by train or car to Ljubljana
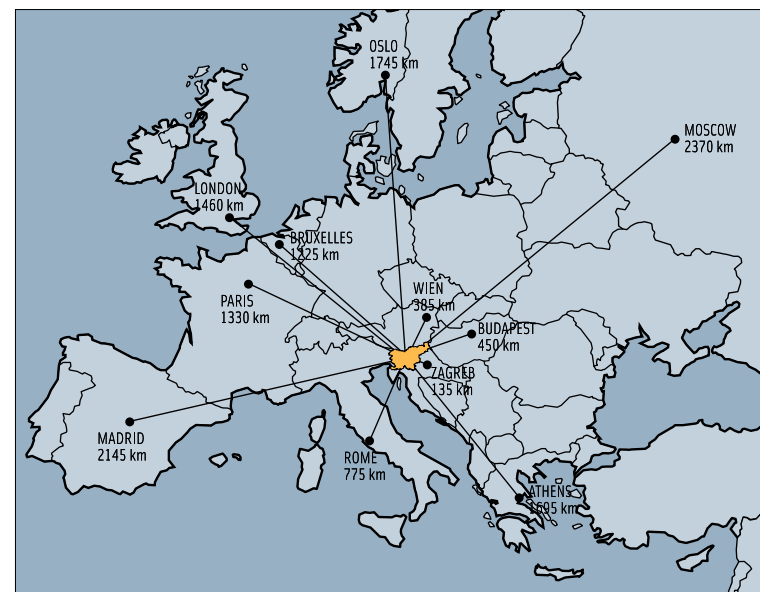
Figure 1: Slovenia in Europe
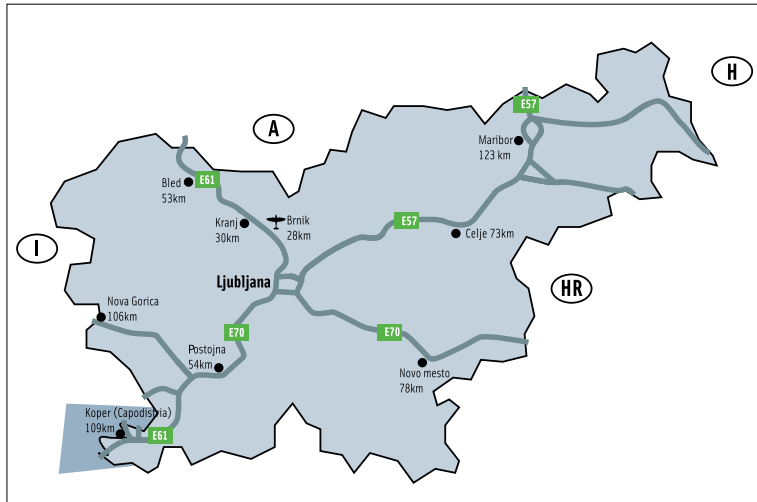
Figure 2: Map of Slovenia

BY RAIL

Ljubljana has good railway links with Austria (Vienna, Klagenfurt, Graz), Germany (Munich), Croatia (Zagreb, Rijeka), Hungary (Budapest) and Italy (Trieste). The above mentioned cities have good international connections with all of the large European cities. Traveling to Slovenia by rail from places further afield, is of course less comfortable and not necessarily cheaper than air travel.

Figure 3: Ljubljana – the Faculty is located within the highlighted area (detailed in Figure 4)

LOCATION OF FRI IN LJUBLJANA

FRI is located in the South-West of Ljubljana (Figure 3) within walking distance of most hotels in the center of Ljubljana. To reach the Faculty from the center take bus lines 1 (direction "Mestni log") or 6 (direction "Dolgi most"). How to reach FRI by car and where to park your car is shown in Figure 4.
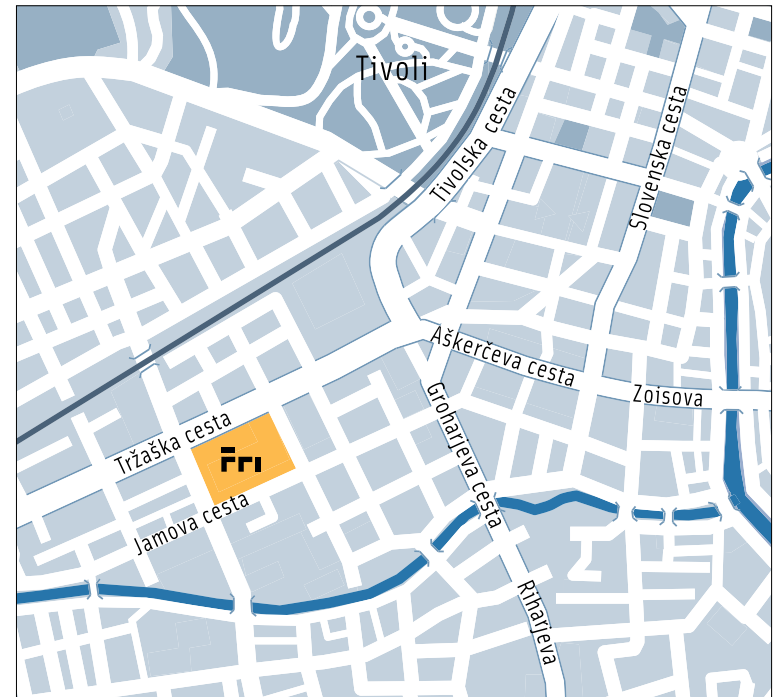
Figure 4: Detailed map of Ljubljana – the location of the Faculty is indicated by the highlighted yellow square

Educational Programs

The academic year at the University of Ljubljana consists of the fall and the spring semester. The courses in the fall semester begin on October 1st and last for 15 full weeks. The spring semester courses start in the second half of February and end in the beginning of June, according to the current academic calendar of the University of Ljubljana. There are three examination periods: winter (from the end of the fall until the beginning of the spring semester), spring (a full month after the spring semester) and fall (from mid August until the end of September). Courses consist of lectures, problem solving classes (tutorials), laboratory work, and independent work assigned to the students. All courses last one semester and the student course load per semester, according to the European Credit Transfer System (ECTS), is 60 ECTS. In most study programs the work load is uniformly distributed among the courses, the majority of the courses at all levels have 6 ECTS.

The Faculty of Computer and Information Science participates in several international educational programs, such as the European Union SOCRATES/ERASMUS program and the CEEPUS program which encourage student and teacher mobility between European universities. The study programs of the Faculty of Computer and Information Science are registered with the European Federation of National Engineering Associations (FEANI) and meet the criteria for the title EUR ING.

UNDERGRADUATE PROGRAMS

The Faculty of Computer and Information Science offers the following 3 year first degree programs,

- university study programme Computer and Information Science
- professional study programme Computer and Information Science
- interdisciplinary university study programme Computer Science and Mathgematics (together with the Faculty of Mathematics and Physics)
- interdisciplinary university study program Administrative Information Systems (together with the Faculty of Administration)

All four first degree programs began running in the academic year 2009 – 2010, when the first year courses were first offered. In the academic year 2010/2011 the full professional study program Computer and Information Science will be offered, while the university study programs will be introduced gradually in the following two academic years with the second year courses introduced in the academic year 2010/2011 and the third year course in the academic year 2011/2012.

At the second degree level, the following programs are or will be offered in the next academic years

- Computer in Information Science commencing in the academic year 2011/2012.
- interdisciplinary program Cognitive sciences, offered jointly with the Faculty of Education, Faculty of Medicine and the Faculty of Arts of the University of Ljubljana, and several other European universities (University of Vienna, Technical University in Budapest, University of Zagreb and Comenius University in Bratislava)

In addition to these new programs which follow the Bologna guidelines, three old undergraduate educational programs are still running. These programs will be gradually replaced by the yearly progression of the new programs in the following academic years. Accordingly, the second year courses of these programs were offered for the last time in the academic year 2009/2010. These programs are

- a four-year undergraduate program (six semesters of lectures, 15 weeks of work in industry, 6 months of Diploma thesis work), which leads to the degree "Dipl. Ing. of Computer and Information Science",
- a four-year "university" program (eight semesters of lectures, 6 months of Diploma thesis work), which leads to the degree "University Dipl. Ing. of Computer and Information Science", and
- a four year interdisciplinary "university" program (eight semesters of lectures, 6 months of Diploma thesis work), which leads to the degree "University Dipl. Ing. of Computer Science and Mathematics".

University study program computer and Information Science

The program leads to the degree "diplomirani inženir računalništva in informatike (UN)".

The first two years consists mainly of core-curriculum courses including mathematics and theoretical foundations of computer science, with one major elective course and one general elective course in the fourth semester. In the third year, elective modules including three courses each are offered. The student is required to choose two modules and, in addition, one general elective course.

The study program concludes with a diploma thesis with a work load of 6 ECTS in the last semester.

FIRST YEAR COURSES:

Semester	Title	ECTS
Fall	Introduction to Programming	6
	Calculus	6
	Discrete Structures	6
	Introduction to Digital Circuits	6
	Physics	6
Spring	Programming and Algorithms	6
	Linear Algebra	6
	Fundamentals of Databases	6
	Computer Communications	6
	Human-Computer Interaction	6

SECOND YEAR COURSES:

Semester	Title	ECTS
Fall	Algorithms and Data Structures	6
	Computer Systems Architecture	6
	Probability and Statistics	6
	Introduction to Artificial Intelligence	6
	Introduction to Information Systems	6
Spring	Theory of Informations and Systems	6
	Operating Systems	6
	Computer Systems Organization	6
	General elective	6
	Major elective	6

SECOND YEAR MAJOR ELECTIVES:

Title	ECTS
Mathematical Modeling	6
Principles of Programming Languages	6
Computer technologies	6

THIRD YEAR COURSES

Semester	Title	ECTS
Fall	Communication and Project Management	6
	Module 1, course 1	6
	Module 1, course 2	6
	Module 2, course 1	6
	Module 2, course 2	6
Spring	Economics and Entrepreneurship	6
	Module 1, course 3	6
	Module 2, course 3	6
	General elective	6
	Diploma thesis	6

ELECTIVE MODULES:

Information Systems
- Course 1: Electronic Business
- Course 2: Organization and Management
- Course 3: Business Intelligence

Management of Information Systems
- Course 1: Information Systems development
- Course 2: Data Management Technologies
- Course 3: Informatics Planning and Management

Software Engineering
- Course 1: Software Development Processes
- Course 2: Web Programming
- Course 3: Software Engineering

Computer Networks
- Course 1: Computer Networks Modeling
- Course 2: Communication Protocols
- Course 3: Mobile and Wireless Networks

Computer Systems
- Course 1: Digital Design
- Course 2: Systems Reliability and Performance
- Course 3: Distributed Systems Computer

Algorithms and System Utilities
- Course 1: Computational Complexity and Heuristic Programming
- Course 2: System Software
- Course 3: Compilers

Artificial Intelligence
- Course 1: Intelligent Systems
- Course 2: Machine Perception
- Course 3: Development of Intelligent Systems

Multimedia
- Course 1: Computer Graphics and Game Technology
- Course 2: Multimedia Systems
- Course 3: Introduction to Design

Professional study program Computer and Information Science

This is an application oriented study program leading to the degree "diplomirani inženir računalništva in informatike (VS)".

The first year consists of core-curriculum courses, while the remaining two years are structured so that the students can choose from of list of major electives according to their individual interests and preferences. The courses are grouped into semesters, and the student is required to choose a total of 5 courses corresponding to 30ECTS in each semester, respecting the required prerequisites for each course. The total work load of the program is 180 ECTS out of which 66 ECTS are mandatory courses, 90 ECTS are major electives, 12 ECTS are general electives, 6 ECTS is industrial practice and 6 ECTS is the diploma thesis.

The general electives are chose from the available study programs at the University of Ljubljana.

FIRST YEAR COURSES:

Semester	Title	ECTS
Fall	Introduction to Computer Science	6
	Programming I	6
	Computer Architecture	6
	Mathematics	6
	Discrete Structures	6
Spring	Programming II	6
	Databases	6
	Computer Communications	6
	Operating Systems	6
	Introduction to Probability and Statistics	6

SECOND YEAR COURSES:

Semester	Title	Prerequisites	ECTS
Fall	Algorithms and Data Structures I		6
	Electronic and Mobile Business		6
	Databases II		6
	Information Systems		6
	Graphic Design		6
	Communications Protocols and Network Security		6
	Computer Organization		6
	Digital Circuits		6
	Computer Graphics		6
	Artificial Intelligence		6
Spring	User Interfaces		6
	Compilers and Virtual Machines	Algorithms and Data Structures I	6
	Algorithms and Data Structures II	Algorithms and Data Structures I	6
	Testing and Quality	Algorithms and Data Structures I	6
	Information Systems Development	Information Systems	6
	Multimedia Content Production	Graphic Design	6
	Digital Signal Processing		6
	Web Technologies	Algorithms and Data Structures I, Communications Protocols and Network Security	6
	Input-Output Systems	Algorithms and Data Structures I	6
	Digital Logic Design	Computer Organization, Digital Circuits	6
	Data Mining	Algorithms and Data Structures I, Artificial Intelligence	6

THIRD YEAR COURSES:

Semester	Title	Prerequisites	ECTS
Fall	Project practicum		6
	Software Engineering	Algorithms and Data Structures I	6
	Information Systems Strategic Planning	Information Systems Development	6
	Multimedia Technologies	Digital Signal Processing	6
	Parallel and Distributed Systems and Algorithms	Algorithms and Data Structures I	6
	System Software	Algorithms and Data Structures I	6
	Process Automation	Input-Output Systems	6
	Embedded Systems	Input-Output Systems	6
	Robotics and Machine Perception	Input-Output Systems, Computer Graphics, Artificial Intelligence	6
	Game Technology and Virtual Reality	Algorithms and Data Structures I, Computer Graphics, Artificial Intelligence	6

Semester	Title	Prerequisites	ECTS
Fall	Decision Systems	Data Mining	6
	Numerical Methods		6
Spring	Industrial Practice		18
	Diploma Thesis		6

University study program Computer Science and Mathematics

This program is oriented towards theoretical computer science and topics in modern discrete and computational mathematics that are closely connected to it. The program leads to the degree "diplomirani inženir računalništva in matematike (UN)".

The first two years contain mandatory core-curriculum courses. The third year contains three mandatory courses, one elective module from the University program Computer and Information Science, major electives with a total work load of 5 ECTS and general electives with a total load of 10 ECTS. The study program concludes with a diploma thesis with a work load of 6 ECTS in the last semester.

FIRST YEAR COURSES:

Semester	Title	ECTS
Fall	Introduction to Programming	6
	Analysis 1	7
	Discrete Structures 1	6
	Introduction to Digital Circuits	6
	Linear algebra	10
Spring	Programming and Algorithms	6
	Fundamentals of Databases	6
	Analysis 2	7
	Discrete Structures 2	6

SECOND YEAR COURSES:

Semester	Title	ECTS
Fall	Algorithms and Data Structures	6
	Computer Systems Architecture	6
	Analysis 3	5
	Introduction to Artificial Intelligence	6
	Combinatorics	7
Spring	Optimization Methods	7
	Operating Systems	6
	Principles of Programming Languages	6
	Computer Communications	6
	Topics in Mathematics	5

THIRD YEAR COURSES:

Semester	Title	ECTS
Fall	Numerical methods	7
	Communication and Project Management	6
	Probability and Statistics	10
	Elective module, courses 1 and 3	12
Spring	Elective module, course 2	6
	Major elective	5
	General electives	10
	Diploma thesis	6

The major elective course is chosen from the following list of courses offered at the Faculty of Mathematics and Physics:

- General Topology
- Algebraic Curves
- Introduction to Geometric Topology
- Affine and Projective Geometry
- Coding Theory and Cryptography
- Financial Mathematics 1
- Game Theory
- Mathematical Modeling
- Numerical Methods II

The general elective courses are chosen from the study programs at the University of Ljubljana.

Doctoral programs

The Faculty of Computer and Information Science offers or participates in the following third degree programs leading towards the degree Doctor of Sciences.

- Computer and Information Science
- Interdisciplinary doctoral program Biosciences, offered jointly with the Biotechnical Faculty, Faculty of Electrical Engineering and the Faculty of Mechanical Engineering
- Humanistics and Social Sciences, offered jointly with the Faculty of Arts, and the Faculty of Social Sciences.

DOCTORAL PROGRAM IN COMPUTER AND INFORMATION SCIENCE

The doctoral program is comprised of

- three required courses
- two elective courses from computer and information science
- two elective courses from computer and information science or another courses offered at the University of Ljubljana
- five seminars

Year 1	Overview course	Elective course from CS	Elective course		Scientific Skills I	Seminar I
Year 2	Elective from CS	Elective course	Research work		Scientific Skills II	Seminar II
	Research work					Seminar III
Year 3	Research work					Seminar IV
	PhD dissertation preparation					Seminar V
	5 ECTS	5 ECTS	5 ECTS	5 ECTS	5 ECTS	5 ECTS

REQUIRED COURSES

The purpose of the **Overview course** is to verify whether the PhD student has a sufficient background in computer science and informatics, as covered by selected undergraduate courses and included in the standard US Graduate Record Examination Subject Test for Computer Science. The other two required courses are **Scientific Skills I** and **Scientific Skills II**, with topics like paper writing, writing project proposals, making good oral and poster presentation, copyright and patent law, ethics in science and similar.

ELECTIVE COURSES

The candidate chooses two of six available elective courses from the list.

- Architectures and algorithms for parallel computing
- Artificial Intelligence
- Computer Systems
- Informatics
- Selected Topics from Software Development
- Topics in Mathematics and Natural Sciences

The other two elective courses can be chosen from the above list, from some courses from the undergraduate study and from other courses offered at the University of Ljubljana.

SEMINARS

There are five seminars, one in each of the first five semesters of the study program. At these seminars the students present their work (e.g. papers, project proposals, posters, theses) to each other and to their mentors.

Research

Research activities (as well as most Diploma, Master and Doctoral theses research) at the Faculty of Computer and Information Science are performed in eighteen research laboratories which are organized in six groups.

The main sources of research funding are Slovenian Research Agency, the Ministry of Higher Education, Science and Technology, Ministry of Defense, European Union programs (COST, 6th and 7th FP), and various bilateral programs with the USA, France (Proteus), Austria, Czech republic, Norway, Portugal, Greece and UK (ALINK). The Ministry of Higher Education, Science, and Technology, together with Slovenian Research Agency also supports the majority of postgraduate students by means of individual scholarships. Many application projects are financed by Slovenian companies.

Besides being at the forefront of basic computer science, our researchers our active in a number of fields of potential interest to partners from industry and government, such as

- microcomputer systems, fuzzy and neuro-fuzzy controllers,
- process informatics and programmable technologies
- GRID technologies and parallel processing
- short SIMD processing
- intelligent RFID systems
- cryptography, security, privacy, digital identity management, intrusion detection
- digital libraries and multimedia information retrieval
- 3D design, visualization and animation, video editing
- e-learning environments
- numerical simulations of physical phenomena
- prototyping of transaction intensive systems
- design of people-focused software development methodologies based on best practices
- Service Oriented Architecture-based system integration
- fraud detection from transaction data (insurance companies, police, banking)
- data mining, machine learning, data visualization
- mobile robotics, applications of AI in robotics
- computer vision, visual cognitive systems
- biometry, human face detection and recognition
- object recognition and tracking in video streams, visual surveillance and forensic
- medical diagnosis and prognosis
- biomedical informatics, genomics, drug development
- biomedical computer systems and imaging

For more information consult the Web pages of individual laboratories (http://www.fri.uni-lj.si/en/laboratories/), or visit the web page with the list of current projects (http://www.fri.uni-lj.si/en/research/projects/)

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RESEARCH ACTIVITIES

Laboratory for Computer Graphics and Multimedia is involved in activities related to multimedia technologies, computer-based education and learning, human-computer interaction, multi-touch technologies, and virtual/augmented reality. The laboratory is a member of the international consortium CoLoS, together with 18 Universities around the world. The main area of interest of CoLoS consortium is computer supported conceptual learning of natural sciences.

The main ongoing activities in the laboratory are dedicated to researches in the following areas:

- digital libraries and multimedia information retrieval,
- standards and specifications for educational content,
- development of interactive educational content,
- e-learning environments and virtual laboratories.

Additionally, we are also active in the development of virtual and augmented reality applications, interactive learning systems, and didactic simulations and visualisation of natural phenomena.

In the past, members of the laboratory cooperated with other research groups in the development of military training systems, medical imaging applications, various simulation tools for computer supported industrial automation, including robotized environments, and computer supported quality control and management systems.

EQUIPMENT

The laboratory is well equipped with professional software tools for 3D design, visualization, animation, and video editing. Some presentation and videoconferencing equipment is also available. The laboratory has also built a multi-touch table, which is used for developing and testing alternative ways of human computer interaction.

RESEARCH PROJECTS

ASPECT: Adopting Standards and Specifications for Educational Content (ECP-2007-EDU-417008). European Project, Best Practice Network, eContentplus Programme, European Commission (2008–2011).

ETNOKATALOG: retrieval of semantic data from folk song and music, based on melodic and metro-rhythmic analysis (J6-0145). Basic Research Project, Slovenian Research Agency (2008–2011).

SAKE: Web Architecture as a Learning Technology for Constructivist e-Learning (3211-09-000541). Structural Funds Project, European Regional Development Fund and Slovenian Ministry of Higher Education, Science and Technology (2009-2010).

DIDIKTA: analysis and development of ICT usage didactics in teaching and learning (V5-0425). Target Research Programme, Slovenian Research Agency and Slovenian Ministry of Education (2008–2010).

MELT: a Metadata Ecology for Learning and Teaching (ECP-2005-EDU-038103). European Project, eContentplus Programme, European Commission (2006–2009).

LGM-1.jpg: Multi-touch table

SELECTED PUBLICATIONS

M. Marolt. Probabilistic Segmentation and Labeling of Ethnomusicological Field Recordings. Proceedings of ISMIR 2009, Kobe, Japan. 2009.

C. Bohak, M. Marolt. Calculating Similarity of Folk Song Variants with Melody-based Features. Proceedings of ISMIR 2009, Kobe, Japan. 2009.

M. Marolt. Non-Negative Matrix Factorization with Selective Sparsity Constraints for Transcription of Bell Chiming Recordings. Proceedings of Sound and Music Computing Conference 2009, Porto, Portugal. 2009.

M. Privošnik. Evolutionary optimization of emergent phenomena in multi-agent systems using heuristic approach for fitness evaluation. Proceedings of 2009 IEEE Congress on Evolutionary Computation, IEEE Press Piscataway, NJ, USA, pp. 1829-1834. 2009.

A. Kavčič. Informatization of learning and training in Slovenian armed forces. Proceedings of the Eurocon 2009, pp. 326-331. 2009.

A. Kavčič. Specifications and standards for use of educational digital content. Research, reflections and innovations in integrating ICT in education, Vol. 1, Badajoz: Formatex, pp. 577-581. 2009.

R. Dorn. Robotika v funkciji kulturne dediščine. Zbornik Osemnajste mednarodne elektrotehniške in računalniške konference - ERK 2009, 21-23. september 2009, Portorož, Slovenija. Ljubljana: IEEE Region 8, Slovenska sekcija IEEE, 2009, zv. B, pp. 237-240. 2009.

M. Marolt. A Mid-Level Representation for Melody-based Retrieval in Audio Collections. IEEE Transactions on Multimedia, December 2008, Vol.10, Issue 8, pp. 1617-1625. 2008.

S. Divjak. Conceptual learning of science and 3D simulations. Selected papers on hands-on science. pp. 170-175. 2008.

S. Divjak. Mobile phones in the classroom. HSCI 2008 : proceedings of the 5th International Conference on Hands-on Science, Formal and Informal Science Education, October 13th-17th, 2008, Espaço Ciência, Olinda-Recife, Brazil. H-Sci, cop. 2008, pp. 28-30. 2008.

J. Južna, A. Kavčič, S. Divjak. Metadata for electronic learning resources. Proceedings of the 10th International Multiconference Information Society IS 2007, 12 October 2007, pp. 194-198. 2007.

R. Timmers, M. Marolt, A. Camurri, G. Volpe. Listeners' emotional engagement with performances of a Scriabin étude: an explorative case study. Psychology of Music 34: 481-510. 2006.

A. Kavčič. Fuzzy User Modeling for Adaptation in Educational Hypermedia. IEEE Transactions on Systems, Man, and Cybernetics, Part C, November 2004, Vol. 34, No. 4, pp. 439-449. 2004.

M. Marolt. A Connectionist Approach to Transcription of Polyphonic Piano Music. IEEE Transactions on Multimedia, June 2004, Vol.6, Issue 3, pp. 439- 449. 2004.

M. Marolt. Networks of Adaptive Oscillators for Partial Tracking and Transcription of Music Recordings. Journal of New Music Research, Vol. 33, No. 1. 2004.

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RESEARCH ACTIVITIES

The laboratory is involved in basic research connected to biomedical signal and imaging data. The main research goals are summarized as following:

- understanding and describing the physiological phenomena,
- use of the computer in modeling and understanding of physiologic relationships,
- locally and remotely monitoring physiologic events, graphically displayed anatomic details and physiologic functions, visualizing and representing biomedical signal and imaging data,
- developing standardized databases to study physiologic mechanisms and to evaluate performance and robustness of recognition techniques,
- characterizing data, and establishing the detection criteria and recognition techniques to automatize as much as possible the analysis of bioelectric patterns, examinations, procedures, and medical practice, in order to improve the quality and reliability of the examinations,
- interpret the data and the results qualitatively and quantitatively,
- develop performance measures and protocols to evaluate detection techniques,
- develop biomedical information technologies and software.

The principal research topic currently underway is the development and evaluation of recognition algorithms for accurate detecting of transient ischaemic events and classifying true ischaemic events from non-ischaemic events in biomedical signal data using the LTST DB (Long-Term ST Database) of human-expert annotated ambulatory electrocardiogram (ECG) records.

The second research topic is maintaining, updating and distribution of standardized international reference-annotated ECG database LTST

DB. The database is result of a multinational research effort and contains 86 24-hour ambulatory recordings with a number of human-expert annotated transient ischaemic and non-ischaemic ST events. The database is intended to serve as a reference set in evaluating the performance of ST analyzers, and as a reference set to study physiologic mechanisms responsible for ischeamia. See: http://www.physionet.org/physiobank/database/ltstdb/ and http://www.physionet.org/challenge/2003/. From 2007 the database is publicly available. See also: http://lbcsi.fri.uni-lj.si/database/.

The next research topic is development of interactive graphic user interface editing tools (SEMIA – semi-automatic) to visualize, display and annotate long-term electrocardiograms. SEMIA, version 3.0.1, to view diagnostic and morphology feature-vector time series, and to examine human annotations of the LTST DB is under GNU General Public License and is available from http://www.physionet.org/physiobank/database/ltstdb/semia/.

The next research topic is the characterization of temporal patterns of transient ischaemic events and time-frequency representations of diagnostic parameters in ambulatory ECG signals. The goals are to differentiate physiologic mechanisms generating ischaemia and predicting impending ischaemia.

Another important contribution of the laboratory to the world community is interactive graphic tool EVAL_ST to evaluate performance and robustness of ischaemia analysers. The tool is under GNU General Public License and is available from http://www.physionet.org/physiotools/eval_st/.

Another research topic concerns comparison of various linear and non-linear signal processing techniques to separate uterine electromyogram (EMG) records of term and pre-term delivery groups with the final goal to predict pre-term delivery.

The Laboratory supports a Web mirror site (http://physionet.fri.uni-lj.si) for a part of Europe to the PhysioNet Web site (http://www.physionet.org) which is located at the Massachusetts Institute of Technology in Cambridge, USA. Maintaining of the PhysioNet Web site is supported by the U.S. National Institutes of Health. Physionet offers free access via the Web to large collections of recorded physiologic signals and related open-source software.

EQUIPMENT

Laboratory owns two high-speed electroencephalographic recording devices to record and monitor electroencephalogram (EEG) signals.

RESEARCH PROJECTS

Metabolic and inborn factors of reproductive health, birth (P3-0124), Slovenian Research Agency (2004–2009).
Metabolic and inborn factors of reproductive health, birth, II (P3-0124), Slovenian Research Agency (2009–2014).
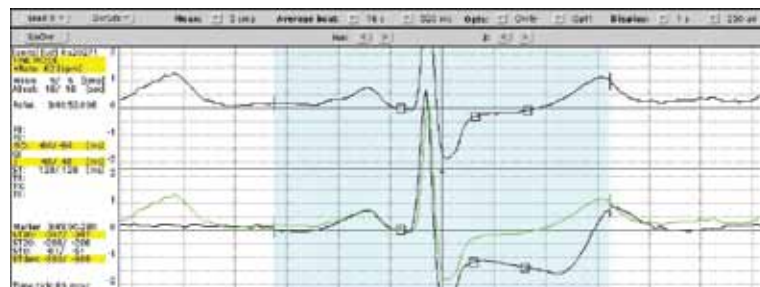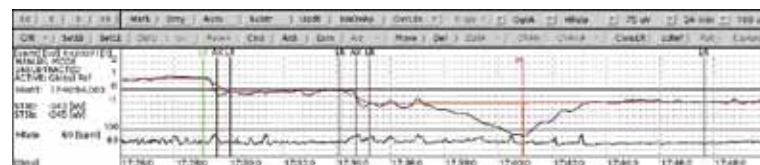
SEMIA, Version 3.0, semi-automated interactive graphic editing tool to annotate ambulatory ECG records.

RESEARCH VISITS

Franc Jager: Division of Health Sciences and technology, Laboratory for computational physiology, Massachusetts Institute of technology, Cambridge, USA, 10. 9. - 18. 9. 2009. Work on joint research topics, help in maintaining PhysioNet Web site (http://www.physionet.org).

SELECTED PUBLICATIONS

J. Faganeli and F. Jager. Automatic classification of transient ischaemic and transient non-ischaemic heart-rate related ST segment deviation episodes in ambulatory ECG records. Physiological Measurement, 31: 323-337, 2010.

G. Fele-Žorž, G. Kavšek, Ž. Novak-Antolič and F. Jager. A comparison of various linear and non-linear signal processing techniques to separate uterine EMG records of term and pre-term delivery groups. *Medical & Biological Engineering & Computing*, 46(9):911-922, 2008.

A. Smrdel and F. Jager. An algorithm to estimate the ST segment level in 24-Hour ambulatory ECG records. *Proc. Computers in Cardiology 2008,* 35:701-704, Bologna, Italy, 2008.

A. Smrdel and F. Jager. Diurnal Changes of the Heart Rate and Sympathovagal Activity for Temporal Patterns of Transient Ischemic Episodes in 24-hour Electrocardiograms. *EURASIP J, Adv. Signal. Process. 2007*, Article ID 32386, 10 pages, 2007.

F. Jager, G.B. Moody, R.G. Mark. Protocol to assess robustness of ST analysers: A case study. *Physiological Measurement*, 25:629-643, 2004.

A. Smrdel and F. Jager. Automated detection of transient ST-segment episodes in 24h electrocardiograms. *Medical & Biological Engineering & Computing*, 42:303-311, 2004.

R. Dorn and F. Jager. SEMIA: semi-automatic interactive graphic editing tool to annotate ambulatory records. *Computer Methods and Programs in Biomedicine,* 75:235-249, 2004.

F. Jager, A. Taddei, G.B. Moody, M. Emdin, G. Antolič, R. Dorn, A. Smrdel, C. Marchesi, R.G. Mark. Long-Term ST Database: A Reference for the Development and Evaluation of Automated Ischaemia Detectors and for the Study of the Dynamics of Myocardial Ischaemia. *Medical & Biological Engineering & Computing*, 41:172–182, 2003.

F. Jager, G.B. Moody, R.G. Mark. Detection of Transient ST-Segment Episodes During Ambulatory ECG-Monitoring. *Computers and Biomedical Research*, 31:305–322, 1998.

F. Jager. Guideliness for Assessing Performance of ST Analyzers. *Journal of Medical Engineering & Technology*, 22(1):25–30, 1998.

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RESEARCH ACTIVITIES

The main research topics include: soft computing, adaptive systems, parallel programming/processing, information theoretic modeling, and natural computing algorithms. Within these areas we are mainly focused on problems where the lack of theoretical knowledge prevents exact solutions and the size of the problems demands parallel programming and/or processing approach.

The first paradigm requires learning by examples and methods based on natural computing algorithms which comprise artificial neural networks, evolutionary algorithms, fuzzy logic and other biologically inspired algorithms. Current work focuses on natural based modeling of the sub-cell structures with Boolean networks.

For the second paradigm we focus on parallel cluster programming by using MPI and OpenMP libraries, and parallel processing within different Grid environments like Condor, Alchemi and Microsoft HPC Cluster. Recently we are involved in the programming of natural computing algorithms on graphical processors using NVidia CUDA tools and libraries.

RESEARCH PROJECTS

Synergy of the technological systems and processes (P2 – 0241). Basic Research Programme (with the Faculty of Mechanical engineering, University of Ljubljana) (2009-2013).

SELECTED PUBLICATIONS

Catarina Silva, Uroš Lotrič, Bernardete Ribeiro, Andrej Dobnikar: Distributed Text Classification with an Ensemble Kernel-based Approach, IEEE Transactions on System Man And Cybernetics, Digital Object Identifier: 10.1109/TSMCC.2009.2038280, 2010.

A. Dobnikar, B. Šter. Structural Properties of Recurrent Neural Networks. Neural Processing Letters, 2009

B. Šter, A. Dobnikar: Building internal maps of a mobile robot, In: X.-J, Jing (ed.): Mobile robots motion planning: new challenges, (Advanced robotics series).Vienna: I-Tech, cop. 2008, str. 503-516.

I. Jeras, A. Dobnikar: Algorithms for computing preimages of cellular automata configurations, Physica-D, 233: 95-111, 2007.

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U. Lotrič: Wavelet Based Denoising Integrated into Multilayered Perceptron. Neurocomputing, 62: 179-196, 2004.

B. Šter: An Integrated Learning Approach to Environment Modelling in Mobile Robot Navigation. Neurocomputing, 57: 213-238, 2004.

B. Šter, A. Dobnikar: Adaptive Radial Basis Decomposition by Learning Vector Quantization. Neural Processing Letters, 18(1): 17-27, 2003.

I. Gabrijel, A. Dobnikar: On-line identification and reconstruction of finite automata with generalized recurrent neural networks. Neural Networks, 16(1): 101–121, 2003.
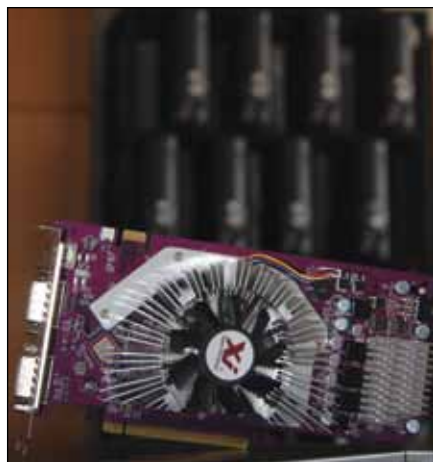
Graphic processing unit and computing cluster

Graphs of initial (left) and trained (center) fully recurrent neural network and speedups achieved on parallel architectures with respect to a standalone computer (right)

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RESEARCH ACTIVITIES

Research activities cover computer architectures, software-hardware co-design, parallel processing, embedded systems, programmable logic, radiofrequency identification and soft computing.

The main research work is dedicated to short SIMD processing and the integration of these new processing facilities into high-level programming languages. Currently, the most significant activities are development of syntax and semantics extensions to the ANSI C in such a way that we could use short SIMD processing facilities in C programming language and development of its vectorizing compiler which is capable to automatically extract short SIMD parallelism from loops. We call it MMC (multimedia C) language. We have also introduced a new data-dependence test for array references with linear subscripts. It is a simple method that can be used to filter out data dependences with a sufficiently large distance between memory references. By checking the distance between the memory references we can filter out data dependences that do not prohibit potential SIMD vectorization and that can be excluded from further, possibly more accurate and expensive, tests. The method is based on checking the minimum and maximum distances between two memory references within the iteration space rather than searching for the existence of an integer solution to the dependency equation. This results in greater accuracy and also in a reduction of the time cost as it computes only the bounds of an integer affine function.

The part of research work is directed toward the development of special computer hardware which, through its programmable ALU, is capable of performing custom selected functions. We are also developing an embedded system with two RISC microprocessors, which is implemented in field-programmable gate.

The latest research activities include studies of radiofrequency identification technology used in supply chain management, wireless tracking of objects to acquire the information used in classification

and prediction models. This part of research includes the use of neural networks, support vector machines and some other methods applicable in design of intelligent RFID systems.

RESEARCH PROJECTS

Medical Image Compression (BI-BA/10-11-026). Slovenian-Bosnian Bilateral Collaboration Project (with University of Banja Luka), Slovenian Research Agency (2010-2011).

RESEARCH VISITS

Mira Trebar: Coventry University, Faculty of Engineering and Computing, UK, 23.2.-6.3. 2009. Socrates/ Erasmus teaching exchange.

Mira Trebar: University of Wolverhampton, School of Computing and Information Science, UK, 23.3.2009-24.4.2009. Research collaboration including RFID technology and preparation of EU project proposal, PSP IST F2F.

SELECTED PUBLICATIONS

P. Bulić, T. Dobravec. An approximate method for filtering out data dependencies with a sufficiently large distance between memory references. *Journal of Supercomputing*, doi: 10.1007/s11227-009-0364-8, pp. 1-19, 2009.

P. Bulic, V. Gustin, D. Sonc, A. Strancar. FPGA-based Integrated Environment for Computer Architecture, *Computer Applications in Engineering Education*, accepted for publication, 2009.

Z. Babić, A. Avramović, P. Bulić. An Iterative Logarithmic Multiplier. *Electrotechnical Review*, accepted for publication, 2009.

P. Bulić, T. Dobravec. Ugotavljanje podatkovne odvisnosti za procesorje z naborom ukazov SIMD. *Electrotechnical Review*, vol. 76, no. 1-2, pp. 13-18, 2009.

M. Trebar, N. Steele. Application of distributed SVM architectures in classifying forest data cover types. *Comput. electron. agric.*, vol. 63, no. 2, 2008.

M. Trebar, Z. Šušterič, U. Lotrič. Predicting mechanical properties of elastomers with neural networks. *Polymer (Guildf.),* vol. 48, iss. 18, 2007.

V. Gustin, P. Bulic, Learning Computer Architecture Concepts with the FPGA-Based 'Move' Microprocessor, *Computer Applications in Engineering Education*, vol. 14, no. 2, 2006.

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P. Bulić, V. Guštin. An Extended ANSI C for Processors with a Multimedia Extension. *International Journal of Parallel Programming,* Vol. 31, No. 2, pp. 107–136. 2003.

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RESEARCH ACTIVITIES

Main research interests of laboratory members are distributed systems design and development: computing cluster, cloud and grid architectures, P2P and distributed systems and service oriented architecture with related technologies, network security and security policies, communication protocols formal validation and testing, computer networks design, mobile computing, agile methodologies in development of software and information systems.

In 2009, we have researched most actively the following areas:

■ In the area of distribute systems architecture, we have studied the system integration techniques with Service Oriented Architecture principles. We have studied usability of these architectures in digital identity management systems, in Enterprise Application Integration and in e-learning systems.

■ We have integrated EAI principles with Slovenian eGovernment initiatives in a model of information system for Slovenian Ministry of Higher Education.

■ In e-learning area, we began to build our virtual laboratory for teaching computer communication courses. The prototype consisting of eleven servers was used by 250 students, each of them with three virtual machines simultaneously. We are continuously improving the virtual lab and evaluating the students' feedback. At the same time we are researching the pedagogical aspects of introducing e-Learning in a cloud (e.g. Virtual Computing Lab) into the teaching process: we are researching and testing a cloud computing infrastructure that will enable our students to complete complex exercises that include multiple servers, diverse network topologies and other resources 24/7, regardless of their location.

Cloud computing physical infrastructure: servers, storage, Infinband switch

Virtual laboratory in a cloud: architecture

EQUIPMENT

Besides the typical office equipment, Computer Communications Laboratory is equipped with a few pieces of advanced networking / distributed systems hardware and software equipment. *Hardware*: one 20 Gb/s Infiniband DDR network switch, two 24-port and two 48-port Dell Gigabit Switches, a Dell Power Vault NAS 745 (4 x 500 GB), an IBM dual processor eServer xSeries 336 storage server with 3 TB of locally attached SCSI storage in an HP MSA-20 enclosure, one SuperMicro storage server with 12 TB of locally attached SATA storage, 11 Dell PowerEdge QuadCore R200 servers each with four Gigabit Ethernet ports and an Infiniband SDR 10 Gb/s connection, 4 Dell Power Edge DualCore Servers and 2 Dell PowerEdge Dual Processor servers, Wireless WiFi Access Points, various mobile devices, ActivCard SmartCard readers and smart cards.

Software: network management tools and utilities, Vmware virtualization tools, Nexenta and Openfiler storage appliance software, databases and development tools, SharePoint Portal Server, Microsoft development tools and utilities; several open-source Java development tools and utilities including Mobile Phone development utilities, …

RESEARCH PROJECTS

SAKE - Web Architecture as a Learning Technology for Constructivistic e-Learning. Together with Laboratory of Computer Graphics and Multimedia and Nil d.o.o., European Regional Development Fund, ESS and MVZT (3211-09-000541), 2009 – 2010.

System and information infrastructure at University of Ljubljana (S-731), Industry-Funded Project, University of Ljubljana (2005–2009).

Digital identity management at University of Ljubljana (V2-0382), Slovene Government-Funded R&D Project (2007–2009).

Enterprise Application Integration at University of Ljubljana, Industry-Funded Project, University of Ljubljana (2007–2010).

Model of information system for Slovenian Ministry of Higher Education (V2-0419), Slovene targeted research program, Government-Funded project, (2008-2009).

INVITED TALKS AND LECTURES

CIGLARIČ, Mojca: Digital identity management strategy. Zagreb: Faculty of Electrical Engineering and Computing, 28. 4. 2009. Invited talk organized by IEEE ComSoc Croatia Chapter and Zavod za telekomunikacijo FER-a.

SELECTED PUBLICATIONS

M. Ciglarič, A. Krevl, M. Pančur. Comparison of attacks on IPv4 and IPv6 protocols. V: SCHREURS, Jeanne (ur.). Euromedia'2009. Ostend: Eurosis-ETI, cop. 2009, str. 122-127.

M. Ciglarič, T. Kosar. Poslovni procesi in storitvena integracija: uporaba v slovenski javni upravi. V: HERIČKO, Marjan (ur.), ŽIVKOVIČ, Aleš (ur.), KOUS, Katja (ur.). Sodobne tehnologije in storitve : OTS 2009 : zbornik štirinajste konference, Maribor, 10. in 11. junij 2009. Maribor: Fakulteta za elektrotehniko, računalništvo in informatiko, Inštitut za informatiko, 2009, str. 17-26.

M. Bagić Babac, A. Babac, M. Ciglarič. Verifying Epistemic Properties of Multi-agent Systems via Action-based Temporal Logic Proc. International Conference on Intelligent Agents, Web Technology and Internet Commerce - IAWTIC'2008. December 2008. IEEE, cop. 2008.

A. Krevl, M. Ciglarič. A framework for developing distributed location based applications. Proc. 20th International Parallel and Distributed Processing Symposium, 2006, Rhodes Island, Greece. Piscataway: IEEE, 2006.

M. Ciglarič, A. Krevl, M. Pančur [et al.]: Security policies in military environments, in Dynamic Communications Management (pp. 19-1 – 19-8), Meeting Proceedings RTO-MP-IST-062. Neuilly-sur-Seine, France: RTO. 2006.

M. Ciglarič. Effective message routing in unstructured peer-to-peer overlays. IEE proc. Commun., October 2005, Vol. 152, No. 5, pp. 673-678.

M. Ciglarič, T. Vidmar. Problematika nestrukturiranih sistemov enak z enakim (Problems in unstructured P2P Systems). Electrotech. Review, 2005, Vol. 72, No. 4, pp 164-170.

M. Trampuš, M. Ciglarič, T. Vidmar. Formalizacija varnostnih politik (Security policy Formalization). Electrotech. Review, 2005, Vol. 72, No. 5, pp. 309-315.

M. Ciglarič. Content networks : distributed routing decisions in presence of repeated queries. *Int. j. found. comput. sci.*, 2004, Vol. 15, No. 3, pp. 555-566.

M. Pančur, M. Ciglarič, M. Trampuš, T. Vidmar. Towards empirical evaluation of test-driven development in a university environment. V: ZAJC, Baldomir (ur.), TKALČIČ, Marko (ur.). *The IEEE Region 8 EUROCON 2003: computer as a tool*: 22-24. September 2003, Faculty of Electrical Engineering, University of Ljubljana, Slovenia : proceedings. Piscataway: IEEE, cop. 2003, vol. 2, pp. 83-86.

Computer Structures and Systems Laboratory

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RESEARCH ACTIVITIES

The primary activities of the Computer Structures and Systems Laboratory are, besides teaching, devoted to scientific research and development projects with various industrial partners.

The principal scientific research directions of the laboratory are alternative processing platforms of the future. A lot of effort is dedicated to the research of Quantum Dot Cellular Automata. Our results were published in some of the most respectable journals in the field such as Nanotechnology. We have recently expanded our research to the field of processing in biological systems (synthetic biology). Our goal is to realize the basic logical primitives like memorizing cells and logical gates of different types with the aid of the National Institute of Chemistry of Slovenia. Our research activities in the field of the alternative processing methods are committed to fuzzy logic, especially fuzzy time, fuzzy automata, as well as implementation of different fuzzy algorithms, such as fire spread prediction models, fuzzy controllers for household devices, fuzzy animats etc. Our research activities are partially financed from European (ESF) partially from national research fund (ARRS).

In addition to the scientific research the members of the laboratory actively cooperate with different industrial partners. We offer them our knowledge in the field of fuzzy systems design, intelligent algorithms design, product optimization, efficiency analysis, reliability analysis, product development (hardware and software), etc. Our past industrial partners were Gorenje d.d., Iskratel d.o.o., Konel d.d., OurSpace d.o.o., ComLand d.o.o. We have also cooperated with government institutions such as General Hospital "dr. Franc Derganc," the Slovenian National Assembly, the Slovenian Ministry of Defense, etc.
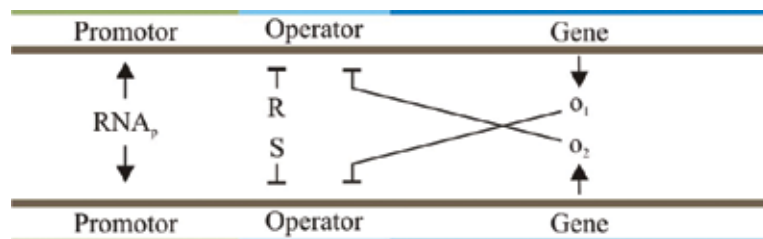
Two parts of DNA strand functioning as RS latch, where RNA_p represents RNA polymerase, R and S input proteins and o_1 and o_2 output proteins.

RESEARCH PROJECTS

Flexible display with an integrated communication module (TP MIR 07/RR/19), Industry-Funded Project, funded by OurSpace d.o.o. (2007–2009).

Analysis of MTBF determination and Selective QinQ implementation (S-619), Industry-Funded Project, funded by Iskratel d.o.o. (2009).

Pervasive computing (P2-0359), Research Programme, funded by Slovenian Research Agency (2009-2011).

Optimization of resiliency and fast convergence in the Ethernet network environment (03/FRI-IT/ES-2006), Industry-Funded Project, funded by Iskratel d.o.o. (2006–2009).

LABORATORY GUESTS

Dragomir Angelov, Technical University of Varna, Varna, Bulgaria, November 2008 – May 2009, Informatisation of industrial processes.

RESEARCH VISITS

Miha Mraz: Technical University of Graz, 24.8.-13.10.2009., Reliability of FSO systems.

Iztok Lebar Bajec: University of Rhode Island, Kingston, RI, USA, 15.10.-23.11.2009, Bio-Inspired Self-Organizing Systems.

INVITED TALKS AND LECTURES

Miha Mraz: Notes on reliability of FSO systems. 8.10. 2009, Technical University of Graz, Austria.

Iztok Lebar Bajec, Frank H. Heppner: Organized Flight in Birds, 10.11.2009, Robot Locomotion Group, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Boston, MA, USA.

Iztok Lebar Bajec: Fuzzy Logic for Modelling and Simulation of Group Behaviour, 17.11.2009, Department of Computer Science and Statistics, University of Rhode Island, Kingston, RI, USA.
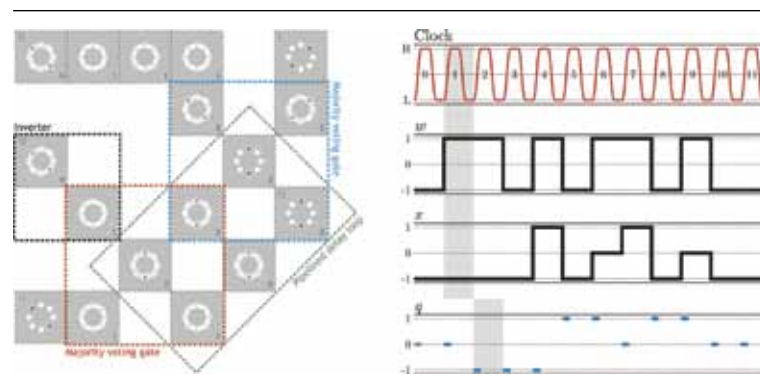
The balanced ternary quantum-dot cellular automata memorizing cell WX, with prerequisite w != 0, and the corresponding simulation results for the sequence of read/write operations: read, write (-1), write (-1), read, write (1), read, write (0), write (1), read, write (0), read, read

SELECTED PUBLICATIONS

I. Lebar Bajec, F.H. Heppner: Organized flight in birds, Animal behaviour, 78(4): 777-789, 2009.

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I. Lebar Bajec, N. Zimic and M. Mraz. The computational beauty of flocking: Boids revisited. *Mathematical and Computer Modelling of Dynamical Systems*, 13(4):331–347, 2007.

I. Lebar Bajec and M. Mraz. Multi-valued logic based on quantum-dot cellular automata. *International Journal of Unconventional Computing*, 3(4):311–322, 2007.

A. Jazbec, M. Mraz, I. Lebar Bajec, N. Zimic. Towards automated cooking process. *Food Research International*, 40(6):733–741, 2007.

I. Lebar Bajec, N. Zimic and M. Mraz. The ternary quantum-dot cell and ternary logic. *Nanotechnology* 17(8):1937–1942, 2006.

I. Lebar Bajec, N. Zimic and M. Mraz. Towards the bottom-up concept: extended quantum-dot cellular automata. *Microelectronic Engineering*, 83(4–9): 1826–1829, 2006.

N. Zimic and M. Mraz. Decomposition of a Complex Fuzzy Controller for the Truck&Trailer Reverse Parking Problem. *Mathematical and Computer Modelling*, 43(5–6):632–645, 2006.

I. Lebar Bajec, N. Zimic and M. Mraz. Simulating flocks on the wing: the fuzzy approach. *Journal of Theoretical Biology*, 233(2):199–220, 2005.

I. Lebar Bajec, P. Trunk, D. Oseli and N. Zimic. Virtual coronary cineangiography. *Computers in Biology and Medicine*, 33(3):293–302, 2003.
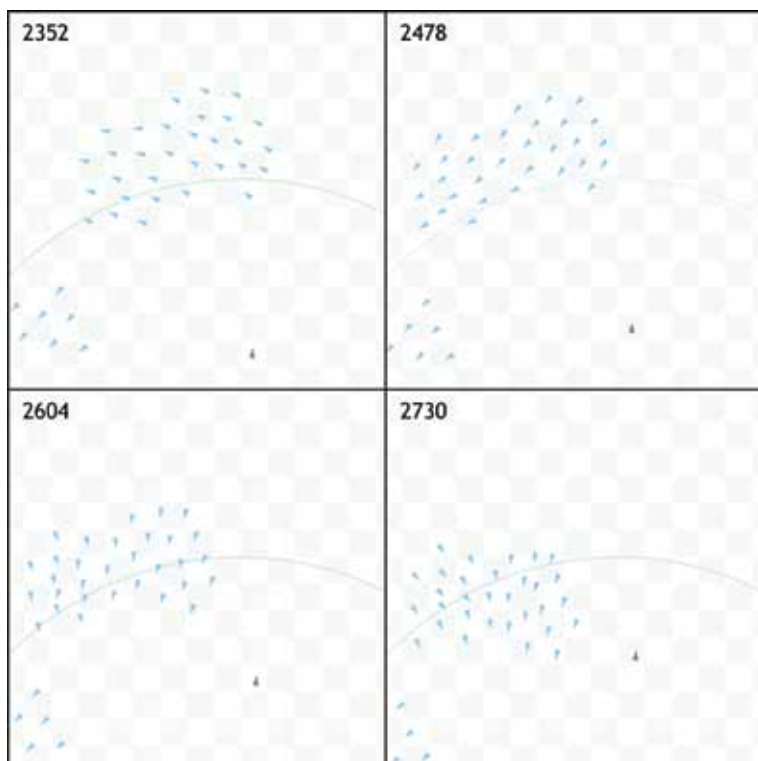
Fuzzy logic based bird flocking simulation displaying behaviour typical for pigeon flocks, where birds, while performing turns, change their position in the flock

M. Mraz. The design of intelligent control of a kitchen refrigerator. *Mathematics and Computers in Simulation*, 56:259–267, 2001.

J. Virant, N. Zimic and M. Mraz. T-type fuzzy memory cell. *Fuzzy Sets and Systems*, 102:175–183, 1999.

M. Mraz, N. Zimic and J. Virant. Intelligent bush fire spread prediction using fuzzy cellular automata. *Journal of Intelligent and Fuzzy Systems*, 7:203–207, 1999.

J. Virant and N. Zimic. Fuzzy automata with fuzzy relief. *IEEE Transactions on Fuzzy Systems*, 3(1):69–74, 1995.

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RESEARCH ACTIVITIES

The Information Systems Laboratory is involved in basic and applied research in the field of Information Systems. The following primary areas of research are currently being pursued:

Software Development Methodologies (SDM). Based on the *collaborative practice research* we strive to define the methodology and supporting tools for designing new or adapting existing SDMs. Specifically, we focus on the methodology socio-technical suitability to both organisation and project-specific requirements. From the topic two PhD theses have been developed. An approach for reengineering methodologies (Agile methodology framework) and supporting tools (Agile Methodology Toolset - AMT, see figure below) present the most important results of this research. We applied the approach in several Slovenian software companies like Marand, RCC-IRC Celje, Datalab, Comland, and IPMIT. We also developed Unified methodology for system development – EMRIS for Government Centre for Informatics and methodology for strategic planning for Telekom (Slovenian telephony operator).

IT/IS Strategy Planning. The strategy planning is one of the research areas that have been traditionally present in the Information systems laboratory since its existence. In the period from 2004 to 2008 we published several methodologies that focus on how to build strategic plans for information systems. The methodologies are based on many years of practical experiences in developing strategic plans for a range of organisations. We developed several strategic plans for the following organisations: KAD (financial institution), Elektro Ljubljana (electricity distribution operator), ELES (Slovenian electric

power transmission company), Slovenian electricity distribution operators association, Informatika, d.d., and Mobitel (Slovenian mobile telephony operator) In the context of IT/IS planning we focus our research on: IS/IT architectures, information systems reengineering, business process reengineering, electronic business, and COBIT and other standards.

Contemporary approaches to software development. In collaboration with software companies we do research on the maturity level of the new approaches to software development. Recently we have been focusing on: "Model-driven development", "Business-rule approach", and "Method engineering".

Mobile business and mobile applications. We explore different mobile applications models focusing on the research of the context-awareness and context-aware mobile application model. The results have been presented as the Methodology for developing mobile applications.

Intelligent Agents and Multi-Agent Systems. In this area we do research on the development of agents – autonomous entities capable of acting in its environment. The research encompasses: research on mutual communication among agents using ACL and use of rules in several aspects, modelling multi-agent systems, using agent oriented modelling languages (AML, AUML) and other agent based methodologies. We focus on utilization of intelligent agents and multi-agent systems for business systems and their information systems.

Semantic web and knowledge discovery. Research on Semantic Web as a next step in the evolution of the Internet is focused on ontologies, rules, rule engines and Semantic Web languages.

Data Mining applications and Decision Support Systems. Our areas of interest are innovative approaches for decision support. We combine research in this area with the research in the area of mobile applications and as result we do research on mobile decision support. We have also developed data mining decision support system based on Oracle Data Mining API and Engine. In the area of applied research we have created several strategic reports on different models of introduction of data mining to information systems.

IT governance. We actively analyse IT processes in different organisations. IT process analyses are performed with regard to COBIT model and ITIL standards. We also analyse efficiency of the informatics in the organisations and their business information architectures.

SOA – Service Oriented Architecture. Service-Oriented Architecture (SOA) is a collection of loosely-coupled, distributed services which communicate and interoperate via agreed standards. A service is a mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description. Services are independent and can run on different platforms. In this area we do research on how SOA focuses on business processes and how the information technology should support these processes with its main motivation to increase the capability of an organisation to address new business requirements

Screenshot of the AMT system

on the short term by reusing existing business logic and data models, thus incurring only minimal cost, resource, and time overheads, while minimizing risks, especially when compared to rewriting entire application systems. From the topic one PhD thesis is being developed. Due to difficulties with complex systems which have become very demanding from the point of view of integration and maintenance, it has become the prevalent paradigm for information system development. We developed IS reengineering and development of SOA based enterprise architecture for Slovenian electricity distribution operators association.

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D. Vavpotič and M. Krisper. An approach for rapid creation of a virtual software development team. V: Managing Worldwide Operations and Communications with Information Technology (IRMA 2007 Proceedings), Vancouver, 2007

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RESEARCH ACTIVITIES

Laboratory of e-media is actively involved in research of security, privacy and identity management with emphasis on cryptographic protocols, formal methods, and also security infrastructure systems like PKI, AAA systems and intrusion detection systems.

Besides, research activities of the laboratory cover qualitative and quantitative modeling of human factor, aiming at development of solutions that support decision making for management of information systems, in particular security policies. The basis for these activities are system approaches.

Results include patented cryptographic protocols that provide security in environments with limited system resources like smart cards and RFIDs. In addition, we are developing simulation models to support management of information systems security, and technological solutions for trust management in global networks. Further, our research results are published in renowned international journals (like those published by Elsevier and IEEE), and in monographs published by Springer and IGI Global.

Besides being involved in national projects, current international collaboration includes projects with Norwegian Computing Centre NR, and collaboration in COST ECONOTEL, COST AT and SEMPOC.

RESEARCH PROJECTS

COST IS0605 - A Telecommunications Economics COST Network - Econ@Tel, International Project (2007–2011).

COST Agreement Technologies (Action IC0801), International Project (2008–2012).

SEMPOC - Simulation Exercise to Manage Power Cut Crises (JLS/2008/CIPS/024), European Project, European Commission (2009–2011).

Pervasive computing (P2-0359), Research Programme, Slovenian Research Agency (2009–2011).

LABORATORY GUEST

Prof. Dr. Jose J. Gonzalez, University of Agder, 3. 9. – 9. 9. 2009, guest lecturing.

RESEARCH VISITS

Prof. dr. Denis Trček: University of Coimbra, Portugal, 1. 10. – 30. 10. 2009. Visiting professor.

David Jelenc: Norsk Regnesentral, Oslo, 7.12. – 14.12. 2009. Strengthening cooperation and presentation of the results of our work.

SELECTED PUBLICATIONS

TRČEK, Denis. Security metrics foundations for computer security. *Comput. j.*, 2009, str. 1-7, doi: 10.1093/comjnl/bxn094. [COBISS.SI-ID 1024172628]

TRČEK, Denis, KOVAČ, Damjan. Formal apparatus for measurement of lightweight protocols. *Comput. stand. interfaces.* [Print ed.], Feb. 2009, vol. 31, no. 2, str. 305-308, ilustr. [COBISS.SI-ID 2557399]

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RESEARCH ACTIVITIES

The Data Technology Laboratory was founded in 2009 and is the youngest laboratory at the Faculty for Computer and Information Science. Its members are involved in basic and applicative research in the fields of data analysis, data representation, data visualization and semantic web:

Data analysis: is a very broad research area. We focus on the segments of business rules management systems, business intelligence, fraud management and (social) networks. Research is divided between academic research and applicative research. Applicative research is closely connected to the fraud management field and transaction intensive information systems architectures.

Data representation: Data entities are typically represented in an ordinary flat form. However such representation is not adequate when we are interested in relations between entities or in patterns in these relations. In that case one must employ some enhanced representation of data like networks. Networks are the most natural representation of any relational domain (hyper pages, social networks etc.) allowing formulation of complex relations between entities. They allow analysis of entities in context of related entities and not in complete isolation. Networks are currently one of the hot topics in many research areas (network analysis, data mining, bioinformatics, etc.). Our research is mainly focused on analysis and mining of networks data and using networks for fraud detection in different fields.

Data visualization: As the volume and complexity of data increases it becomes very difficult for users to effectively explore large-scale datasets. A possible solution for this problem is visualization (graphical representation of data). Visualizing large amounts of data allows us to see patterns that may otherwise remain hidden and it allows us also to quickly grasp and process large amounts of data
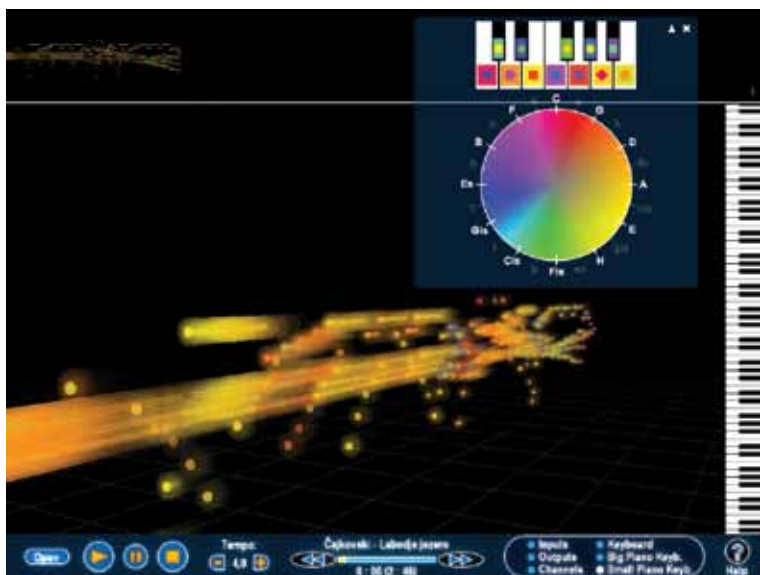
Realtime visualization of midi sequence

Group of related traffic accidents

that would otherwise require a lot of time to study. Visualizations are used in many fields (medicine, education, geovisualizations, data-mining, financial data analysis etc.) and employ different visualization techniques (graphs, cluster diagrams, volume rendering etc.), but just any arbitrary visualization might not be useful and may even lead to flawed conclusions. An important aspect of visualization is also dynamics of representation and interactivity (e.g. dynamical adjustment of mapping in real-time).

Semantic web: Current version of World Wide Web is consisted of several mutually connected documents that are presented to human users by computers. These documents originated in interconnected systems where every user could contribute. This also results in a fact that information quality cannot always be guaranteed. Current World Wide Web consists of data, information and knowledge, but the role of computers at this stage is only to deliver and represent the content of the documents that describe knowledge. To integrate different information resources users have to manually interpret these data. Semantic Web tends to improve current World Wide Web with computers processing, interpreting, integrating data on the web and with this approach aiding human users in discovering complex knowledge. Semantic Web is focused towards sharing and reusing of data and not documents. The research area emphasizes establishment of common framework to enable sharing and reusing data among applications and enterprises.

LABORATORY GUEST

Prof. dr. Veljko Milutinović, IEEE Fellow, University of Belgrade, School of Electrical Engineering, Concept Modelling for Knowledge Search.
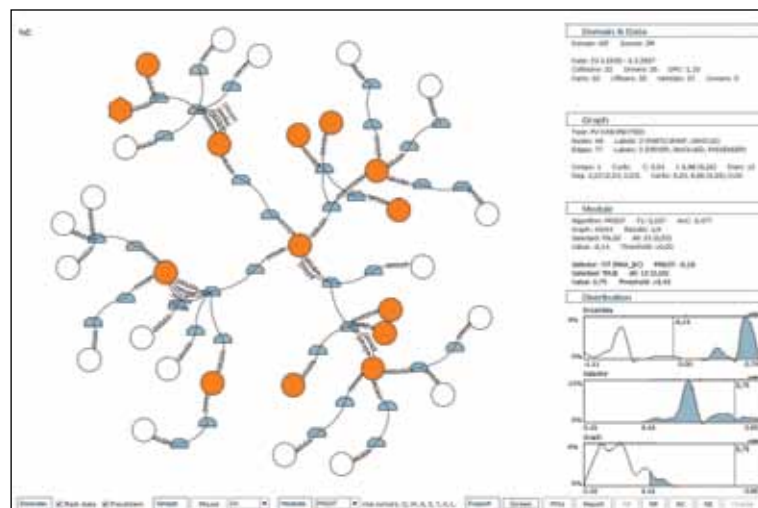
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B. Žvanut and M. Bajec. A tool for IT process construction. In: Information and software technology. Apr. 2010, vol. 52, no. 4, pp. 397-410.

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D. Lavbič and M. Krisper. Rapid ontology development. In: The 19th European-Japanese Conference on Information Modelling and Knowledge Bases, 2009, Maribor, Slovenia.

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RESEARCH ACTIVITIES

Staff members perform research in the areas of approximation and randomized algorithms, algorithms for problems in combinatorial optimization (routing, covering, and location problems, flexibility in optimization problems), parallel computation (mapping and scheduling, algorithms in parallel systems), grid computing (data replication on Data Grids, P2P-based distributed search), compiler design (parsing methods and attribute grammars), linear algebra (matrix multiplication), and operating systems design. As of 2006, the Laboratory is a member of the PlanetLab, an open platform for developing, deploying, and accessing planetary-scale services.

RESEARCH PROJECTS

Crisis Managment Simulator (M2-0217). Target Research Programme, Slovenian Research Agency (2007–2009).

Parallel and Distributed Systems (P2-0095). Research Programme, jointly with Jozef Stefan Institute and Faculty of Electrical Engineering, University of Ljubljana. Slovenian Research Agency (2009-2012).

SELECTED PUBLICATIONS

J. Mihelič, B. Robič. Flexible-attribute problems. *Computat. Optimiz. Appl.* (accepted for publ.)

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T. Ungerer, B. Robič, J. Šilc. A survey of processors with explicit multithreading. *ACM Comp Surveys* 35(1):29–63,2003.

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RESEARCH ACTIVITIES

The Laboratory for Architecture and Signal Processing is dedicated to research, undergraduate, and postgraduate education in computer architecture and digital signal processing. The laboratory is engaged in national and international research projects that include development projects for the industry. The following areas of research are currently being pursued:

1. In Computer Architecture: Design and development of special-purpose computers, both hardware and software. Comparative studies of superscalar and VLIW processors. DSP processor design and architecture. Cache replacement and coherence preservation strategies. Input/output architectures. Integrated entertainment and automation systems for "smart home" houses.

2. In Digital Signal Processing: Design and development of algorithms, hardware and software. Complexity of integer minimax approximation problem. Theoretical aspects and performance bounds for finite wordlength digital filters. In particular, bounds for minimax integer polynomial approximation over collections of non-overlapping intervals are investigated. A general purpose finite wordlength FIR design program was developed during the course of this work. Various applications of DSP processors are studied and implemented. Among them is a low-cost DSP processor based spectrum and vibration analyzer that is now in production.

3. In Speech Processing: Speech recognition over telephone lines. Trainable high quality speech synthesis. Considerable experience from collaboration in the COST-232 European project has been acquired. The laboratory contributed to the collection of the European multi-English database. In the framework of a project with the Slovenian Telekom one of the first real-time systems for speaker-independent recognition of Slovenian digits and control words over the telephone has been developed. A national database of 780 speakers from all across Slovenia has been collected. A new technique that uses asymmetrical window functions for feature extraction and dynamically adjusted window length was tested and implemented.

RESEARCH PROJECTS

ARM9 microcomputer system - education tool for computer science students. Industry funded-project with Asyst Electronic Ltd. (2007-2009).

Parallel and Distributed Systems (P2-0095). Research Programme, jointly with Jozef Stefan Institute and Faculty of Electrical Engineering, University of Ljubljana. Slovenian Research Agency (2009-2012).

SELECTED PUBLICATIONS

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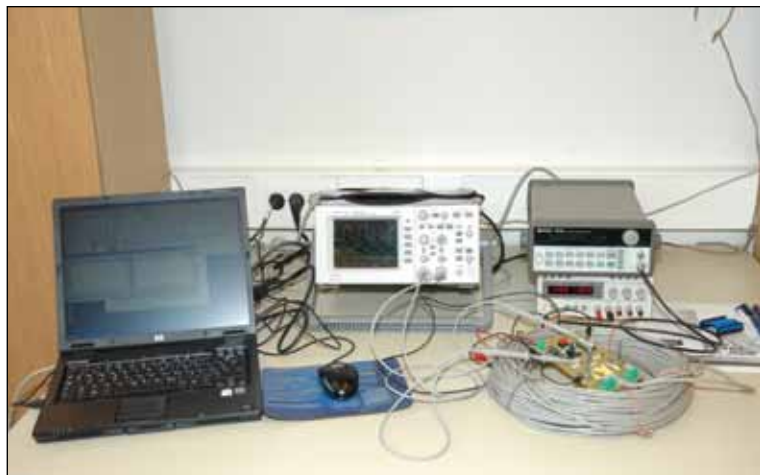
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D. M. Kodek and K. Steiglitz. Comparison of optimal and local search methods for designing finite word length FIR digital filters. *IEEE Transactions on Circuits and Systems,* CAS-28, pp. 28-32, 1981.

D. M. Kodek. Design of optimal finite wordlength FIR digital filters using integer programming techniques. *IEEE Trans. on Acoustics Speech and Signal Processing*, vol. ASSP-28, no. 3, pp. 304-308, June 1980.

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RESEARCH ACTIVITIES

The Software Engineering Laboratory is involved in teaching and research in the areas of Software Engineering and Information Systems with an emphasis on Software Quality Management, Software Metrics, Information Systems Development, Information Systems Audit and Control, Data Warehousing, and Graph Grammars. The staff has recently worked on two international projects within the EC TEMPUS and INCO-COPERNICUS programs, as well as on several development projects for the industry. The following areas of research are currently being pursued:

1. In Software Quality Management: Comparative studies of different software quality models (CMMI, ISO 9000 family of standards, SPICE, Bootstrap etc.). Adaptation of CMMI to the needs of small organizations. Personal and Team Software Process.

2. In Software Metrics: Different approaches to software measurements (e.g. GQM, bottom-up). Measuring performance of agile software development methods. Definition of appropriate metrics for the development of applications in a database environment.

3. In Information Systems Audit and Control: Investigation of systematic approaches (such as COBIT) to IT control and audit in order to help IT professionals in developing and maintaining information systems that would satisfy fiduciary, security and quality requirements.

4. In Information Systems and Data Warehouses: Agile methodologies for information systems development. Development of administrative and management information systems for higher education institutions. Information quality assessment and improvement.

e-Študent: web-based student records information system

5. In Graph Grammars: Graph grammars as a generalization of textual grammars. Parsing graph grammars and translating graph-based languages. Using developed theory and tools for solving relevant problems in various computer science domains. *6. Web User Behavior Analysis:* Using stochastic model for user behavior analysis. Separating interleaved web sessions using graph search algorithms.

RESEARCH PROJECTS

E-student: Web-based student records information system covering enrolment, examination records, degree records, and various statistical surveys. University of Ljubljana, partly supported by the Slovenian Ministry of Information Society (2001-2009).

RESEARCH VISITS

L. Fürst: Department of Computer and Information Sciences, University of Alabama at Birmingham, USA, 5.–12. 9. 2009. Presenting work on graph difference algorithms and graph grammar parsing.

INVITED TALKS AND LECTURES

L. Fürst: Graph difference and graph grammar parsing with an application to UML metamodels, 9. 9. 2009, an invited talk at the University of Alabama at Birmingham, USA.

SELECTED PUBLICATIONS

V. Mahnič, N. Žabkar. Using COBIT Indicators for Measuring Scrum-based Software Development. *WSEAS Transactions on Computers*, 7(10): 1605-1617, 2008.

L. Fürst, S. Fidler, A. Leonardis. Selecting features for object detection using an AdaBoost-compatible evaluation function. *Pattern recognition letters*, 29(11): 1603-1612, 2008.

V. Mahnič. Teaching information system technology in partnership with IT companies. *Organizacija (Kranj)*, 41(2): 71-78, 2008.

V. Mahnič, I. Vrana. Using stakeholder-driven process performance measurement for monitoring the performance of a Scrum-based software development process. *Electrotechnical review*, 74(5): 241-247, 2007.

V. Mahnič, N. Žabkar. Introducing CMMI measurement and analysis practices into scrum-based software development process. *International journal of mathematics and computers in simulation*, 1(1): 65-72, 2007.

I. Rožanc, V. Mahnič. Teaching software quality with emphasis on PSP. *Organizacija*, 38(8): 454-464, 2005.

M.Poženel, V.Mahnič, M.Kukar. Using stochastic model for improving HTTP log data pre-processing, *Proc. 12th International Conference of Information Society IS 2009*, pp. 50-53, Ljubljana, Slovenia, 2009.

L. Fürst, M. Mernik, V. Mahnič. A parser for context-sensitive graph grammars, *Proc. 18th International Electrotechnical and Computer Conference ERK 2009*, pp. 255-258, Portorož, Slovenia, 2009.

N. Žabkar, V. Mahnič. Assessing scrum-based software development process measurement from COBIT prospective. *New aspects of computers: Proc. 12th WSEAS International Conference on Computers*, pp. 589-594, Heraklion, Greece, 2009.

V. Mahnič, I. Rožanc, M. Poženel. Using e-business technology in a student records information system. *Recent advances in e-activities: Proc. 7th WSEAS International Conference on E-Activities*, pp. 80-85, Cairo, Egypt, 2008.

V. Mahnič, B. Grum. An undergraduate course in information systems technology at the University of Ljubljana in partnership with IBM. *Reinforcing partnerships in engineering education: conference proceedings (Monash engineering education series)*, pp. 185-188, Monash University, Melbourne, Australia, 2007.

M. Poženel, V. Mahnič. Data Webhouse: A tool for monitoring the use of a Web based information system. *Proc. 13th International Conference of European University Information Systems, EUNIS 2007,* Grenoble, France, 2007.

Computer Vision Laboratory

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RESEARCH ACTIVITIES

The laboratory is involved in basic research in computer vision, with emphasis on object segmentation, recognition and tracking, face detection, face and iris recognition, panoramic imaging, texture processing, medical imaging, range image interpretation, real-time and multimedia applications.

Analysis and tracking of objects in video sequences is applied to studies of human locomotion, roulette gaming instruments and golf. Superquadric models are used for range image interpretation and also for object tracking in sequences of intensity images. Possible applications of range image interpretation include automatic creation of CAD models for reverse engineering applications, creation of models for virtual reality applications, and part-based object recognition.

We study human face detection and recognition in difficult illumination conditions. We are interested in using such techniques for smart advertising and digital signage. Panoramic images are created in different ways and for different purposes: for depth reconstruction, for mobile robot navigation, for designing efficient user interfaces, for visual surveillance applications.

An ongoing collaboration with the New media department of the Academy of Fine Arts at the University of Ljubljana supports the creation of interactive art installations using the latest information technology. The art projects serve as an excellent frame for testing our research results in practical applications, in particular, we applied face detection in the installation "15 seconds of fame",

Average image of a female and male student at the Faculty of Computer and Information Science.

body position tracking in "Virtual skiing" and locomotion-based person identification in "Coincidence-matrix-dating club" project. We are interested in the use of unconventional user interfaces based on computer vision in the context of computer games. In 2008 we established a GameTeam within the laboratory with a number of student members working on projects like 3D Maze, Bubbles and Virtual Painter.

We are involved in applications in the areas of biometry systems, image based computer forensics, gaming systems, visual quality control, surveillance applications and smart advertising.

RESEARCH PROJECTS

Computer vision (P2-0214), Basic Research programme funded by the Slovenian Research Agency (2009–2014).

INVITED TALKS AND LECTURES

P. Peer: Advances in multimedia with focus on computer vision and art, invited lecture. In: VIPSI 2009 : conference proceedings. Belgrade: Academic Mind, pp. 1-5.

SELECTED PUBLICATIONS

B. Simončič, P. Peer. FRI rehab 3D : FRI Rehab 3D: 3D-reconstruction of the cuboid based on a single camera used in rehabilitation of the human hand. Electrotechnical Review 76(4): 229-234, 2009.

P. Peer, B. Batagelj. Art - a perfect testbed for computer vision related research. In: M. Grgić, K. Delač, M. Ghanbari (Eds.), Recent advances in multimedia signal processing and communications, (Studies in computational intelligence, vol. 231). Berlin; Heidelberg: Springer, pp. 611-629, 2009.

P. Peer, F. Solina. Real time panoramic depth imaging from multiperspective panoramas using standard cameras. In: T. Matsuda

(Ed.). Robot vision : new research. New York: Nova Science Publishers, pp. 189-210, 2009.

L. Šajn, I. Kononenko. Image segmentation and parameterization for automatic diagnostics of whole-body scintigrams : basic concepts. In: G. Schaefer, A. E. Hassanien, J. Jiang (Eds.), Computational intelligence in medical imaging : techniques and applications. Boca Raton; London; New York: CRC Press; Taylor & Francis Group, pp. 347-377, 2009.

L. Šajn, I. Kononenko. Multiresolution image parameterization for improving texture classification. EURASIP Journal on Advances in Signal Processing, 2008(1): 1-12, 2008.

P. Peer and L. G. Corzo. Local Pixel Value Collection Algorithm for Spot Segmentation in Two-Dimensional Gel Electrophoresis Research. Comparative and Functional Genomics, 7(1): 77-85, 2007.

P. Peer and F. Solina. Where physically is the optical center? Pattern recognition letters, 27(10): 1117-1121, 2006.

L. G. Corzo, J. A. Penaranda, P. Peer. Estimation of a fluorescent lamp spectral distribution for color image in machine vision. Machine Vision and Applications, 16(5):306–311, 2005.

F. Solina. 15 seconds of fame. Leonardo, 37(2):105–110+125, 2004.

J. Krivic, F. Solina. Part-level object recognition using superquadrics. Computer Vision and Image Understanding, 95(2):105–126, 2004.

A. Jaklič, F. Solina. Moments of Superellipsoids and their Application to Range Image Registration. IEEE Transactions on Society, Man and Cybernetics-Part B: Cybernetics, 33(4):648–657, 2003.

A. Jaklič, A. Leonardis and F. Solina. Segmentation and Recovery of Superquadrics. Volume 20 of Computational Imaging and Vision. Kluwer, Dordrecth, 2000.

B. Prihavec and F. Solina. User interface for video observation over the internet. Journal of Network and Computer Applications, (21):219–237, 1998.

A. Leonardis, A. Jaklič, and F. Solina. Superquadrics for segmentation and modeling range data. IEEE Transactions on Pattern Recognition and Machine Intelligence, 19(11):1289–1295, November 1997.

F. Solina and R. Bajcsy. Recovery of parametric models from range images: The case for superquadrics with global deformations. IEEE Transactions on Pattern Analysis and Machine Intelligence, 12(2):131–147, 1990.

Visual Cognitive Systems Laboratory

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* also with Computer Vision Laboratory

** also with Laboratory for Mathematical Methods in Computer and Information Science

RESEARCH ACTIVITIES

Visually enabled cognitive systems are intelligent artificial systems that use vision among other sensors in order to act and interact in everyday situations. Examples include mobile robots, intelligent environments, mobile computing devices, intelligent transportation systems, cognitive assistants, etc. The Visual Cognitive Systems Laboratory is involved in basic research of such systems, with emphasis on visual learning, recognition and categorisation. Other activities include panoramic imaging for mobile robotics and range image modeling and interpretation.

Research in the area of visually enabled cognitive systems focuses on various theories regarding requirements, architectures, forms of representation, kinds of ontologies and knowledge, and varieties of mechanisms relevant to integration and control of vision systems. In this context, cognitive vision implies functionalities for knowledge representation, learning, reasoning about events and structures, recognition and categorization, and goal specification, all of which are concerned with the semantics of the relationship between the visually enabled agent and its environment. This requires a vast effort in a multidisciplinary understanding of cognitive processes, involving studies in cognitive psychology, neuroscience, and linguistics.

In the past, our research in the area of visual learning and recognition has primarily focused on subspace methods, which enable direct view-based building of visual representations and

subsequent visual recognition of objects, scenes, and activities. Our main research achievement in the framework of subspace methods is development of robust approaches to both learning and recognition. We have also developed methods for incremental subspace learning that enable updating of representations and therefore facilitate continuous life-long visual learning.

Recently, continuous learning has become a major topic of our research; we have been developing a general framework for continuous learning of visual concepts by learning associations between automatically extracted visual features and linguistic descriptions of the scene. This learning is performed in an interactive manner in a dialogue with a human; we have been exploring different learning strategies ranging from fully autonomous to completely tutor guided learning. Our research has also shifted towards learning scalable representations suitable for recognition and detection of a large number of object categories. Within this framework, we developed an approach which learns a hierarchy of spatially flexible compositions in an unsupervised, statistics-driven manner. Applications include recognition of objects, scenes, and activities in visual cognitive tasks, such as surveillance and cognitive assistants. In mobile computing, we are developing methods that use visual context and geo-referenced intelligent maps for smart vision-based positioning, and for direct camera based interaction with objects in urban environments.

Our theoretical findings on visual learning and recognition are often integrated and implemented on mobile robots. Specifically, we use two in-door and one out-door mobile platforms equipped with omnidirectional and stereo camera setups. We are also implementing direct interaction and object manipulation with a Katana HD6M light weighted robot arm with the aim of developing methods for robust and adaptive interaction of the robot with its environment that would enable studying object affordances. On the other hand, the research in mobile computing is being integrated and tested on the state of the art mobile phones, which come equipped with numerous sensors and enough computing power and connectivity to support the development of ubiquitous visually aware cognitive agents. Both robots and gadgets shall ultimately be able to perceive and understand their environment through interaction, to categorise and recognise objects and subjects around them as well as actions they are performing, and will be able to communicate with humans and other agents on a semantic level.

RESEARCH PROJECTS

Computer vision, P2–0214. Basic research programme, Slovenian Research Agency (2009–2014).

VISIONTRAIN - Computational and Cognitive Vision Systems: A Training European Network (MRTN-CT-2004-005439, FP6-2002-Mobility-1). FP6 IST Programme Project, European Commission (2005–2009).

POETICON - The Poetics of Everyday Life: Grounding Resources and Mechanisms for Artificial Agents (FP7-ICT-215843-POETICON). FP7 ICT Programme Project, European Commision (2008–2010).

An artificial cognitive system learning object affordances

COGX - Cognitive Systems that Self-Understand and Self-Extend (ICT – 215181) FP7 ICT Programme Project, European Commission (2008-2012).

Computer vision for mobile computing and interaction (J2–221 (C). Basic Research Project, Slovenian Research Agency (2009–2010).

LABORATORY GUESTS

Sergio Roa, DFKI, Saarbrücken, Germany, 25.3. – 27.3.2009, Collaboration on the CogX project.

Michael Zillich, ACIN, Technische Universität Wien, Vienna, Austria, 10.6 - 12.6.2009, Collaboration on the CogX project.

RESEARCH VISITS

Alen Vrečko: DFKI, Saarbrücken, Germany, 12.7. – 18.7.2009. Collaboration on the CogX project.

Marko Boben, Sanja Fidler: Max Planck Institut, Tübingen, Germany, 15.8. - 22.8.2009. Collaboration on POETICON project.

Marko Mahnič, Alen Vrečko: DFKI, Saarbrücken, Germany, 20.9. – 25.9.2009. Collaboration on the CogX project.

Danijel Skočaj, Alen vrečko, Marko Mahnič: KTH Stockholm, Sweden, 30.11. – 2.12.2009. Collaboration on the CogX project.

INVITED TALKS AND LECTURES

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, 21.6.2009, an invited keynote talk at the First Workshop on Stochastic Image Grammars, in conjunction with CVPR'09, Miami.
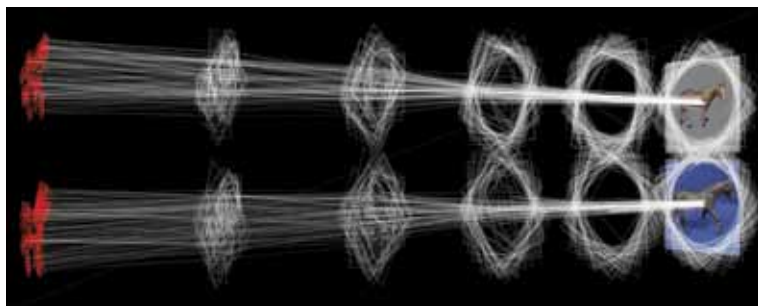
Object categorization by hierarchical matching to a prototype

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, 29.8.2009, an invited talk at the Second International Workshop on Shape Perception in Human and Computer Vision, in conjunction with ECVP'09. Regensburg.

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, an invited talk at Workshop on Trends in Computer Vision, July 2009, Technical University Prague, Czech Republic.

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, an invited lecture at University of Birmingham, August 2009, United Kingdom.

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, an invited lecture at University of Surrey, 7.9.2009, United Kingdom.

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, an invited lecture at University of British Columbia, December 2009, Canada.

Aleš Leonardis: Learning a Hierarchical Compositional Shape Vocabulary for Multi-class Object Representation, an invited lecture at Simon Fraser University, December 2009, Canada.

AWARDS

Matej Kristan: Vodovnikova nagrada - Vodovnik Award for excellent research achievements relating to doctoral thesis, Faculty of Electrical Engineering, University of Ljubljana

Matej Kristan: Award for excellent research achievements in the last years, Faculty of Computer and Information Science, University of Ljubljana

Matej Kristan: Innovation award for applicative project "Intelligent security system for surveillance of small areas", at Innovation forum, sponsored by Slovenian business and foreign investment agency.

SELECTED PUBLICATIONS

S. Fidler, M. Boben, A. Leonardis. Evaluating multi-class learning strategies in a hierarchical framework for object detection. Proc. Advances in Neural Information Processing Systems conference, pp 1-9, 2009.

S. Fidler, M. Boben, A. Leonardis. Optimization framework for learning a hierarchical shape vocabulary for object class detection. Proc. British Machine Vision Conference 2009, 7th-10th September, London, U.K. 2009.

M. Kristan, D. Skočaj and A. Leonardis. Online Kernel Density Estimation for Interactive Learning. Image and Vision Computing, 2009.

M. Kristan, J. Perš, S. Kovačič and A. Leonardis. A Local-motion-based probabilistic model for visual tracking. Pattern Recognition, Vol. 42, No. 9, pp. 2160-2168, 2009.

S. Fidler, M. Boben, A. Leonardis. Similarity-based cross-layered hierarchical representation for object categorization.In Proceedings of IEEE Conference on Computer Vision and Pattern Recognition 2008.

B. Leibe, A. Leonardis and B. Schiele. Robust Object Detection with Interleaved Categorization and Segmentation. International Journal of Computer Vision, Special Issue on Learning for Recognition and Recognition for Learning, Vol. 77, no. 1-3, pp. 259-289, 2008.

A. Štimec, M. Jogan, A. Leonardis. Unsupervised learning of a hierarchy of topological maps using omnidirectional images. International Journal on Pattern Recognition and Artificial Intelligence., Vol. 22, No. 4, pp. 639-665, 2008.

D. Skočaj and A. Leonardis. Incremental and robust learning of subspace representations. Image and Vision Computing, vol. 26, no. 1, pp. 27-38, 2008.

D. Skočaj, A. Leonardis, and H. Bischof. Weighted and robust learning of subspace representations. Pattern Recognition, vol. 40, no. 5, pp. 1556-1569, May 2007.

S. Fidler, D. Skočaj, and A. Leonardis, "Combining reconstructive and discriminative subspace methods for robust classification and regression by subsampling", IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 28, no. 3, pp. 337-350, March, 2006.

M. Jogan, E. Žagar, A. Leonardis. Karhunen-Loeve expansion of a set of rotated templates. IEEE Transactions on image processing, 2003, Vol 12, No 7, pp. 817– 825, 2003.

M. Jogan, A. Leonardis. Robust Localization using an Omnidirectional Appearance-based Subspace Model of Environment. Robotics and Autonomous Systems, Volume 45, Issue 1, pp. 51–72, Elsevier Science, 2003.

A. Leonardis, H. Bischof, and J. Maver. "Multiple Eigenspaces", Pattern Recognition, 35, no. 11, pp. 2613–2627, 2002. Twenty-Ninth Annual Pattern Recognition Society Award. Selected as the most original manuscript from all 2002 Pattern Recognition issues.

A. Leonardis and H. Bischof. Robust recognition using eigenimages. Computer Vision and Image Understanding, 78(1):99–118, 2000.

A. Jaklič, A. Leonardis and F. Solina. Segmentation and Recovery of Superquadrics, volume 20 of Computational imaging and vision. Kluwer, Dordrecht, 2000.

A. Leonardis and H. Bischof. An efficient MDL-based construction of RBF networks. Neural Networks, 11(5):963–973, July 1998.

H. Bischof and A. Leonardis. Finding optimal neural networks for land use classification. IEEE Transactions on Geoscience and Remote Sensing, 36(1):337–341, January 1998.

A. Leonardis, A. Jaklič, and F. Solina. Superquadrics for segmentation and modeling range data. IEEE Transactions on Pattern Recognition and Machine Intelligence, 19(11):1289–1295, November 1997.

R. Bajcsy, S. Wook Lee, and A. Leonardis. Detection of diffuse and specular interface reflections and inter-reflections by color image segmentation. International Journal of Computer Vision, 17(3):241–272, 1996.

A. Leonardis, A. Gupta, and R. Bajcsy. Segmentation of range images as the search for geometric parametric models. International Journal of Computer Vision, 14:253–277, 1995.

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RESEARCH ACTIVITIES

The laboratory carries out research in machine learning, data mining, inductive logic programming, qualitative reasoning, and AI approaches to robotics, systems control, bioinformatics, and information visualization. Research results concern the learning from noisy structured (attribute-based) and semi-structured data for classification, regression and clustering, constructive induction and discovery of attribute interactions, combining logical and numerical learning. A notable aspect of much of this research is its application to problems in systems control, game playing and analysis, ecological modeling, reconstruction of human control skill, robotics, and applications of AI in mechanical engineering. Members of the laboratory are also engaged in research in the area of bioinformatics, in particular, in designing computational methods for knowledge

DictyExpress, a popular web-based tool for *Dictyostelium* gene expression analytics, runs in any web browser, but feels just like a desktop application.

discovery in functional genomics and bioinformatics, reconstruction of biological networks, sequence analysis, and biomedical diagnosis and prognosis.

In 2009, the laboratory's demo on autonomous robot learning by experimentation (http://www.ailab.si/xpero/) was awarded the first prize at the European Exhibition in Future Emergent Technologies, Prague, April 2009. This work was done as part of the XPERO project. Our Research Program "Artificial Intelligence and Intelligent Systems", carried out in part by this laboratory, was in 2006 listed among the best research programs funded by the Slovenian research agency ARRS. Also in 2006, a former member of this laboratory Aleks Jakulin, received the prestigious best European AI dissertation award, sponsored by ECCAI for his dissertation Attribute Interactions in Machine Learning. This was already the second dissertation award, after Dorian Šuc, received by PhD students who did their work in the Artificial Intelligence Laboratory. In 2007, Ivan Bratko received the national Zois award for outstanding scientific achievements. The member of the laboratory Janez Demšar was elected by students as best professor in the interdisciplinary study program Computer Sc. and Mathematics in academic year 2008/09.

The laboratory is also the principal developer of a major open-source data mining package Orange (www.ailab.si/orange), which interfaces with Python and also has an attractive and easy-to-use visual programming interface. Besides being the core development and research tool for the lab, Orange gained its popularity as the principal Python-based data mining tool and has a substantial community of users world-wide. Another popular software product, also developed within the laboratory, is GenePath (http://www.genepath. org), known to be the only available software package that supports interactive epistasis analysis for gene network reconstruction from mutant-based experimental data. We are also developing a set of web-

based bioinformatics tools. A very popular one within community of biologists that studies a social amoeba *Dictyostelium discoideum* is dictyExpress (http://www.ailab.si/dictyexpress), an interactive, web-based exploratory data analytics application providing access to over 1,000 gene expression experiments from Baylor College of Medicine. Other notable and recent developments include software packages for chess tutoring, qualitative modelling and argument-based machine learning.

RESEARCH PROJECTS

Artificial Intelligence and Intelligent Systems (P2–0209). Research Programme funded by Slovenian Research Agency (2009-2014).

X-MEDIA – Large Scale Knowledge Sharing and Reuse Across Media (FP6-26978). FP6 IST Programme project, European Commission (2006-2010).

XPERO – Learning by Experimentation (IST-29427). FP6 IST Programme project, European Commission (2006-2009).

Qualitative modeling from data (J2-2194). Basic Research Project, Slovenian Research Agency (2009-2012).

Data and knowledge integration methods for network systems biology (J2-2197). Basic Research Project, Slovenian Research Agency (2009–2012).

Knowledge technology approaches in drug discovery: analysis and experiment planning in high-throughput genetics (L2-1112). Applied Research Project, Slovenian Research Agency (2008–2011).

Computational Phenomics (J2-9699). Basic Research Project, Slovenian Research Agency (2007–2009).

Artificial intelligence approaches to knowledge discovery in functional genomics (BI-IT/05-08-011), Slovenian-Italian Bilateral Project (with University of Pavia), Slovenian Research Agency, (2006-2009).

LABORATORY GUESTS

Dr. Angelo Nuzzo, University of Pavia, Italy, 21.11. – 30.11.2009. Collaboration in bilateral project.

Francesca Mulas, University of Pavia, Italy, 2.11. – 30.11.2009. Collaboration in bilateral project.

Sanja Brdar, University of Novi Sad, Serbia, 1.10. – 31.6.2010. Basileous exchange.

Riccardo Beretta, University of Pavia, Italy, 15.10. – 28.2.2010. Collaboration in bilateral project.

RESEARCH VISITS

T. Curk: Baylor College of Medicine, Houston, USA, 11.10. – 19.10.2009. Bioinformatics of transcription factor regulation in *D. discoideum*.

B. Zupan: Baylor College of Medicine, Houston, USA, 11.10. – 19.10.2009. Bilateral project collaboration.

The AI Lab's Nao robot at the Future Emergent Technologies Exhibition, Prague, April 2009. The scientific message of the demonstration "A day in the life of the Nao robot" was to show how a robot can autonomously learn by performing experiments in its environment. The demonstration won the first prize at the exhibition.

G. Rot: Baylor College of Medicine, Houston, USA, 11.10. – 19.10. 2009. Development of dictyExpress.

B. Zupan: University of Pavia, Italy. 1.1. – 15.6.2009. Research in bioinformatics of tissue engineering.

INVITED TALKS AND LECTURES

B. Zupan: Knowledge-based data analytics, 16.2.2009, University of Pavia, Pavia.

I. Bratko: Trends in Artificial Intelligence, 15.4.2009, Slovenian Informatics Conf., Portorož.

SELECTED PUBLICATIONS

J. Demšar. Algorithms for subsetting attribute values with Relief. *Machine Learning* 78(3): 421-428, 2010.

M. Toplak, T. Curk, J. Demšar, B. Zupan: Does replication groups scoring reduce false positive rate in SNP interaction discovery? *BMC Genomics* 11:58, 2010.

R. Franco-Duarte, L. Umek, B. Zupan, D. Schuller: Computational approaches for the genetic and phenotypic characterization of a *S. cerevisiae* wine yeast collection. *Yeast* 26 (12): 675-692, 2009.

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RESEARCH ACTIVITIES

Laboratory for Cognitive Modeling (LKM) was officially founded in 2001. LKM carries out research in cognitive modeling, machine learning, neural networks, picture and data mining. Research results concern the modeling of noisy data related to cognitive, medical, biological and other processes. We are developing, testing and applying new approaches and algorithms for modeling from numeric, symbolic and pictorial data, and new approaches to building, evaluation and explanation of models, derived from data. Recent research is related to development of methods for evaluating the utility of ordinal attributes, for evaluating the reliability of single models' predictions in classification and regression, for evaluating the reliability of clustering, for explaining single predictions by arbitrary classification or regression model, and for efficient parametrization of images using a subset of possible image resolutions. LKM collaborates with psychologists, physicians, biologists, physicists and chemists. A notable aspect of much of this research is its application to problems in image analysis, medical diagnosis, ecological modeling, alternative medicine, and studies of consciousness.

RESEARCH PROJECTS

Artificial Intelligence and Intelligent Systems (P2–0209). Research Programme funded by Slovenian Research Agency (2009-2014).

Prediction of betting tips from users' bets selections. Industry-funded project, funded by Intension d.o.o., Maribor (2008-2009).

Electricity load forecasting supported by prediction explanation and prediction reliability estimates, Bilateral Collaboration Project (Slovenia-Portugal), Slovenian Research Agency (2010-2011).

Integration of data mining and high-performance computer modeling for coronary artery disease, (SI-SR/10-11-020). Bilateral Collaboration Project, Slovenian Research Agency (2010–2011).

Machine Learning of Imbalanced Data. Bilateral Collaboration Project (Slovenia-Czech Republic), Slovenian Research Agency (2010–2011).

LABORATORY GUESTS

Prof. dr. Petr Savicky, University of Prague, 11.9.2009–17.9.2009 and 10.12.2009–18.12.2009, research collaboration on Artificial intelligence and intelligent systems.

INVITED TALKS AND LECTURES

Zoran Bosnić: Estimation of individual prediction reliability using sensitivity analysis of regression models, 12.10.–16.10.2009, invited lecture. In: M. Bohanec et al. (eds). Proceedings 12th International Multi-conference Information Society - IS 2009, volume A, Ljubljana: Institut Jožef Stefan, p. 7-10.

SELECTED PUBLICATIONS

I. Kononenko, M. Kukar: *Machine Learning and Data Mining: Introduction to Principles and Algorithms*, Horwood publ., 2007 (454 pages).

E. Štrumbelj, I. Kononenko: An efficient explanation of individual classifications using game theory. *J. Mach. Learn. Res.* 2010, 11[1]:1-18

E. Štrumbelj, I. Kononenko, M. Robnik Šikonja. Explaining instance classifications with interactions of subsets of feature values. *Data & Knowledge Engineering,* 68(10):886-904, 2009.

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M. Robnik-Šikonja, I. Kononenko: Explaining classifications for individual instances. *IEEE Trans. Knowl. Data Eng.*, 2008, 20:589-600.
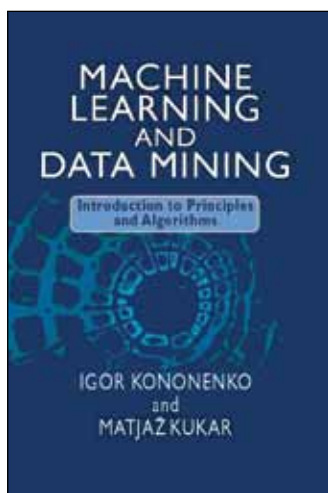
The book by two members of LKM was published by Horwood and represents the appreciation of our research work.

We collaborate with several Universities and Institutes from Greece, Portugal, Spain, Czech Republic and Belgium.

I. Kononenko:, M. Robnik-Šikonja: Non-myopic feature quality evaluation with (R)ReliefF. In: LIU, H., MOTODA, H.(Eds.). *Computational methods of feature selection.*. Boca Raton; London; New York: Chapman & Hall/CRC, 2008, pp. 169-191

P. Savicky, M. Robnik Šikonja. Learning random numbers: a MATLAB anomaly, *Applied artificial intelligence,* 22(3):254-265, 2008.

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L. Šajn, I. Kononenko: Multiresolution image parametrization for improving texture classification. *EURASIP J. Adv. Signal Process*, 2008, pp. 1-12.

M. Robnik-Šikonja, K. Vanhoof: Evaluation of ordinal attributes at value level. *Data Mining and Knowledge Discovery*, 14:225-243, 2007.

Z. Bosnić, I. Kononenko: Estimation of individual prediction reliability using the local sensitivity analysis. *Appl. Intell.*, 2007, 29(3)187-203

L. Šajn, I. Kononenko, M. Milčinski: Computerized segmentation and diagnostics of whole-body bone scintigrams. *Comput. med. imaging graph.*. 2007, 31(7) 531-541.

M. Bevk, I. Kononenko: Towards symbolic mining of images with association rules: Preliminary results on textures. *Intelligent Data Analysis*, 10(4)379-393, 2006.

M. Kukar. Quality assessment of individual classifications in machine learning and data mining. *Knowledge and information systems*, 2006, 9(3) 364-384.

M. Robnik-Šikonja, I. Kononenko. Theoretical and Empirical Analysis of ReliefF and RReliefF, *Machine Learning Journal*, 53: 23-69, 2003.

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RESEARCH ACTIVITIES

The research activities of the our lab involve various fields of mathematics with special emphasis on applications to computer and information science. Special emphasis is on research in the following fields of mathematics and computer science:

- scientific computing and numerical solutions of differential equations, where we study methods for geometric integration of ordinary differential equations, as well as numerical simulations of fluid flow by means of open source tools for computational fluid dynamics (CFD) analysis,
- graph theory, mostly topological and structural properties of graphs, and colorings problems of graphs, both in connection with graph symmetries and embedding properties,
- algebraic topology, in particular algebraic invariants of topological spaces with group actions, as well as computational topology and topological data analysis,
- nonlinear dynamical systems and their application in geometry, physics and mechanics,
- computational geometry and geometry of cycles (in cooperation with members of the Faculty of Electrical Engineering and the Faculty of Mathematics and Physics) with applications to surface modeling,
- commutative algebra and linear algebra, in particular, studying the variety of commuting nilpotent matrices over algebraically closed fields and certain classes of matrices over semirings,
- Brownian motion and martingales and their applications to analysis.

Several members of the lab participate in the research groups of the Institute of Mathematics, Physics, and Mechanics. Members of the lab are involved in joint research work with other research groups at the Faculty of Computer and Information Science and the Faculty of Electrical Engineering and with the following institutions: NTNU Trondheim, Norway, University of Hamburg, Germany, P.J.Šafarik University in Košice, Slovakia, University of Sevilla, Spain, Yokohama National University, Japan, Simon Fraser University, Canada, University of Melbourne, Australia, and others.

We organize the Mathematical seminar at the FRI, where members of the lab and other researchers report on current work, connected to the research and teaching activities of the lab.

Among applied projects, we are developing a program based on the open source C++ library OpenFoam for numerical simulation of fluid flow and hydrodynamic drag in the context of CFD. Efficient tools for triangulation and mesh generation, and for visualization are also included. In cooperation with the Computer Structures and Systems Laboratory members of the lab are working on algorithms for developing and evaluating mechanical random generators.

RESEARCH PROJECTS

Holomorphic mappings and foliations, harmonic analysis and hamiltonian systems (J1-2152). Basic Research Project, Slovenian Research Agency (2009-2012).

LABORATORY GUESTS

Jose Antonio Vilches, Universidad de Sevilla. 22.6.–27.6.2009. Greg Conner, Brigham Young University at Provo, Utah, USA. 10.7.–15.7.2009.

RESEARCH VISITS

Neža Mramor Kosta: Brigham Young University at Provo, Utah, USA, 29.5.–10.6.2009.

INVITED TALKS AND LECTURES

Neža Mramor Kosta: On the cohomology of locally free groups, 4.6.2009, Department of Mathematics, Brigham Young University at Provo, Utah.

SELECTED PUBLICATIONS

M. J. Chávez, G. Fijavž, A. Márquez, A. Nakamoto, E. Suárez. Geometric Realization of Möbius Triangulations, SIAM J. Discrete Math., 2009, vol. 23, no. 1, p. 221-232.

G. Jerše, N. Mramor Kosta, Ascending and descending regions of a discrete Morse function, Comput. Geom., 42 (2009), 6-7, 639-651..

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D. Bokal, G. Fijavž, D. R. Wood. The minor crossing number of graphs with an excluded minor. Electron. J. Comb. (online journal), 2008, vol. 15, no. 1, r4 (13 p).

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J. Jaworowski, N. Mramor-Kosta. The degree of maps of free G-manifolds. J. fixed point theory appl. (Print), 2007, vol. 2, no. 2, str. 209-213.

A. Turković, B. Orel, M. Lučić-Lavčević, P. Dubček, M. Pavlović, Z. Crnjak Orel, S. Bernstorff. GISAXS study of temperature evolution in nanostructured CeVO[sub]4 films. Sol. energy mater sol. cells. [Print ed.], 2007, vol. 91, no. 14, str. 1299-1304.

B. Mohar, A. Vodopivec, On polyhedral embeddings of cubic graphs, Combin. Probab. Comput. 15 (2006), 877--893.

Laboratory for cryptography and computer security

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RESEARCH ACTIVITIES

Our laboratory focuses on cryptography and computer security. We also study coding theory and statistical design.

With the dramatic development of telecommunications and information processing the demand for information is rapidly increasing. However, with the electronic revolution, information faces new and potentially more damaging security threats. It is namely much easier to intercept and alter electronic information than its paper predecessor, and besides, attack can be delivered remotely.

Information and computer security describes all measures taken to make services available and to prevent unauthorized use of electronic data, regardless whether it takes the form of *disclosure*, *alteration* and *destruction* of the data concerned, or *verification of authenticity* and *data integrity*, such as *digital cash* (carrier of value) and *digital signature*. Among preventive measures, *cryptography* provides the highest security in accordance with its flexibility for digital media. Cryptography and computer security influences cryptographic systems and applications for *networks* (Internet), *finances* (banks, stock market) and *telecommunications*. In particular we focus on public-key cryptosystems based on elliptic curves, algorithmic number theory, applications of finite fields and coding theory.

The main mathematical background for cryptology is algebraic combinatorics (including number theory and discrete mathematics), which is being used in two other important areas of our activity: *statistical design theory* and *coding theory*. The first one provides an optimal search for sample-sets and is being used, for example, in the design of digital communications. The second one constructs data carriers known as error-correcting codes (e.g. for CDs, wireless

communication, satellites), since it is too expansive and inefficient to prevent all errors and it is easier to correct them (e.g. CD with a hole of 1mm in diameter still produces a perfect sound).

RESEARCH PROJECTS

Anonymization of data (L1-9659). Applied Research Project funded by Slovenian Research Agency and Ministry of Health (2007-2009).

Cryptosystems with elliptic curves over prime fields and smartcards for use by MO/SV (M2-0206). Target Research Programme, Slovenian Research Agency (2007-2009).

LABORATORY GUESTS

Prof. Rob Gallant, Memorial University, Newfoundland, Canada, 8.6.– 17.6.2009. Efficient implementation of elliptic curve arithmetic and security of discrete algorithm problem.

Prof. Jack H. Koolen, Postech, Pohang, South Korea, 29.1.–6.2.2009. Open problems in distance-regular graphs.

Prof. Jovan Golić, Telecom Italy, Torino, Italy, 28.12.2008– 4.1.2009. Random number genarators in hardware.

RESEARCH VISITS

Aleksandar Jurišić: University of Wisconsin, Madison, USA, September, 2009. Characterizations of Q-polynomial distance-regular graphs.

Aleksandar Jurišić: Worcester Polytechnic Institute, USA, April, 2009. Classification of cometric association schemes.

INVITED TALKS AND LECTURES

Aleksandar Jurišić: Distance-regular graphs with tails, 26.4.2009, AMS meeting, WPI, USA.

Aleksandar Jurišić: A characterization of Q-polynomial distance-regular graphs, 6.2.2009, Algrebraic combinatorics at Adriatic coast - (AC)^2 Conference, Koper, Slovenia.

SSmart cards enable us to securely store private keys.

With error-correcting codes it is possible to receive quality pictures sent by space-probes. We cite Barry Cipra: "Error-correcting codes are a kind of safety net--mathematical insurance against the vagaries of an imperfect material world."

Aleksandar Jurišić, "Combinatorics of distance-regular graphs", Sept. 14, 2009, Combinatorics Seminar, Department of Mathematics, University of Wisconsin - Madison, Madison, Wisconsin, USA
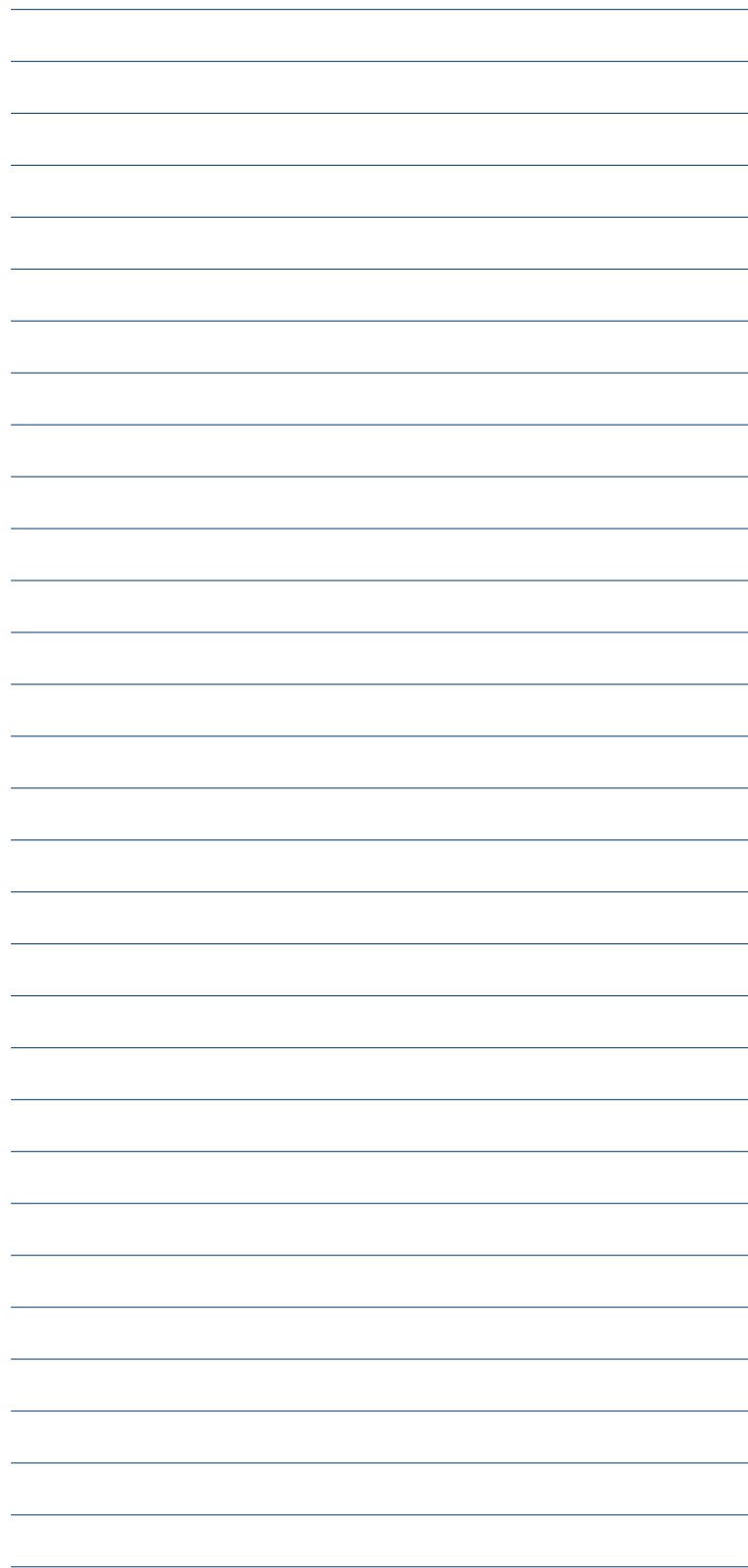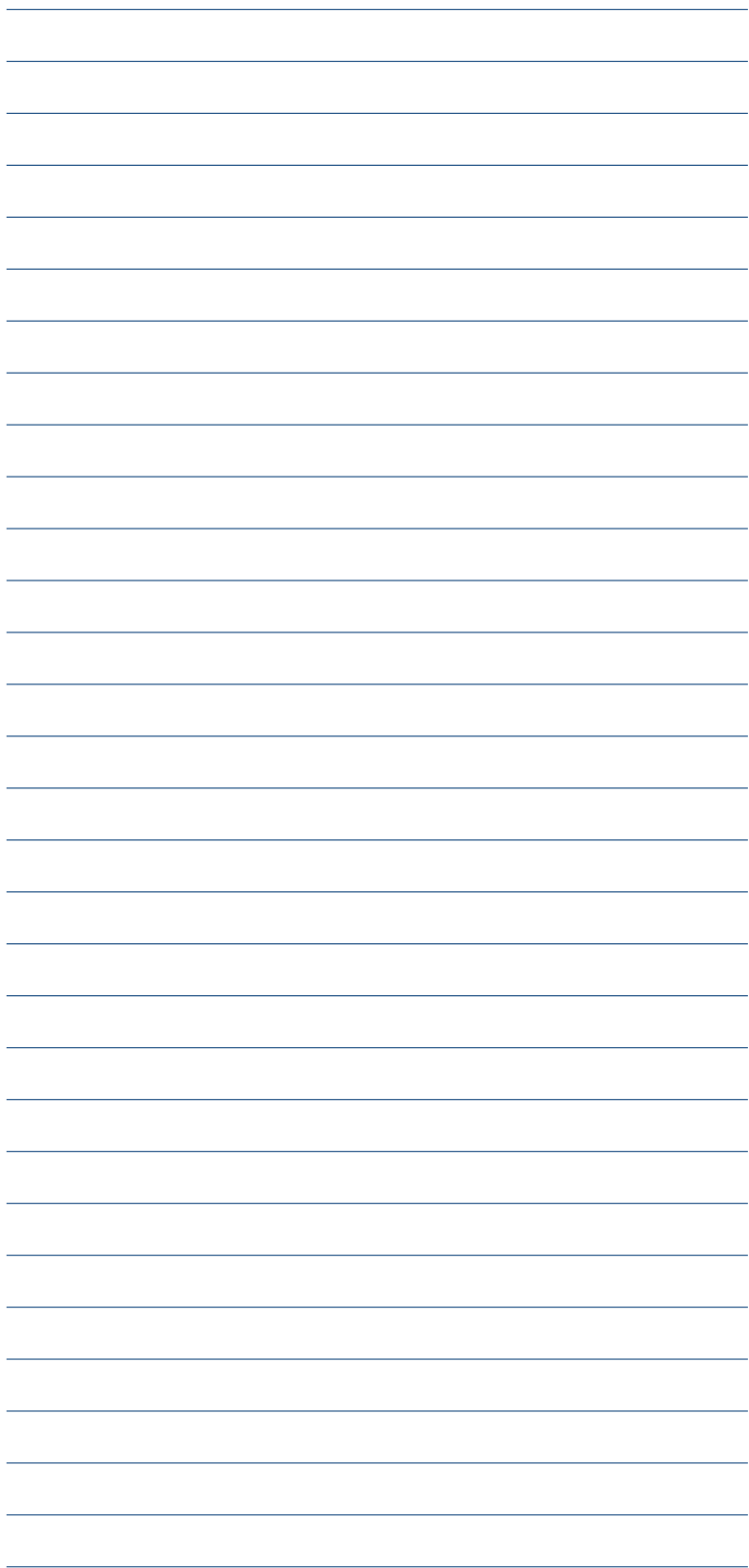
SELECTED PUBLICATIONS

A. Jurišić, P. Terwilliger and A. Žitnik, Distance-regular graphs with light tails, Europ. J. Combin. (2009), doi: 10.1016/j.ejc.2009.08.007.
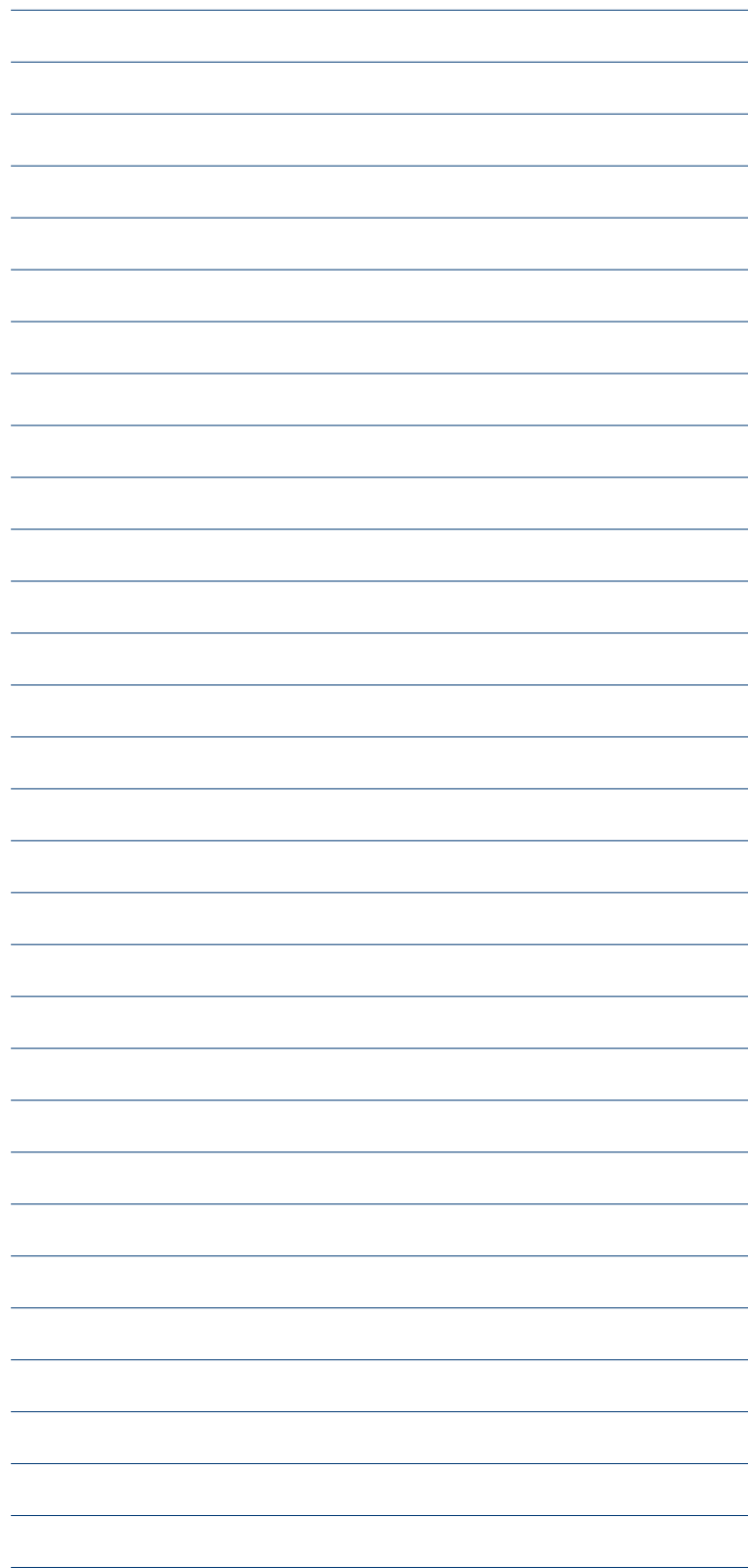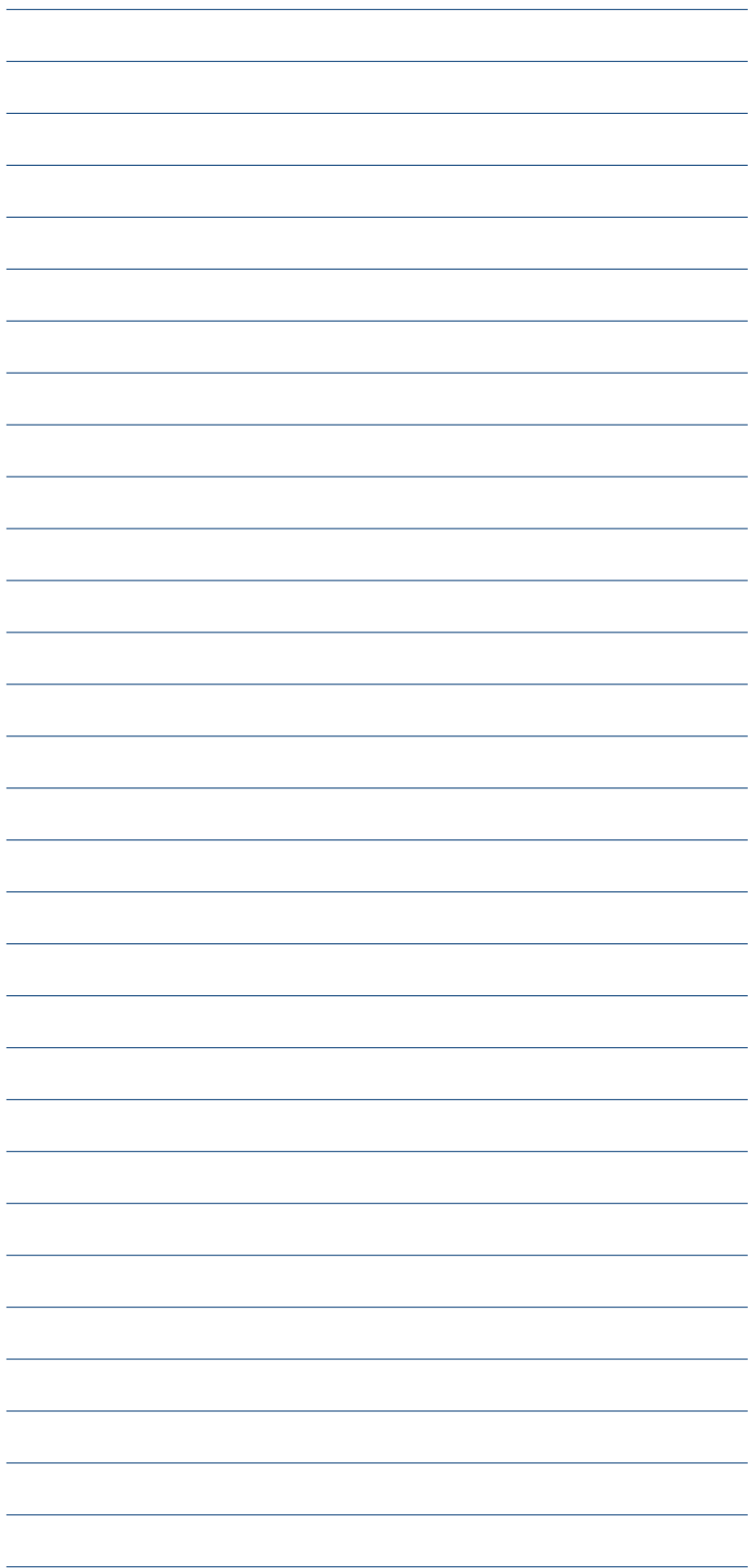
A. Jurišić and P. Terwilliger, Pseudo-1-homogeneous distance-regular graphs, Journal of Algebraic Combinatorics 28 (2008), 509-529.

A. E. Brouwer, A. Jurišić and J. H. Koolen, Characterization of the Patterson graph, J. of Algebra 320 (2008), 1186-1199.

K. Coolsaet and A. Jurišić, Using equality in the Krein conditions to prove nonexistence of certain distance-regular graphs, J. Combin. Theory (A) 115 (2008), 1086-1095.

K. Coolsaet, A. Jurišić and J. H. Koolen, On triangle-free distance-regular graphs with eigenvalue multiplicity equal to the valency, Europ. J. Combin. 29/5 (2008), 1186-1199.