

University of Ljubljana
Faculty of Computer
and Information Science



Survey of Activities

in 2012



Faculty of
Computer and
Information
Science
University of
Ljubljana

**Survey of
Activities
in 2012**

Ljubljana
2013

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Foreword



This booklet provides some basic information on the Faculty of Computer and Information Science at 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 had a lengthy roster of alumni, some of whom have achieved distinction in academic and professional circles in Slovenia and abroad. The Faculty has a number of active research groups that attract funding from various EU and international programs as well as funding from Slovenian and foreign industry.

Due to the high demand for computer and information science graduates, the Faculty has avoided the trend of declining enrollment as in some other engineering and science disciplines. We actively promote the study of computer and information science by offering free summer workshops for high school students. During the academic year we also provide help to selected high schools with after-class activities. Besides the core of computer science, recently implemented study programs designed according to the Bologna principles enable an interdisciplinary approach to computer science education and should help to attract students from diverse backgrounds. We also aim at further opening our studies and making them accessible to international students. Part of the Master Studies and the entire Doctoral Program is conducted in English and particular attention is given to attracting promising international doctoral students. 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. Currently, the Faculty's most pressing problem is the shortage of space. The construction of the new Faculty building and associated facilities already started in 2010 and is expected to be finished in 2014.

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 find some interesting material in the booklet to establish contacts with our Faculty members.

Nikolaj Zimic
Dean

Faculty of Computer and Information Science



About FRI

General Information

Dean **Prof. Dr. Nikolaj Zimic**

Associate Dean for Education **Prof. Dr. Neža Mramor Kosta**

Associate Dean for Research **Prof. Dr. Blaž Zupan,**
Prof. Dr. Matjaž B. Jurič (from October 1st, 2012)

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FRI

The Faculty of Computer and Information Science (FRI) was established in 1996 as an independent faculty of the University of Ljubljana. The undergraduate program in computer science had commenced before, in 1973, when the faculty staff was engaged within the former Faculty of Electrical Engineering and Computer Science. The study program first started as an elective program after the second year of electrical engineering study. In 1982 an independent four-year program in computer science began. In 2008 the first generation of students was enrolled into the newly designed programs in computer science at all degrees, which are internationally comparable and follow the bologna guidelines.

Up till now more than 3080 students have completed undergraduate programs in computer science and obtained an undergraduate university degree. At the graduate level more than 380 Master's degrees (M.Sc.) and 130 Doctoral degrees (Ph.D.) in Computer and Information science have been awarded. Currently, there are about 1400 undergraduate and graduate students at the Faculty. The Faculty has 172 employees, of which 150 are teaching and research staff.

The central building that houses FRI is shared with the Faculty of Electrical Engineering. FRI has seven teaching laboratories equipped with a total of about 450 networked personal computers and 21 lecture halls. All classrooms are covered by wireless network (Eduroam). Twenty research laboratories are equipped with about 530 personal computers or workstations, and maintain a range of web servers and several medium-sized computational clusters. 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 that is engaged primarily in publishing textbooks for students.

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 serviced by Adria, the national Slovenian air carrier, as well as number of other major European airlines.

BY PASSENGER CAR

Ljubljana is connected to all neighboring countries by a good highway system.

BY AIR AND RAIL

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

Via Germany: By plane to Munich or Frankfurt and by train, car, shuttle (such as GoOpti.com) or plane to Ljubljana (a direct train goes once every day, there are two flights daily from Munich and Frankfurt to Ljubljana).

Via Croatia: By plane to Zagreb and by train, shuttle (such as GoOpti.com) or car to Ljubljana.

Via Italy: By plane to Venice or Trieste and by car or shuttle (such as GoOpti.com) to Ljubljana.

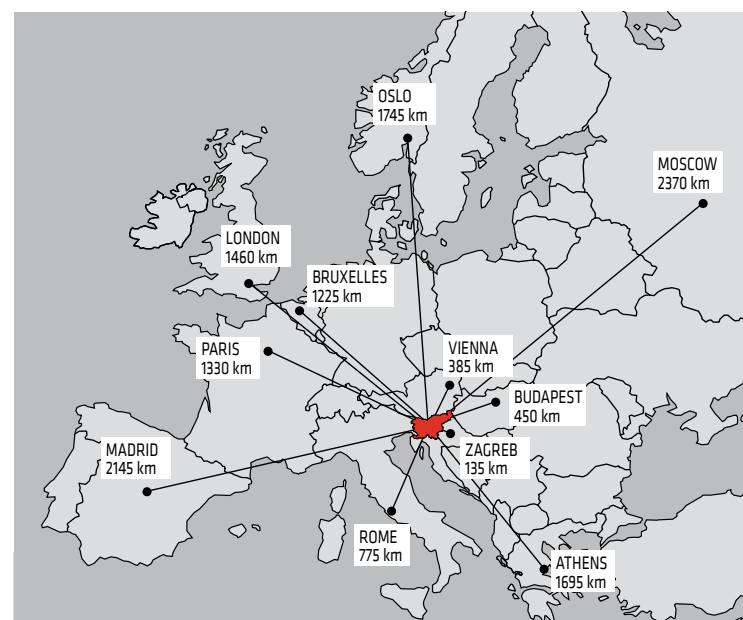


Figure 1: Slovenia in Europe

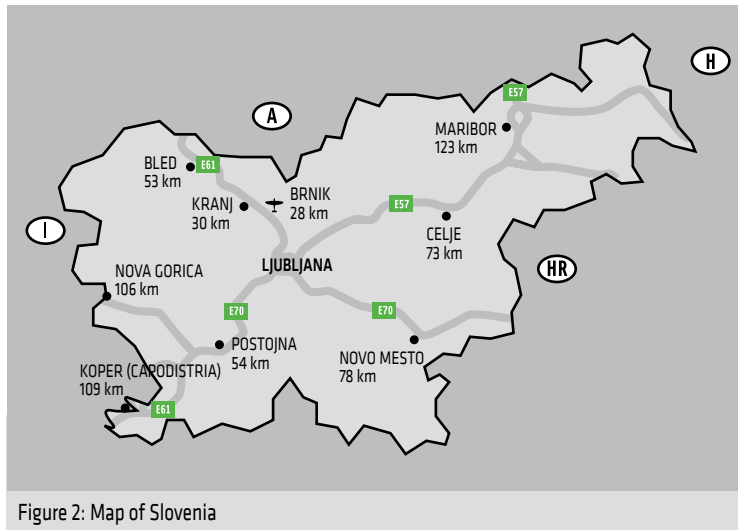


Figure 2: Map of Slovenia

BY RAIL

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

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 you must take bus line 1 (direction “Mestni log”) or 6 (direction “Dolgi most”). Map on Figure 4 shows how to reach FRI by car.



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

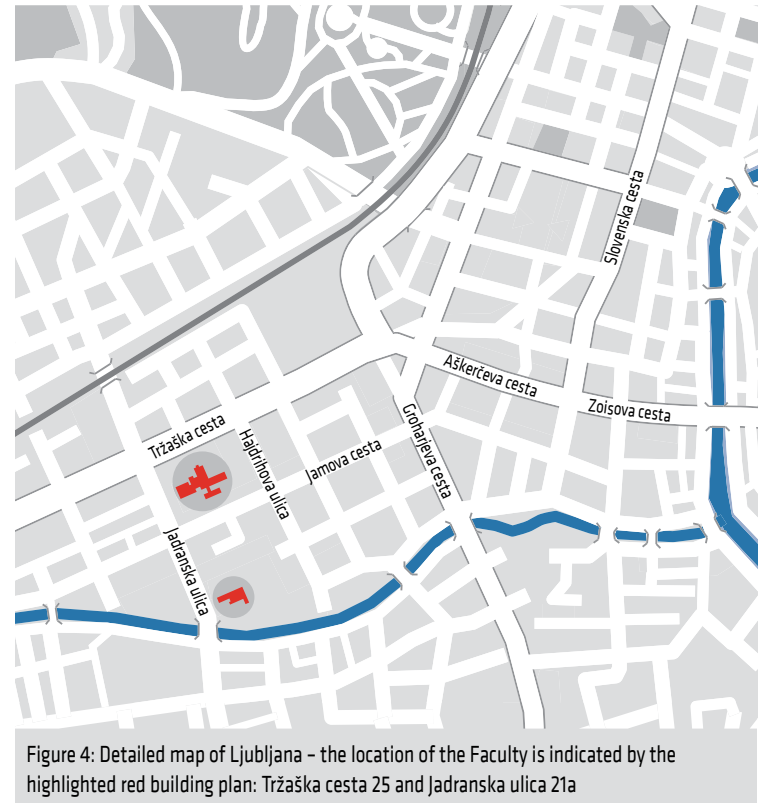


Figure 4: Detailed map of Ljubljana – the location of the Faculty is indicated by the highlighted red building plan: Tržaška cesta 25 and Jadranska ulica 21a

Educational Programs

The academic year at the University of Ljubljana consists of the fall and the spring semester. 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 semester until the beginning of the spring semester), spring (a full month after the end of the spring semester) and fall (from mid-August until the end of September). At the Faculty of Computer and Information Science the 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 30 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, and the Erasmus Mundus BASILEUS program for exchange between European and Western Balkan universities. The study programs of the Faculty of Computer and Information Science are registered with the Slovenian quality assurance agency for higher education and the European Federation of National Engineering Associations (FEANI) and they meet the criteria for the title EUR ING.

UNDERGRADUATE PROGRAMS

The faculty of computer and information science offers the following first cycle programs:

- university study program Computer and Information Science
- professional study program Computer and Information Science
- interdisciplinary university study program Computer Science and Mathematics, together with the Faculty of Mathematics and Physics of the University of Ljubljana
- interdisciplinary university study program Administrative Information Systems, together with the Faculty of Administration of the University of Ljubljana

All four first cycle programs last three years. They consist of six semesters of course work and have a total work load of 180 ECTS.

At the second cycle level, the following programs are offered:

- master study program Computer and Information Science
- interdisciplinary master study program Computer Science and Mathematics, offered jointly with the Faculty of Mathematics and Physics of the University of Ljubljana
- interdisciplinary master study 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 of Budapest, University of Zagreb and Comenius University in Bratislava)

The second cycle master study programs last two years. They consist of 4 semesters of course work with a total work load of 120 ECTS.

FRI

University Study Program Computer and Information Science

The program leads to the degree “diplomirani inženir računalništva in informatike (UN)”, abbr. “dipl. ing. rač. (UN)”.

The first two years contain the core-curriculum courses including mathematics and theoretical foundations of computer science, one major elective course and one general elective course in the fourth semester. In the third year, elective modules consisting of three courses each are offered. The student is required to choose two modules. In addition there is one compulsory course in each semester and one general elective course in the spring semester. The general electives are chosen from appropriate courses offered in the available study programs at the University of Ljubljana.

The study program concludes with an undergraduate 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 application oriented study program leads to the degree “diplomirani inženir računalništva in informatike (VS)”, abbr. “dipl. ing. rač. (VS)”.

The first year consists of core-curriculum courses, while the remaining two years are structured so that the students can choose from a 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 30 ECTS 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, 78 ECTS are major electives, 12 ECTS are general electives, 18 ECTS is practice within the industry and 6 ECTS is the undergraduate thesis.

The general electives are chosen from appropriate courses offered in 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 and Algorithms and Data Structures I	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, Algorithms and Data Structures II	6	
	Information Systems Strategic Planning	Information Systems Development	6	
	Multimedia Content Production	Digital Signal Processing, Algorithms and Data Structures I, Algorithms and Data Structures II	6	
	Parallel and Distributed Systems and Algorithms	Algorithms and Data Structures I, Algorithms and Data Structures II	6	
	System Software	Algorithms and Data Structures I, Algorithms and Data Structures II	6	
	Process Automation	Input-Output Systems	6	
	Embedded Systems	Input-Output Systems, Algorithms and Data Structures II	6	
	Robotics and Machine Perception	Computer Graphics, Artificial Intelligence, Algorithms and Data Structures II	6	
	Game Technology and Virtual Reality	Algorithms and Data Structures I, Algorithms and Data Structures II, Computer Graphics, Artificial Intelligence	6	
	Decision Systems	Data Mining, Algorithms and Data Structures II	6	
	Numerical Methods		6	
	Spring	Industrial Practice		18
		General elective		6
Diploma Thesis			6	

FRI

Interdisciplinary 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)”, abbr. “dipl. ing. rač. mat. (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, a major elective with a work load of 5 ECTS chosen among the courses offered at the Faculty of Mathematics and Physics, and general electives with a total load of 10 ECTS. The study program concludes with an undergraduate thesis with a work load of 4 ECTS in the last semester.

FIRST YEAR COURSES:

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

SECOND YEAR COURSES:

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

THIRD YEAR COURSES:

Title	ECTS
Numerical methods	7
Communication and Project Management	6
Probability and Statistics	10
Elective module, courses 1 and 3	12
Elective module, course 2	6
Major elective	5
General electives	10
Undergraduate thesis	4

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

FRI

Interdisciplinary University Study Program Administrative Information Systems

The study program is offered jointly by the Faculty of Administration and the Faculty of Computer and Information Science and leads to the title “diplomirani upravni informatik”.

The joint study program is designed to provide students with knowledge in computer technologies, internet and new information technologies as well as in administration-legislation, economics and management, required for understanding public and business administration.

The first year consists of core courses in both fields with 6 ECTS of elective subjects, while the second and third year courses provide the students with a broad understanding of both study fields. The program concludes with a diploma thesis with a work load of 16 ECTS in the last semester.

FIRST YEAR COURSES:

Title	ECTS
Introduction to Programming	6
Theory of Public Administration	8
Basic Economics	7
Theory of Organisation	7
Fundamentals of Probability and Statistics	6
Informatics	8
Programming and Algorithms	6
Database Basics	6
Elective subjects	6

SECOND YEAR COURSES:

Title	ECTS
Methods and Techniques for Decision-Making Process Support in Public Administration	4
Computer Communication	6
Introduction to Artificial Intelligence	6
Legislative Regulation of Public Administration	6
Human Resource Management in Public Administration	7
Business Process Informatisation in Public Administration	7
Data management technologies	6
Web Programming	6
Elective subjects	12

THIRD YEAR COURSES:

Title	ECTS
Communication and Project management	6
Planning and Governance	6
Information Systems Development	6
Administrative Procedure and Judicial Review of Administrative Acts	8
Information Systems in Public Administration	6
Management in the Public Sector	6
E-business	6
Thesis	16

FRI

Master Study Program Computer and Information Science

The program leads to the degree “magister inženir računalništva in informatike”, abbr. “mag. inž. rač”.

The first year consists of 4 mandatory courses including mathematics and core-curriculum topics in computer and information science, 4 major elective courses and 2 general elective courses. In the second year, students choose 6 additional major elective courses, while a work load of 24 ECTS is devoted to the preparation of the master thesis.

FIRST YEAR COURSES

Title	ECTS
Mathematics II	6
Programming	6
Major elective	6
Major elective	6
General elective	6
Algorithms	6
Computer systems	6
Major elective	6
Major elective	6
General elective	6

SECOND YEAR COURSES

Title	ECTS
Major elective	6
Major elective	6
Major elective	6
Major elective	6
Major elective	6
Major elective	6
Master thesis	24

MAJOR ELECTIVE COURSES

Title	ECTS
Artificial Intelligence	6
Wireless Sensors Networks	6
Unconventional Computing	6
Perception in Cognitive Systems	6
Biomedical Signal and Image Processing	6
Advanced Software Development Methods	6
Digital Signal Processing	6
Computability and Computational Complexity	6
E Learning	6
Machine Learning	6
Introduction to Bioinformatics	6
Information Security and Privacy	6
Numerical Mathematics	6
Computer Sound Production	6
Soft and Natural Computing Algorithms	6
Data Mining	6
IT Governance	6
Information and interaction design	6
Cryptography and Computer Security	6
Exploiting Processors' Performance	6
Computer Forensics	6
Contemporary Approaches in Information Systems Development	6
Discrete Mathematics	6
Management of production and service processes	6
Cloud Computing	6
Computational topology	6



FRI

Master Study Program Computer Science and Mathematics

The program leads to the degree “magister inženir računalništva in matematike”, abbr. “mag. inž. rač. mat.”

The first year consists of 2 mandatory and 2 elective courses in computer science, 5 elective courses in mathematics, and a total of 11 ECTS is devoted to general elective course. The second year consists of only elective courses: 4 in mathematics, 3 in computer science and 1 in either mathematics or computer science. In addition, a work load of 17 ECTS is given to the preparation of the master thesis which is distributed throughout the spring semester of the second year. Among the mathematics elective courses, the students are required to choose 4 out of the group A and 5 out of the group B in the list of courses.

FIRST YEAR COURSES

Title	ECTS
Major elective in mathematics	5
Major elective in mathematics	5
Major elective in mathematics	5
Major elective in computer science	6
Major elective in computer science	6
General elective	3
Algorithms	6
Computer systems	6
Major elective in mathematics	5
Major elective in mathematics	5
General elective	8

SECOND YEAR COURSES

Title	ECTS
Major elective in mathematics	5
Major elective in mathematics	5
Major elective in computer science	6
Major elective in computer science	6
Major elective in mathematics	5
Major elective in mathematics	5
Major elective in computer science	6
Major elective in mathematics or computer science	5
Master thesis	17

MAJOR ELECTIVE COURSES IN COMPUTER SCIENCE

Title	ECTS
Artificial Intelligence	6
Perception in Cognitive Systems	6
Advanced Software Development Methods	6
Digital Signal Processing	6
Computability and Computational Complexity	6
Machine Learning	6
Introduction to Bioinformatics	6
Soft and Natural Computing Algorithms	6
Data Mining	6
Information and interaction design	6
Contemporary Approaches in Information Systems Development	6
Theory of programming languages	6

MAJOR ELECTIVE COURSES IN MATHEMATICS, GROUP A

Title	ECTS
Logic in computer science	5
Computer aided geometric design	5
Computational geometry	5
Coding theory and cryptography	5
Probability methods in computer science	5

MAJOR ELECTIVE COURSES IN MATHEMATICS, GROUP B

Title	ECTS
Data analysis and visualization	5
Selected topics in computational mathematics	5
Selected topics in numerical analysis	5
Selected topics in game theory	5
Mathematics by computer	5
Symbolic computation	5
Graph theory	5
Selected topics in discrete mathematics	5
Combinatorics 2	5
Optimization methods 2	5
Cryptography and security	5

Doctoral Programs

FRI

The Faculty of Computer and Information Science offers or participates in the following third cycle 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
- Humanistic and Social Sciences, offered jointly with the Faculty of Arts, and the Faculty of Social Sciences.

DOCTORAL PROGRAM IN COMPUTER AND INFORMATION SCIENCE

Doctoral program in Computer and Information Science is designed to deepen the candidate's knowledge of computer science and information technology, while also provided training in soft skills for research and development. We recommend it both to students who intend to pursue careers in academia and to students who intend to carry out demanding and innovative development in the computing industry.

The entire courseware, lectures and exams are in English. The span of the doctoral program is three years.

1st year

The first study year is composed of the qualifying exam, research work, two electives either from FRI's catalogue of offered courses or suitable courses from other departments, two intensive courses in computer science chosen from FRI's offered selection, Research Skills I, Research Skills II, Seminar I and Seminar II.

2nd year

In the second year, the candidate takes part in Seminar III and Seminar IV, but primarily focuses on research which is guided by the candidate's mentor and on which candidate closely collaborates with the chosen laboratory. To advance to the third year the candidate must have an approved thesis topic which includes giving a written description and a defense.

3rd year

The third year is reserved for research and preparation of the doctoral thesis, which the candidate will present within Seminar V.

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

The doctoral program is comprised of

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

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, preparing 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
- Artificial Intelligence
- Computer Systems
- Informatics
- Selected Topics from Software Development
- Mathematical Methods in Computer Sciences

The other two elective courses can be chosen from the above list or from other doctoral study programs at the University of Ljubljana or other universities with combined workload of at least 10 ECTS.

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 Undergraduate, Master, and Doctoral theses research) at the Faculty of Computer and Information Science are performed in twenty research laboratories that are organized into six groups. The main sources of research funding are the Slovenian Research Agency, the Ministry of Education, Science, Culture and Sport, the Ministry of Defense, European Union programs (COST, 6th and 7th Framework Programme), EU structural funds, industry partners, and various bilateral programs including those in USA, France, Austria, Czech Republic, Norway, Portugal, Greece and the UK. The Ministry of Education, Science, Culture and Sport, together with the Slovenian Research Agency also supports the majority of postgraduate students by means of individual scholarships. Many application projects are financed by Slovenian and European companies.

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

- Microcomputer systems,
- GRID technologies and parallel processing,
- Cloud computing,
- Fuzzy and neuro-fuzzy controllers,
- 3D design, visualization and animation, video editing,
- Process informatics and programmable technologies,
- Short SIMD processing,
- Intelligent RFID systems,
- Cryptography, security, privacy, digital identity management, intrusion detection,
- Digital libraries and multimedia information retrieval,
- 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,
- Data mining, machine learning, data visualization,
- Mobile robotics, applications of artificial intelligence 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, and
- Biomedical computer systems and imaging.

More information on individual laboratories and current projects is provided at the Faculty's web pages at <http://www.fri.uni-lj.si/en>.

Laboratory for Computer Graphics and Multimedia

Head:
Assistant Professor
Dr. Matija Marolt

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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:

- multimedia information retrieval and digital libraries,
- natural user interfaces,
- standards and specifications for educational content,
- e-learning environments and virtual laboratories.

Additionally, we are also active in the development of visualizations, virtual and augmented reality applications, interactive learning systems, and didactic simulations and visualization 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, 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. To support the natural user interface research the laboratory also has some Kinect depth sensors.

RESEARCH PROJECTS

Click to homeland: a multimedia presentation of cultural heritage of Slovenian emigrants (V5-1033). Target Research Programme, Slovenian Research Agency and Government's Office for Slovenians Abroad (2010-2012).

SELECTED PUBLICATIONS

M. Marolt (2012). Automatic Transcription of Bell Chiming Recordings. IEEE Transactions on Audio, Speech and Language Processing, vol 20, no. 3, pp. 844-853.

A. Kavčič. Implementing Content Packaging Standards. Proceedings of the Eurocon 2011, pp. 1-4, 2011.

A. Kavčič. Importance of Standards and Specifications for Electronic Learning Materials. Invited Lecture at SIRIKT 2011. Proceedings of the International Conference Enabling education and research with ICT, SIRIKT 2011, Kranjska Gora, April 2011, pp. 158-164.

M. Marolt. Automatic Transcription of Bell Chiming Recordings. IEEE Transactions on Audio, Speech, and Language Processing, to be published, 2011.

G. Strle, M. Marolt. Etnomuza : digitalni multimedijski arhiv slovenskih ljudskih pesmi in glasbe. Tradit. - Inšt. slov. narodop. Ljublj., 2010, letn. 39, št. 2, str. 149-166.

M. Marolt, M. Lefeber. It's time for a song - transcribing recordings of bell-playing clocks. Proceedings of ISMIR 2010, Utrecht, The Netherlands. 2010.

J. Južna, A. Kavčič. Packaging standards for electronic learning materials. Proceedings of the International Conference Enabling education and research with ICT, SIRIKT 2010, Kranjska Gora, April 2010, pp. 644-650. 2010.



Multi-touch table

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

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.

Laboratory for Biomedical Computer Systems and Imaging

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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 physiological phenomena, using computers in modeling and understanding of physiologic relationships, locally and remotely monitoring physiologic events, graphically displaying anatomic details and physiologic functions, visualizing and representing biomedical signal and imaging data, developing standardized databases to study physiologic mechanisms and to evaluate the performance and robustness of recognition techniques, characterizing data, establishing detection criteria and recognition techniques to automatize the analysis of bioelectric patterns to a high a degree as possible, examinations, procedures, and medical practice, in order to improve the quality and reliability of examinations, and to interpret data and 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 accurately detecting transient ischemic events and classifying true ischemic events from non-ischemic 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 distributing the 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 ischemic and non-ischemic 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 ischemia. See:

- <http://www.physionet.org/physiobank/database/ltstadb/> and
- <http://www.physionet.org/challenge/2003/>.

From 2007 the database is publicly available. See also:

- <http://lbsci.fri.uni-lj.si/database/>.

The next research topic is the 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 the human annotations to the LTST DB is under GNU General Public License and is available at <http://www.physionet.org/physiobank/database/ltstadb/semia/>.

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

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

Another research topic concerns the 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.

Another research topic is automated detection of macula in retinal images and quantitative assessment of auto fluorescence in retinal images.

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. Maintenance 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

The laboratory owns two high-speed electroencephalographic recording devices to record and monitor electroencephalogram (EEG) signals and one EEG Holter recorder.

RESEARCH PROJECTS

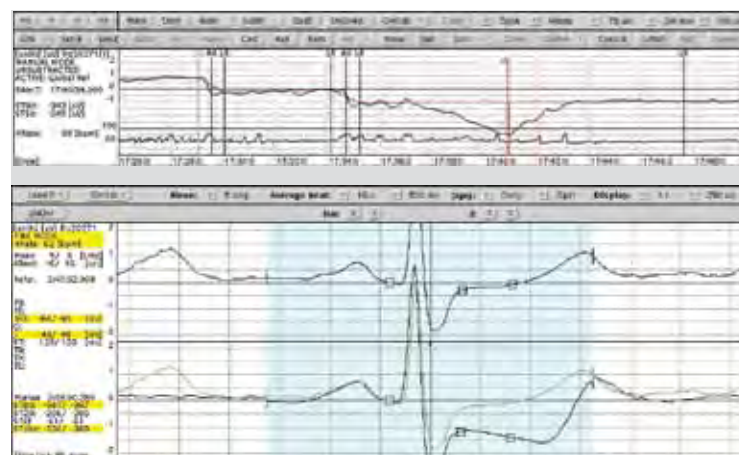
Metabolic and inborn factors of reproductive health, birth (P30124). Research Programme, Slovenian Research Agency (2004–2014).

LABORATORY GUESTS

Ms.C. Cattleya Duanggate, Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand. From 1. 10. 2012. Lotus project, Doctorate exchange and degree.

RESEARCH VISITS

Franc Jager: Massachusetts Institute of Technology, Cambridge, USA, Laboratory for computational physiology, 22. 8 - 26. 8. 2012. The purpose of visit was joint work on enhancement of the Term-Preterm ElectroHysteroGram Database (TPEHG DB) (in the scope of P30124 research project) which we developed and posted on Physionet. The database (<http://www.physionet.org/pn6/tpehgdb/>) is intended to serve as a reference set for developing automated techniques to predict preterm birth; and on enhancement of the Long term ST Database (LTST DB) with newly derived feature-vector time series of Karhunen-Loeve coefficients.



SEMIA, Version 3.0, semi-automated interactive graphic editing tool to annotate ambulatory ECG records

SELECTED PUBLICATIONS

A. Smrdel and F. Jager. Automatic classification of long-term ambulatory ECG records according to type of ischemic heart disease. *BioMedical Engineering OnLine*, 10: 107, 2011.

A. Mincholé, F. Jager and P. Laguna. Discrimination between ischemic and artifactual ST segment events in Holter recordings. *Biomedical signal processing control*, 5: 21-31, 2010.

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. 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.

F. Jager, A. Taddei, G.B. Moody, M. Emdin, G. Antoliè, 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. Guidelines for assessing performance of ST analyzers. *Journal of Medical Engineering & Technology*, 22(1): 25-30, 1998.

Laboratory of Adaptive Systems and Parallel Processing

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RESEARCH ACTIVITIES

The main research topics include: soft computing, adaptive systems, parallel processing, information theoretic modeling, evolutionary biosynthesis, natural computing algorithms, and reinforcement learning supported by Monte Carlo methods. 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 a parallel processing approach or guided exploration.

The first paradigm requires learning by example 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 sub-cell structures with Boolean networks, and new efficient methods for data clustering.

For the second paradigm we are focusing on parallel cluster programming by using MPI and OpenMP libraries, and parallel processing within different Grid environments like Condor and Microsoft HPC Server. We are also involved in the programming of natural computing algorithms and information-theory based algorithms on graphical processors using NVidia CUDA tools and libraries.

The third paradigm comprises reinforcement learning and Monte Carlo methods. We are researching Monte Carlo Tree Search extensions to direct the exploration of sub-optimal solutions in very large state spaces.

EQUIPMENT

nVidia Tesla C2050 GPU Computing Processor, Computing cluster, FPGA design boards

RESEARCH PROJECTS

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

Dubai duty free high bay rack warehouse control system. Industry Funded Project, Iskra Impuls (2012-2013).

RESEARCH VISITS

Branko Šter: Warsaw University of Technology, Institute of Control and Industrial Electronics, Poland, 25. 6. 2012 – 27. 7. 2012. Research work.

SELECTED PUBLICATIONS

N. Ilc, A. Dobnikar: Generation of a clustering ensemble based on a gravitational self-organizing map. *Neurocomputing* 96: 45-56, 2012.

U. Lotrič, P. Bulič: Applicability of approximate multipliers in hardware neural networks. *Neurocomputing*, 96: 57-65, 2012.

N. Ilc. Modified Dunn's cluster validity index based on graph theory. *Prz. Elektrotech.*, 2: 126-131, 2012.

D. Sluga, T. Curk, B. Zupan, U. Lotrič. Acceleration of information-theoretic data analysis with graphics processing units. *Prz. Elektrotech.* 2: 136-139, 2012.

B. Šter, R. Gaber, M. Avbelj, R. Jerala, A. Dobnikar. Design of information processing in cells using artificial gene repressors. *Prz. Elektrotech.*, 2: 105-109, 2012.

A. Dobnikar, U. Lotrič, B. Šter (ur.): Adaptive and natural computing algorithms: 10th international conference ICANNGA 2011, Ljubljana, Slovenia, April 14-16, 2011, Lecture notes in computer science, 6593, 6594, Berlin, Heidelberg, Springer, 2011.

J. Zupanc, D. Drobne, B. Šter: Markov random field model for segmenting large populations of lipid vesicles from micrographs. *Journal of liposome research*, 21: 215-323, 2011.



We organize the annual competition in mobile robotics Robo Liga FRI. Student teams from technical and science faculties compete with LEGO Mindstorms NXT sets in solving a challenging task

J. Zupanc, A. Dobnikar, D. Drobne, J. Valant, D. Erdogmus, E. Bas: Biological reactivity of nanoparticles: mosaics from optical microscopy videos of giant lipid vesicles. *J. biomed. opt.*, 16: 026003:1-10, 2011.

C. Silva, U. Lotrič, B. Ribeiro, A. Dobnikar: Distributed text classification with an ensemble kernel-based learning approach. *IEEE trans. syst. man cybern., Part C Appl. rev.*, 40: 287-297, 2010.

A. Dobnikar, B. Šter: Structural properties of recurrent neural networks. *Neural Process. Lett.*, 29: 75-88, 2009.

Laboratory for Computer Architecture

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RESEARCH ACTIVITIES

Research activities cover computer architectures, software-hardware co-design, parallel processing, embedded systems, programmable logic, soft computing, radiofrequency identification (RFID), and supply chain management.

A majority of research activities include the development of approximate arithmetic circuits for signal processing and adaptive systems. Analysis and research are oriented to the solution of approximate multiplier applicability and squarer in hardware implementation of DSP algorithms and neural networks where a shorter time delay of proposed methods and efficient implementations is more important than accuracy. Another part of work is dedicated to GPU implementation of algorithms for automatic analysis of remote sensing images.

Furthermore, the research activities also include studies and development of cold chain control and shelf life prediction by using radiofrequency identification technology (RFID) in supply chain management and wireless tracking of objects to acquire the information used in traceability



QR code used to access traceability data (RFID-F2F)

systems. For larger amount of collected data is very important to build classification and prediction models by using neural networks, support vector machines (SVMs) and some new methods applicable in design of intelligent RFID systems, or pervasive computing research oriented towards Internet of Things.

Moreover, our research activities also include the field of heterogeneous parallel computing and architectures. Currently we are focusing on the field of self-adaptive strategies for heterogeneous architectures, specifically mixed multi- and many-core systems. The self-adaptive strategies are intended for problems that have a non-constant complexity during the run-time. With these strategies we modify the execution environment (i.e. load-balancing, thread organization, merging the workloads and other auto-tuning procedures) of the application during run-time in order to meet one of the following constraints: the real-time constraint or the power consumption constraint.

RESEARCH PROJECTS

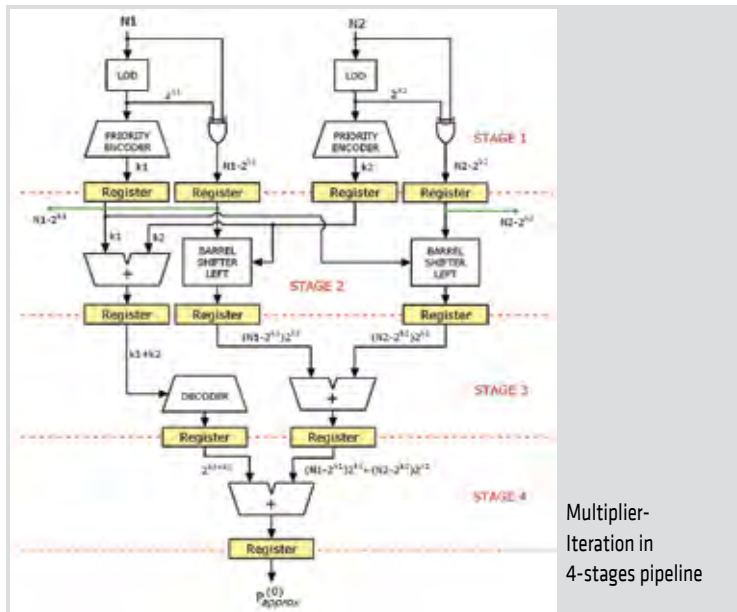
RFID-F2F, RFID from Farm to Fork. CIP-ICT-PSP European project, European Commission (2010-2012), finished in August 2012.

LABORATORY GUESTS

Aleksej Avramović, Faculty of Electrical Engineering, University of Banja Luka. 23. 9. 2012 – 28. 9. 2012. Collaboration on “Approximate squaring circuits for DSP”.

RESEARCH VISITS

Mira Trebar: University of Cartagena, Spain, 12. 3. 2012 – 17. 3. 2012. Research collaboration on “RFID technology in solving traceability problem in EU F2F-RFID project”.



Rok Češnovar: University of Paderborn, Germany, 13. 9. 2012 – 14. 10. 2012. Research visit on the topic of “Self-adaptive strategies for heterogeneous many-/multi-core systems”.

SELECTED PUBLICATIONS

- U. Lotrič, P. Bulić. Applicability of approximate multipliers in hardware neural networks. *Neurocomputing* 96: 57-65, 2012.
- P. Bulić, V. Guštin, D. Šonc, A. Štrancar. An FPGA-based integrated environment for computer architecture. *Computer applications in engineering education*, 2011, in press.
- A. Parreno Merchante, A. Alvarez Melcon, M. Trebar, A. GRAH, P. Filippin. Improvement of traceability processes in the farmed fish supply chain. *LISS 2012 : proceedings of 2nd International Conference on Logistics, Informatics and Service Science, Beijing, China*, vol. 2, pp. 373-379, 2012.
- V. Risojević, A. Avramović, Z. Babić, P. Bulić. A simple pipelined squaring circuit for DSP. *XXIX IEEE International Conference on Computer Design, ICCD 2011: pervasive computing*, Amherst, MA, USA, pp. 162-167, 2011.
- Z. Babić, A. Avramović, P. Bulić. An iterative logarithmic multiplier. *Microprocessors and Microsystems*, vol. 35, no. 1, pp. 23-33, 2011.
- P. Bulić, T. Dobravec. An approximate method for filtering out data dependencies with a sufficiently large distance between memory references. *Journal of Supercomputing*, vol. 56, no. 2: pp. 226-244, 2011.
- R. Češnovar, P. Bulić, T. Dobravec. Optimization of a single seam removal using a GPU. *The 17th International Conference on Parallel and Distributed Processing Techniques and Applications, PDPTA*, pp. 330-335, Las Vegas, USA, 2011.

M. Trebar A. Grah, A. MELCON, A. PARRENO, Towards RFID traceability systems of farmed fish supply chain. *Proc. of 19th International Conference on Software, Telecommunications and Computer Networks, SoftCOM 2011*, pp. 1-6, Split, Croatia, 2011.

L. Finžgar, M. Trebar, Use of NFC and QR code identification in an electronic ticket system for public transport. *Proc. of 19th International Conference on Software, Telecommunications and Computer Networks, SoftCOM 2011*, pp. 1-6, Split, Croatia, 2011.

I. Cuinas, L. Catarinucci, M. TREBAR, RFID from Farm to Fork: traceability along the complete food chain. *Proc. of PIERS 2011 in Marrakesh March 20-23: The Electromagnetics Academy*, pp. 1370-1374, Marakesh, Morocco, 2011.

Computer Communications Laboratory

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RESEARCH ACTIVITIES

The main research interests of our laboratory members are communication protocols, formal protocol validation and testing, computer networks design, distributed systems design and development, computing clouds and grid architectures, service oriented architecture with related technologies, network security and security policies, sustainable ICT and practical use of agile methodologies for the development of software and information systems.

In 2012, we have researched most actively the following areas:

- In the area of e-learning, we have built our virtual laboratory in a cloud for teaching computer communications and other courses. The infrastructure of eleven servers was used by more than 400 students, most of them with at least three virtual machines. 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: how to enable our students to perform complex exercises that include multiple servers, diverse network topologies and other resources 24/7, regardless of their location.

- Our research also included hybrid public-private clouds, sky computing and integration of several e-learning related systems in a cloud. Further we made a proof of concept of virtual cloud possibilities for learning cloud administration in a cloud environment.
- In the area of communication protocols, we have researched IPv4 to IPv6 transition mechanisms and routing protocols in vehicular networks. Further, we have tested identity management, authentication, authorization and remote administration protocols integration in large production environments and in cloud systems.
- In cooperation with University of Ljubljana's IT department we are researching identity management and application integration technologies and systems.
- In the area of agile methodologies, we have studied the impact of test-first programming on productivity, code complexity, tests properties (branch coverage) and the mutation score indicator.

EQUIPMENT

Besides the typical office equipment, the Computer Communications Laboratory is equipped with a few pieces of advanced networking / cloud computing 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 (2 TB), 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, a private cloud consisting of 11 Dell PowerEdge QuadCore R200 servers each with four Gigabit Ethernet ports and an Infiniband SDR 10 Gb/s connection, 4 Dell PowerEdge



Cloud computing - physical infrastructure: servers, storage, Infiniband switch

DualCore Servers and 2 Dell PowerEdge Dual Xeon Processor servers, 4 802.11b/g/n wireless 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, Redmine project management software, Moinmoin Wiki, Microsoft development tools and utilities; several open-source Java development tools and utilities including Mobile Phone development utilities, ...

RESEARCH PROJECTS

Integration module Esperanto and Identity portal maintenance for the University of Ljubljana. Industry-Funded Project, University of Ljubljana (2011-2012).

Identity management, remote administration and cloud architecture in Iskratel. Industry-funded project, Iskratel d.d. (2012-2012).

EPSIAE - Green IT: Entering Sustainability within academic ICT studies. European Project (Framework Programmes), European Commission (2010-2013).

KC CLASS - Cloud Assisted Services (3211-10-000467), Structural Funds Project, EU and Ministry of education, science, culture and sport (2011-2013).

LABORATORY GUESTS

Dr. Pedram Hayati, Senior Security Consultant, Stratsec Security / Curtin University, Australia. 16. 12. – 30. 12. 2012. Exploring vulnerability of different cloud service providers regarding malicious usage by a new generation of botnet known as botcloud - a C&C botnet operated from the Cloud infrastructure.

RESEARCH VISITS

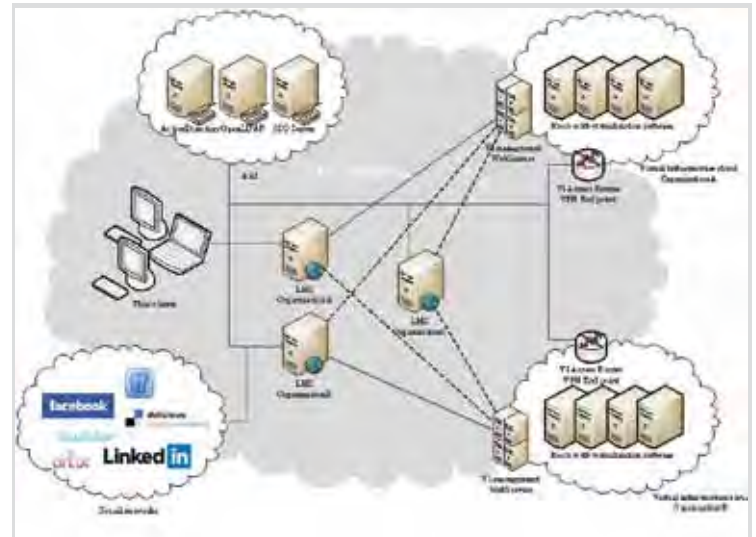
Andrej Krevl: InHolland University of Applied Sciences, Amsterdam, Netherlands, 25.3.2012 – 31.3.2012. Research of sustainability-related contents within academic ICT studies.

SELECTED PUBLICATIONS

N. Škoberne, O. Maennel, I. Phillips, R. Bush, J. Žorž, M. Ciglarič. IPv4 Address Sharing Mechanism Classification and Trade-Off Analysis. IEEE Transactions on Networking 2012 (under final review).

M. Pančur, M. Ciglarič. Impact of test-driven development on productivity, code and tests: A controlled experiment, *Information and Software Technology* 53 (2011), pp. 557-573 DOI information: 10.1016/j.insof.2011.02.002.

N. Škoberne, M. Ciglarič. Practical Evaluation of Stateful NAT64/DNS64 Translation, *Adv. electr. comput. eng.*, 2011, vol. 11, no. 3, pp. 49-54. <http://www.aece.ro/abstractplus.php?year=2011&number=3&article=8>.



Virtual laboratory in a cloud: architecture

M. Ciglarič, A. Krevl, M. Jeličič, A. Brodnik. Laboratory as a service: architecture, implementation and experiences. *Asia-Pac. collab. educ. journal*, 2010, vol. 6, no. 2, str. 69-86.

M. Ciglarič, S. Mavsar. Raziskovanje omrežnih napadov: muholovec Simx. *Elektroteh. vestn.*, 2010, letn. 77, št. 4, str. 173-178.

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.

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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.

M. Ciglarič, T. Vidmar: Use of Internet Technologies for Teaching Purposes, *European Journal of Engineering Education*, Vol. 23, No. 4, 1998, pp. 497 – 502.

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RESEARCH ACTIVITIES

The principal scientific research directions of the laboratory are alternative processing platforms and methods of the future as well as soft computing applied to modeling of biological systems. A lot of effort is dedicated to the research of computational biology, ternary processing using Quantum-dot Cellular Automata and fuzzy logic based collective behavior. Our results have been published in Nanotechnology and Animal Behavior, the most respectable journals in their respective fields. The laboratory consists of three active groups, the Computational Biology Group, the Quantum-dot Cellular Automata Group, and the Collective Behavior Group.

The Computational Biology group in cooperation with the National Institute of Chemistry of Slovenia studies synthetic biology structures used for processing in biological systems. Research is oriented towards

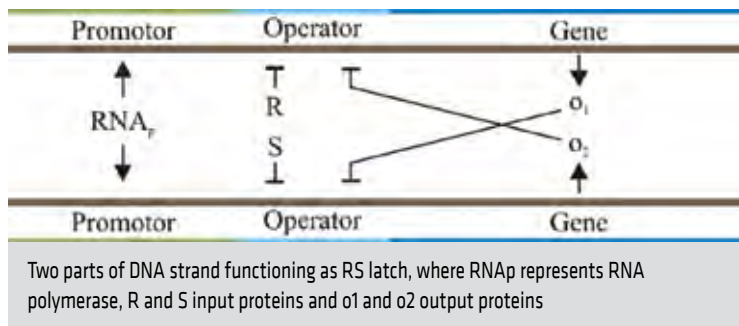
the establishment of new modeling approaches, parameter estimation techniques, sensitivity and robustness analyses and performance evaluation. The goal is to fully automatize the design of synthetic biological systems with predefined functionalities. The laboratory members working in this field attended the iGEM 2012 student competition as mentors to the modeling part of team Slovenia, which among others achieved best model prize and second absolute position among 190 teams. The laboratory members are also developing new modeling methods in the field of cancer treatment with photodynamic therapy (PDT) in cooperation with R. E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology.

The Quantum-dot Cellular Automata group is involved with studies of nano-scale devices capable of performing computation at very high switching speeds and consuming extremely small amounts of electrical power. The devices have been proposed in 1993 by Craig Lent, et al. as a physical implementation of an automaton using quantum-dot cells and combine the discrete nature of both cellular automata and quantum mechanics. Lent's automaton is intended as a binary processing platform that will eventually replace the current transistor switching circuits. The proposal quickly gained popularity and it was first fabricated in 1997. Our group with the premise that future processing platforms should not disregard the advantages of multi-valued processing extended Lent's automaton so that it supports ternary processing. Our research activities are concentrated on the general problem of planning and routing in quantum-dot cellular automata, the analysis of the ternary quantum-dot cell parameter space, but mostly with processing structures implemented using ternary quantum-dot cells.

The Collective Behavior group uses soft computing methods to model coordinated behavior in biological systems. Animal groups such as fish schools, insect swarms and bird flocks are frequently admired in awe as they exhibit complex coordinated behavior. May these behaviors result from social interactions among individuals or be fruit of our pattern seeking mind we are researching soft computing algorithms that allow controlled entities to display behaviors similar to those observed in nature. Our aim is to support Biologists in forming or proving their hypotheses about why and how animal groups behave as they do. Our group, under the premise that most of the existing knowledge about the behavior of bird flocks is available in the form of descriptions and explanations of the perceived behavior collected by field ornithologists, developed a fuzzy logic based computer model of bird flocking which uses fuzzy logic to describe an individual's drives. Simulations performed using the model present behavior remarkably similar to behaviors of natural flocks. Our research activities are concentrated on the extension of the model to support studies of various collective behaviors, such as: bird flocks landing and takeoff, sensory system studies, predator/prey relations, and flocking behavior under predation.

RESEARCH PROJECTS

Pervasive computing (P2-0359). Research Programme, Slovenian Research Agency (2009-2012).



KC OPCOMM - Open Communication Platform for Service Integration (3211-10-000468), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

RFID-F2F, RFID from Farm to Fork. CIP-ICT-PSP European project, European Commission (2010-2012).

Computer vision for mobile computing and interaction (J2-221). Basic Research and Application Project, Slovenian Research Agency (2009-2012).

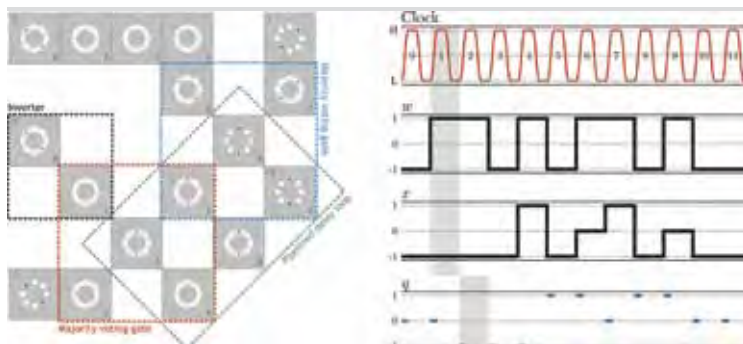
LABORATORY GUESTS

Hristo Petrov, Technical University of Varna, Varna, Bulgaria. June-September 2012. Internship.

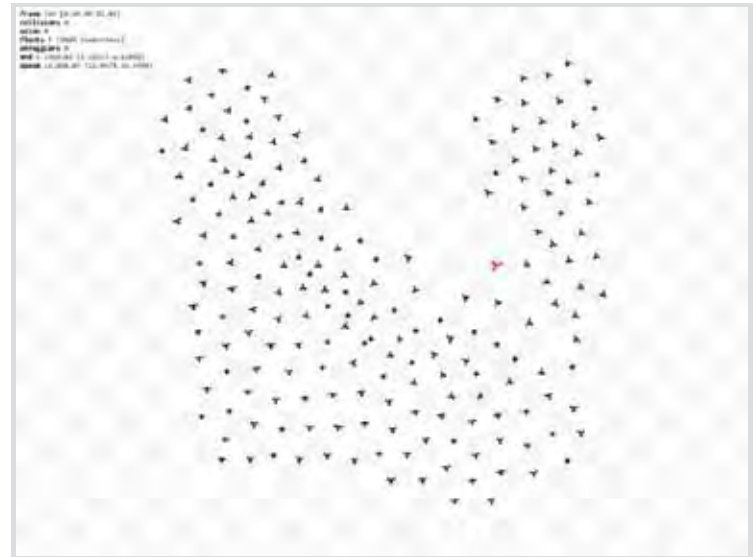
Denitsa Tranova, Technical University of Varna, Varna, Bulgaria. June-September 2012. Internship.

Ivan Rusev, Technical University of Varna, Varna, Bulgaria. June-September 2012. Internship.

Hristo Hristoskov, Technical University of Varna, Varna, Bulgaria. October 2011-January 2012. PhD thesis research



The balanced ternary quantum-dot cellular automata memorizing cell WX, with prerequisite $w \neq 0$, 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



A frame from synflocks, our fuzzy logic based bird behavior simulator, using which we are currently investigating predator/prey relations, more precisely the interplay of flocking behavior and various predation strategies

SELECTED PUBLICATIONS

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M. Moškon, M. Mraz. Modelling and analysing the information processing capabilities of simple biological systems. *Math. model. anal.*, Sep. 2012, vol. 17, no. 4, p. 467-484.

M. Janež, P. Pečar, M. Mraz. Layout design of manufacturable quantum-dot cellular automata. *Microelectron. j.*, Jul. 2012, vol. 43, no. 7, p. 501-513.

M. Moškon, Š. Novak, M. Medeot, I. Lebar Bajec, N. Zimic, M. Mraz. Solving the logistic problems with optimal resource assignment using fuzzy logic methods, accepted for publication in *Journal of Advanced Transportation*, 2011.

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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.

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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 methodologically socio-technical suitability to both organization and project-specific requirements. From this 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, IPMIT, ZZI. We have also developed a Unified methodology for information systems development – EMRIS for Government Centre for Informatics. We also developed a model of resistance to change that evaluates the economic risks of using specific parts of information systems. The model is currently being applied in NLB (the largest Slovenian bank) and Employment Service of Slovenia.

IT/IS Strategy Planning and Enterprise Architecture. Strategy planning is one of the research areas that have been traditionally present in the Information systems laboratory since its existence. In the period between 2004 and 2008 we published several methodologies that focus on how to build strategic plans for information systems. In the last edition we integrated an enterprise architecture framework, which enables the design of strategic enterprise architecture during plan development. These methodologies are based on many years of practical experiences in developing strategic plans for a wide range of organizations. We developed strategic plans for the following organizations: the Employment Service of Slovenia, KAD (financial institution), Elektro Ljubljana (electricity distribution operator), ELES (Slovenian electric power transmission company), Slovenian electricity distribution operators association, Informatika, d.d., Mobitel (Slovenian mobile telephony operator) and government institutions. Recently, we also developed enterprise architectures, organized and executed workshops for Iskratel (telephony and networks solutions developer) and Employment Service of Slovenia. In the context of IT/IS planning we focus our research on: enterprise architecture, IS/IT architectures, information systems reengineering, business process reengineering, electronic business, COBIT and other IT governance 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, modeling multi-agent systems, using agent oriented modeling languages (AML, AUML) and other agent based methodologies. We focus on the 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 the 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 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 analyze IT processes in different organizations. IT process analyses are performed with regard to COBIT model and ITIL standards. We also analyze the efficiency of the informatics in the organizations and their business information architectures.

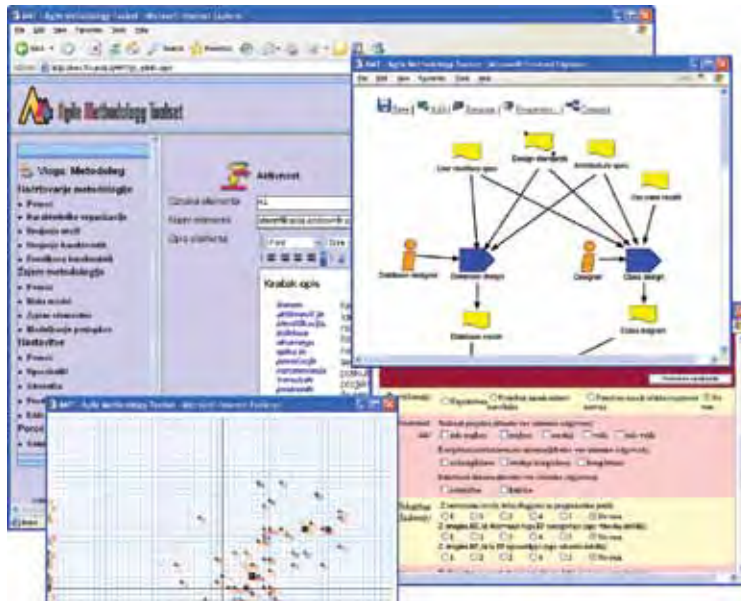
SOA – Service Oriented Architecture. Service-Oriented Architecture (SOA) is a collection of loosely-coupled, distributed services which communicate and interoperate via agreed standards. A service is a mechanism to enable access to one or more capabilities, where said access is provided using a prescribed interface and is exercised consistently 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 organization to address new business requirements in 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 this 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 systems development. We developed IS reengineering and the development of SOA based enterprise architecture for Slovenian electricity distribution operators association.

RESEARCH PROJECTS

KC CLASS - Cloud Assisted Services (3211-10-000467), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

KC OPCOMM - Open Communication Platform for Service Integration (3211-10-000468), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

Pervasive computing (P2-0359), Research Programme, Slovenian Research Agency (2009-2012).



Screenshot of the AMT system

LABORATORY GUESTS

Olegas Vasilecas, Gediminas Technical University, Lithuania. November 2012. Research work in the field of information systems development methodologies, business rules and ontologies.

Jan Mendling, Institute for Information Business at Wirtschaftsuniversität Wien (WU Vienna), Austria. 1.6.2012 - 31.8.2012. Lecture: Automatic Derivation of Service Candidates from Business Process Model Repositories.

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T. Hovelja, O. Vasilecas, R. Rupnik. A model of Influences of Environmental Stakeholders on Strategic Information Systems Planning Success in an Enterprise. Technological and Economic Development of Economy. In press.

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M. Trkman and P. Trkman. A wiki as intranet : a critical analysis using the Delone and McLean model. Online inf. rev., vol. 33, no. 6, pp. 1087-1102, 2010.

D. Vavpotič, M. Bajec. An approach for concurrent evaluation of technical and social aspects of software development methodologies. Information and software technology, vol. 51, no. 2, pp. 528-545, 2009.

Sasa, Ana; Juric, Matjaz; Krisper, Marjan: Service-Oriented Framework for Human Task Support and Automation, IEEE Transactions on Industrial Informatics, vol. 4(4), 2008.

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RESEARCH ACTIVITIES

The Laboratory of e-media is actively involved in research areas of security, privacy and trust management with an emphasis on cryptographic protocols, formal methods, security infrastructure systems like PKI and AAA. In addition, the laboratory's research activities cover quantitative modeling of human factor, aimed at the development of solutions that support decision making for the management of information systems and critical infrastructures. The foundations for these activities are methodologies like system dynamics and quantitative assessment dynamics (QAD).

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 the management of information systems security, and technological solutions for trust management in global networks. Furthermore, our research results have been published in renowned international journals (like those published by Elsevier and IEEE), and in monographs published by Springer, Francis & Taylor (chapter contribution) and IGI Global (chapter contribution).

Finally, laboratory members are (or have been) nominated to serve on board of important EU and international organizations (e.g., MB of ENISA, ISC NATO Panel). They also serve as reviewers for renowned publishers (of scientific journals and monographs), they are examiners and jury members for PhDs at other EU universities, and lecturers at other universities and international events.

RESEARCH PROJECTS

Pervasive computing (P2-0359), Research Programme, Slovenian Research Agency (2009–2012).

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

COST IC0906 - Wireless Networked Moving Objects. International Project. (2010-1014).

LABORATORY GUESTS

Prof. Dr. Vladimir Zadorozhny, University of Pittsburgh, USA. 4. 7. 2012. Discussions about future scientific collaboration (we already have had one common project proposal submitted), and collaboration in events organized by University of Pittsburgh.

RESEARCH VISITS

Eva Zupančič, B.Sc.: University of Tallin, April – May 2012. Research visit.

INVITED TALKS AND LECTURES

Prof. Dr. Denis Trček.; University of Zurich, Zurich, Switzerland, 4. 10. 2012 – 5. 10. 2012. Short visit and invited talk.

SELECTED PUBLICATIONS

TRČEK, Denis. An integrative architecture for a sensor-supported trust management system. *Sensors*, Aug. 2012, vol. 12, no. 8, pp. 1-14.

TRČEK, Denis. Security metrics foundations for computer security. *Comput. j.*, 2010, vol. 53, no. 5, pp. 1106-1112, doi: 10.1093/comjnl/bxp094.

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TRČEK, Denis, ABIE, Habtamu, SKOMEDAL, Åsmund, STARC, Iztok. Advanced framework for digital forensic technologies and procedures. *J Forensic Sci*, 2010, pp. 1-10, doi: 10.1111/j.1556-4029.2010.01528.x.

TRČEK, Denis, JÄPINNEN, Pekka. RFID security. V: ZHANG, Yan (ur.), YANG, Laurence Tianruo (ed.), CHEN, Jiming (ed.). *RFID and sensor networks : architectures, protocols, security, and integrations, (Wireless networks and mobile communications)*. Boca Raton: Taylor & Francis, 2010, pp. 147-168.

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RESEARCH ACTIVITIES

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

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 fields of fraud management 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



Identification and visualization of patterns of relationships among entities

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 the analysis of entities in the 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 that would otherwise require a lot of time to study. Visualizations are used in many fields (medicine, education, geo-visualizations, data-mining, financial data analysis etc.) and employ different visualization techniques (graphs, cluster diagrams, volume rendering etc.), but just any arbitrary visualization may not be inherently 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: The current version of the World Wide Web consists 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 the fact that information quality cannot always be guaranteed. The 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

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Š. Furlan and M. Bajec. Holistic approach to fraud management in health insurance. In: *Journal of information and organizational sciences*, 2008, vol. 32, no. 2, pp. 99-114.

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RESEARCH ACTIVITIES

Laboratory for Integration of Information Systems has been focusing on the research and development in the field of integration and interoperability of information systems, architectures and platforms. Integration and interoperability is an important topic and covers all aspects of software and information systems development. Laboratory for Integration of Information Systems focuses specifically on software platforms, particularly Java Enterprise Edition and .NET, Service Oriented Architectures (SOA) and Cloud Computing (with focus on IaaS/PaaS/SaaS).

SOA is a set of principles and methodologies for designing and developing software in the form of interoperable services. We research technologies which enable execution, configuration and adaption of business processes in wider and comprehensive scenarios. Cloud Computing represents technologies that provide computation, software, data access, and storage services via the internet. It enables to address new areas and to develop innovative software solutions, IT services, and efficient cost-effective usage of information resources. This technology provides significant progress in the economy, government and academic circles, particularly in the field of competitiveness, business optimization and innovation. Our laboratory conducts research, development and mentoring for the development of complex Java EE and SOA/BPM solutions, e-services and e-content, and Cloud Computing solutions. This allows to address new areas and to find innovative solutions.

In collaboration with important partners such as Oracle, IBM, and Microsoft we are working on many projects that incorporate following research fields and technologies:

- Integration and interoperability methods of information systems,
- Service-Oriented Architecture (SOA) which include:
 - Integrated SOA + BPM life cycle
 - Evaluation and optimization of SOA
 - Management of SOA architecture
 - Service design based on the concept of service science
- Cloud computing (IaaS, PaaS, SaaS):
 - Infrastructure as a Service
 - Platform as a Service
 - Software as a Service
- Multitier architecture
- Java Enterprise Edition, Java EE and .NET platforms
- Architectural and technological aspects of integration and interoperability
- Middleware
- Integration platform technologies
- Service platforms and Web services
- Application and Process Servers

RESEARCH PROJECTS

KC CLASS - Cloud Assisted Services (3211-10-000467), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

KC OPCOMM - Open Communication Platform for Service Integration (3211-10-000468), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

LABORATORY GUESTS

Prof. Dr. Klaus-Dieter Schewe, Johannes Kepler University, Austria, Chief Scientific Officer, Software Competence Center Hagenberg, Austria, 22.

10. 2012. Lecture: An ambient ASM specification of a client-centric cloud interaction architecture.

INVITED TALKS AND LECTURES

Matjaž B. Jurič: Impact of SOA on information system development, 19.9.-21.9.2012, an invited lecture at 23rd Central European Conference on Information and Intelligent Systems, Varaždin, Croatia.

Matjaž B. Jurič: Overview of important innovations in Java EE 7 technologies (Pregled novosti v najpomembnejših Java EE 7 tehnologijah), 17.10.2012, an invited talk at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Matjaž B. Jurič, Gregor Srdić: IBM BPM 7.5 demo presentation (IBM BPM 7.5. demo predstavitev), 4.4.2012, an invited talk at IBM forum 2012-The future is Smart (Prihodnost je modra), Portorož, Slovenia.

Matjaž B. Jurič, Marcel Križevnik, Jernej Zorko: Transactional integration Java EE servers in the case of WebLogic-WebSphere, 29.5.-30.5.2012, invited lecture at 1st conference Java 2012, Zagreb, Croatia.

Matjaž B. Jurič: What's new in Java EE 7 and transitions to cloud, 29.5.-30.5.2012, invited lecture at 1st conference Java 2012, Zagreb, Croatia.

Matjaž B. Jurič: Towards a comprehensive SOA governance model, 10.8.-12.8.2012, invited lecture at International Conference on Management and Service Science (MASS 2012), Shanghai, China.

Rok Povše, Robert Dukarič, Matjaž B. Jurič: Towards a cloud-enabled Java EE platform, 22.10.-25.10.2012, invited lecture at CLASS 2012, Bled, Slovenia.

Robert Dukarič, Matjaž B. Jurič: A unified architecture of IaaS cloud solutions, 22.10.-25.10.2012, invited lecture at CLASS 2012, Bled, Slovenia.

Marcel Križevnik, Matjaž B. Jurič: Transactional integration Java application servers using EJB, JMS and WS-AT (Transakcijsko povezovanje Javanskih aplikacijskih strežnikov z uporabo EJB, JMS in WS-AT), 16.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Aleš Frece, Matjaž B. Jurič: SOA Governance – how to manage and lead introduction to SOA (SOA Governance – kako upravljati in voditi vpeljavo SOA), 15.10.2012, invited talk at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Rok Povše, Jernej Zorko, Matjaž B. Jurič: The development of the interlayer business logic using EJB, JMS and JPA (Razvoj vmesnega sloja poslovne logike z uporabo EJB, JMS in JPA), 17.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Martin Potočnik, Matjaž B. Jurič: Developing web services using JAX-WS and JAX-RS (Razvoj spletnih storitev z uporabo JAX-WS in JAX-RS), 17.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Rok Povše, Matjaž B. Jurič: Web application development using JSF (Razvoj spletnih aplikacij z JSF), 17.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Marcel Križevnik, Matjaž B. Jurič: Developing BMP/SOA applications using Oracle BPM and SOA Suite (Razvoj BPM/SOA aplikacij z uporabo Oracle BPM in SOA Suite), 17.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Matej Hertiš, Matjaž B. Jurič: Moving Java applications into the cloud and cloud interoperability (Prenos Javanskih aplikacij v oblak in interoperabilnost računalniškega oblaka), 16.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Matjaž B. Jurič, Marcel Križevnik: New trends in BPM/SOA and presentation of new developments in BPM Suite and SOA Suite 12c (Novi trendi na področju BPM/SOA ter predstavitev novosti v BPM Suite in SOA Suite 12c), 15.10.2012, invited lecture at 17th Annual SIOUG Meeting, Ljubljana, Slovenia.

Eva Zupančič: Trust and reputation modeling in multi-agent systems, 18.4.2012, invited lecture at University of Technology, Talin, Estonia.

Eva Zupančič, Denis Trček, Kuldar Taveter: Agent-oriented engineering of trust management systems, 15.10.-16.10.2012, invited lecture at 1st International Conference on Agreement Technologies (AT2012), Dubrovnik, Croatia.

Eva Zupančič, Denis Trček, Iztok Starc, Eliot Rich: Analysis of reconnection policies during a major power cut crisis using a system dynamics simulation model, 10.8.-12.8.2012, invited lecture at International Conference on Management and Service Science (MASS 2012), Shanghai, China.

SELECTED PUBLICATIONS

A. Frece, M.B. Jurič. Complete and reusable description of message structural constraints in web service interfaces. *Computer Standards and Interfaces*, 35(2): 218-230, 2013.

M. Križevnik, M.B. Jurič. Data-bound variables for WS-BPEL executable processes. *Computer Languages, Systems and Structures*, 38(4):279-299, 2012.

R. Dukarič, M.B. Jurič. Towards a unified taxonomy and architecture of cloud frameworks. *Future generation computer systems*, pp. 1-29, 2012.

B. Brumen, M. Hölbl, K. Harej, T. Welzer-Družovec, M. Heričko, M.B. Jurič, H. Jaakkola. Learning process termination criteria. *Informatica (Vilnius)*, 23(3):1-16, 2012.

A. Frece, M.B. Jurič. Modeling functional requirements for configurable content- and context- aware dynamic service selection in business process models. *Journal of Vis. Lang. and Comp.*, 23(4):223-247, 2012.

R. Povše, P. Adziewski, B. Paspalovski, M.B. Jurič. Delavnica: JSF 2 – izdelava tehnološkega prototipa za razvoj spletnega nivoja z uporabo JSF 2. 3 zv. (96; 58; 53 str.). Ljubljana, 2012.

R. Povše, M.B. Jurič. Pregled in primerjava tehnologij za spletni sloj v Javi EE. 88 str. Ljubljana, 2012.

M. Križevnik, A. Hrnčič, B. Paspalovski, M.B. Jurič. Razvoj prezentacijskega nivoja z uporabo Java FX 2. 90 str. Ljubljana, 2012.

M. Križevnik, M.B. Jurič. Uporaba dobrih praks pri razvoju spletnih storitev. 43 str. Ljubljana, 2012.

E. Zupančič, D. Trček. Deployment of trust management system in environment of e-commerce. *Lect. notes comput. sci.*, pp. 484-493, 2012.

Laboratory for Algorithms and Data Structures

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RESEARCH ACTIVITIES

The laboratory performs 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

Parallel and Distributed Systems (P2-0095). Research Programme, jointly with Jozef Stefan Institute and Faculty of Electrical Engineering, University of Ljubljana. Slovenian Research Agency (2009-2013).

SELECTED PUBLICATIONS

P. Bulič, T. Dobravec. An approximate method for filtering out data dependencies with a sufficiently large distance between memory references. *J. supercomput.* 56(2):226-244, 2011.

J. Mihelič, B. Robič. Flexible-attribute problems. *Computat. Optimiz. Appl.* 47:553-566, 2010.

J. Mihelič, A. Mahjoub, C. Rapine, B. Robič. Two-stage flexible-choice problems under uncertainty. *Eur.J.Oper.Res.* 201(2):399-403, 2010.

T. Dobravec, B. Robič: Restricted shortest paths in 2-circulant graphs. *Comput. Commun.* 32(4):685-690, 2009.

A. Sulistio, U.Čibej, S.K.Prasad, R. Buyya. GarQ: An efficient scheduling data structure for advance reservations of grid resources. *Int.j.parallel emergent distr.syst.* 24(1):1-19, 2009.

A. Sulistio, U.Čibej, S. Venugopal, R. Buyya, B. Robič. A toolkit for modelling and simulating Data Grids: An extension to GridSim. *Concurr. Comput.* 20(13):1591-1609, 2008.

R. Trobec, M. Šterk, B. Robič. Computational complexity of the parallel meshless local Petrov-Galerkin method. *Comput. Struct.* 87(1,2):81-90, 2008.

B. Robič, P. Korošec, J. Šilc. Ant colonies and the mesh partitioning problem. In Olariu S, Zomaya Y.A. *Handbook of bioinspired algorithms and applications p. 285-319, Chapman e-Hall / CRC, 2006.*

U. Čibej, B. Slivnik, B. Robič. The complexity of static data replication in data grids. *Parallel Comput.* 31:900-912, 2005.

B. Slivnik, B. Vilfan. Producing the left parse during bottom-up parsing. *Inf. Proc. Letters* 96:220-224, 2005.

J. Mihelič, B. Robič. Solving the k-center problem efficiently with a dominating set algorithm. *J.Comput. Inf. Tech.* 13(3):225-233, 2005.

P. Korošec, J. Šilc, B. Robič. Solving the mesh-partitioning problem with an ant-colony algorithm. *Parallel Comput.* 30(5-6):785-801, 2004.

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

Laboratory for Architecture and Signal Processing

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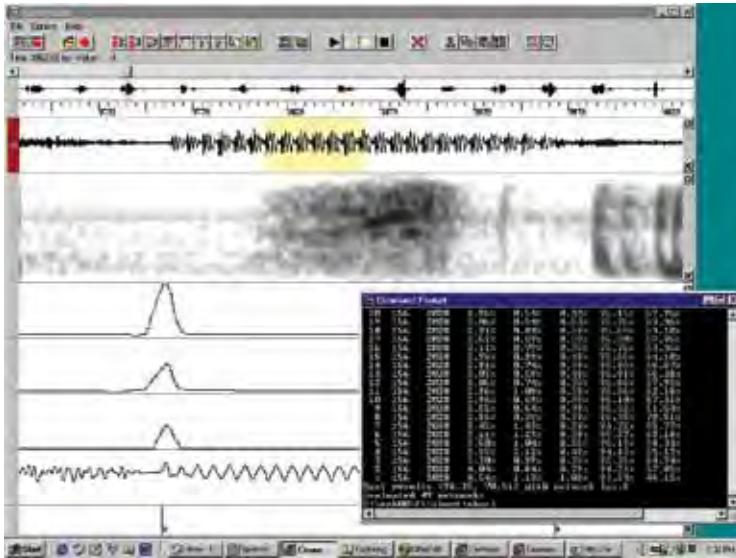
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RESEARCH ACTIVITIES

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



Speech recognition system that students use during the Digital Signal Processing course

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, Asyst Electronic Ltd. (2007-20012).

Parallel and Distributed Systems (P2-0095). Research Programme, jointly with Jozef Stefan Institute and Faculty of Electrical Engineering, University of Ljubljana. Slovenian Research Agency (2009-2013).

RESEARCH VISITS

Dušan M. Kodek: Department of Computer Science, Princeton University, USA, 26. 3. – 5. 4. 2012. Collaboration on development of bounds for uniform integer polynomial approximation.

SELECTED PUBLICATIONS

D. M. Kodek. LLL algorithm and the optimal finite wordlength FIR design. *IEEE Transactions on Signal Processing*, vol. 60, no. 3, pp. 1493-1498, March 2012.

R. Rozman, D. M. Kodek. Using asymmetric windows in automatic speech recognition. *Speech Communication*, vol. 49, no. 4, pp. 268-276, April 2007.

D. M. Kodek and M. Krisper. Telescopic rounding for suboptimal finite wordlength FIR digital filter design. *Digital Signal Processing*, vol. 15, no. 6, pp. 522-535, Nov. 2005.

D. M. Kodek and M. Krisper. Optimal algorithm for minimizing production cycle time of a printed circuit board assembly line. *International Journal of Production Research*, vol. 42, no. 23, pp. 5031-5048, Dec. 2004.

D. Šonc. A version of the byte radix sort algorithm suitable for the implementation in hardware. *Proc. of Eurocon 2003 International Conference on Computer as a Tool*, Ljubljana, Slovenia, vol. 2, pp. 66-69, Sep. 22-24, 2003.

R. Rozman and D. M. Kodek. Improving speech recognition robustness using non-standard windows. *Proc. of Eurocon 2003 International Conference on Computer as a Tool*, Ljubljana, Slovenia, vol. 2, pp. 171-174, Sep. 22-24, 2003.

A. Štrancar, R. Rozman, D. M. Kodek. Parametrizacija govornega signala z dinamičnim določanjem dolžine okna. *Proc. of ERK 2003 Conference*, Portorož, Slovenia, pp. 481-484, Sep. 25-26, 2003.

D. M. Kodek and M. Krisper. An algorithm for computing the optimal cycle time of a printed circuit board assembly line. *Informatica (Ljublj.)*, vol. 27, no. 1, pp. 105-114, Apr. 2003.

R. Rozman, A. Štrancar, D. M. Kodek. Uporaba načela "deli in vladaj" v sistemih za razpoznavanje govora. *Proc. of ERK 2002 Conference*, Portorož, Slovenia, vol. B, pp. 239-242, Sep. 23-25, 2002.

D. M. Kodek. An approximation error lower bound for integer polynomial minimax approximation. *Electrotechnical Review*, vol. 69, pp. 266-272, 2002.

D. M. Kodek. Design of optimal finite wordlength FIR digital filters. *Proceedings of the 1999 European Conference on Circuit Theory and Design ECCTD'99*, vol.1, pp. 401-404, Stresa, Italy, 1999.

D. M. Kodek. Limits of finite wordlength FIR digital filter design. *Proceedings of the 1997 IEEE International Conference on Acoustics, Speech, and Signal Processing ICASSP 97*, pp. 2149-2152, Munich, 1997.

D. M. Kodek. Conditions for the existence of fast number theoretic transforms. *IEEE Transactions on Computers*, C-30, pp. 359-361, 1981.

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.

Software Engineering Laboratory

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RESEARCH ACTIVITIES

The Software Engineering Laboratory is involved in teaching and researching in the areas of Software Engineering and Information Systems with an emphasis on Agile Software Development Methods, Software Quality Management, Software Metrics, Graph Grammars, Information Systems Development, Information Systems Audit and Control, and Data Warehousing. 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 staff has also developed the University of Ljubljana student records information system. The following areas of research are currently being pursued:

1. In Agile Software Development Methods: Factors affecting successful adoption. Agile software project management. Balancing agility and discipline.

2. In Software Quality Management: Adaptation of CMMI to the needs of small organizations. Personal and Team Software Process. Quality assurance in agile projects.

3. 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.

4. In Graph Grammars: Graph grammars as a generalization of textual grammars. Parsing graph grammars and translating graph-based languages. Graph grammar induction. Using developed theories and tools for solving relevant problems in various computer science domains.

5. In Web User Behavior Analysis: Using stochastic model for user behavior analysis. Separating interleaved web sessions using graph search algorithms.

6. 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.

7. 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.

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 (2001-2012).

INVITED TALKS AND LECTURES

Viljan Mahnič: Agile software development using Scrum, 4.10.2012, an invited talk at the conference "Information Technology for Practice 2012", Ostrava, Czech Republic.

SELECTED PUBLICATIONS

V. Mahnič, T. Hovelja. On using planning poker for estimating user stories. *Journal of Systems and Software*, 85(9): 2086-2095, 2012.

V. Mahnič. A capstone course on agile software development using Scrum. *IEEE Transactions on Education*, 55(1): 99-106, 2012.

L. Fürst, M. Mernik, V. Mahnič. Graph grammar induction as a parser-controlled heuristic search process. *Lecture notes in computer science*, 121-136, 2012.

V. Mahnič, N. Žabkar. Measuring progress of Scrum-based software projects. *Electronics and Electrical Engineering*, 18(8): 73-76, 2012.

L. Fürst, V. Mahnič. A cooperative development system for an interactive introductory programming course. *World transactions on engineering and technology education*, 10(2): 122-127.

L. Fürst, M. Mernik, V. Mahnič. Improving the graph grammar parser of Rekers and Schür. *IET Software*, 5(2): 246-261, 2011.

V. Mahnič. A case study on agile estimating and planning using Scrum. *Electronics and Electrical Engineering*, 2011. No. 5: 123-128, 2011.

V. Mahnič. Teaching Scrum through team-project work : students' perceptions and teacher's observations. *International Journal of Engineering Education*, 26(1): 96-110, 2010.

M. Poženel, V. Mahnič, M. Kukar. Separation of interleaved Web sessions with heuristic search. 10th IEEE International Conference on Data Mining, 14-17 December 2010, Sydney, Australia., pp. 411-420.

M. Poženel, V. Mahnič, M. Kukar. Separating interleaved HTTP sessions using a stochastic model. *Informatika (Ljublj.)*, 34(2): 199-205, 2010.

V. Mahnič, S. Georgiev, T. Jarc. Teaching Scrum in cooperation with a software development company. *Organizacija (Kranj)*, 43(1): 40-48, 2010.

I. Rožanc. One year later : the effect of the Bologna reform on algorithms and data structures course teaching. In: N. Mastorakis (ed.). *Recent researches in educational technologies*. WSEAS Press, 2011, pp. 221-226

M. Poženel, V. Mahnič, M. Kukar. Heuristic best-first search in separation of interleaved Web sessions. Workshop on Analysis of Complex Networks at ECML PKDD, *ACNE 2010*, pp. 63-74, Barcelona, Spain, 2010.

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.

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, I. Vrana. Using stakeholder-driven process performance measurement for monitoring the performance of a Scrum-based software development process. *Electrotechnical review*, 74(5): 241247, 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.

Computer Vision Laboratory

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RESEARCH ACTIVITIES

The laboratory is dedicated to research in computer vision and multimedia in general.

Topics that are of interest are capture, processing and interpretation of 3D visual data, understanding and interpretation of the human form in images (face detection, face recognition, gait recognition, fingerprint recognition), machine learning in computer vision, and the use of images in computer-human interaction.

Application areas that we work in are interpretation of medical images, interactive visual signage systems, 3D documentation in archaeology and cultural heritage, multimedia applications for learning sign language,

recognition of text in natural and urban scenes, computer games, forensic analysis of images and video, analysis of images in sports, information design, and interactive new media art installations.

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.

Art projects serve as an excellent framework for testing research ideas in practical applications.

RESEARCH PROJECTS

Computer vision (P2-0214). Basic Research Programme, Slovenian Research Agency (2009-2014).

Consulting with 3D scanning and modeling in archaeology. Applied research project, Magelan skupina, raziskave, proizvodnja, trgovina in storitve, d.o.o., Kranj (2011-).

Documentation of roman cargo ship in river Ljubljanica near Vrhnika, Applied research project, Institute for the Protection of Cultural Heritage of Slovenia (2012).

KC CLASS - Cloud Assisted Services (3211-10-000467), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

KC OPCOMM - Open Communication Platform for Service Integration (3211-10-000468), Structural Funds Project, Ministry of education, science, culture and sport (2011-2013).

Text detection in images of natural scenes. Industry-Funded Project, Iks, d.o.o. (2009-2013).

Gait recognition. Industry-Funded Project, Mega M d.o.o. (2011-2014).

Web pages and web hosting for the production of the opera L'Orfeo by Claudio Monteverdi. A collaboration of Academy of Music, Academy of Theatre, Radio, Film and Television, Academy of Fine Arts and Faculty of Computer and Information Science, <http://orfej.fri.uni-lj.si>.

LABORATORY GUESTS

Marco Busiol, student of Academy of Fine Arts, Venice, Italy. October 2012 – March 2013. Internship under program Leonardo.

RESEARCH VISITS

Dr. Luka Šajn: The Rudjer Bošković Institute, Zagreb, Croatia, September 2012.

Dr. Luka Šajn, Summer school on image processing 2012. Vienna, Austria, July 4.-13. 2012.

Tadej Zupančič, Vision and Sports Summer School 2012, Czech Technical University, Prague, 27.-31.8.2012.



A virtual city sculpture for the project Design in the city, Month of design, Ljubljana, 18 October – 18 November 2012

INVITED TALKS AND LECTURES

L. Šajn: Multiresolution image parametrization for improving texture classification, 5. 10. 2012, an invited talk at Institut Ruđer Bošković, Zagreb.

N. Bovcon. [Video umetnost] : oddaja Petkov poudarek. Ljubljana: Radio Slovenija, 3. program - ARS, 17. 8. 2012. <http://tvslo.si/predvajaj/petkov-poudarek/ava2.143480884>.

AWARDS

Franc Solina, Information Society Lifetime Achievement Award, 2012.

Domen Pogačnik, Evaluating photo aesthetics using machine learning, Faculty Prešeren Award for students (Mentor prof. dr. Franc Solina).

Bronze medal for innovation entitled "Fingerprint verification system" given by the Chamber of Commerce and Industry of Slovenia,

authors: P. Peer, J. Bule, M. Tovšak, A. Rotovnik (MIEL d.o.o.), M. Meža (MEGA M d.o.o.), June 2012.

EXHIBITIONS

N. Bovcon, J. Fingušt Prebil, E. L. Kozak G. Krnc, D. Mahnič, V. Mervič, M. Peternel, E. Stermitz, A. Vaupotič, T. Žbonta., N. Bovcon (ed.). *Atlas 2012 : katalog razstave Atlas - Mesec oblikovanja, Dizajn v mestu*. Ljubljana: ArtNetLab, 2012.

N. Bovcon, J. Fingušt, E. L. Kozak G. Krnc, V. Mervič, A. Vaupotič, T. Žbonta. *Atlas 2012: razstava v okviru Design Expo*. Ljubljana: Gospodarsko razstavišče, 18. - 19. 10. 2012

N. Bovcon, J. Fingušt, B. Klemenc, E. L. Kozak, G. Krnc, D. Mahnič, V. Mervič, A. Vaupotič, T. Žbonta. *Atlas: razstava v povečani resničnosti v okviru Dizajn v mestu, Mesec oblikovanja*. Ljubljana: Mesec oblikovanja, 18. 10.-18. 11. 2012.

N. Bovcon, E. L. Kozak, G. Krnc, D. Mahnič, V. Mervič, A. Vaupotič. *Atlas, 5. 12. 2011: künstlerisches Ereignis*. Kassel, 9. 6. - 16. 9. 2012.

N. Bovcon, J. Fingušt, Prebil, E. L. Kozak, G. Krnc, D. Mahnič, V. Mervič, E. Stermitz, A. Vaupotič, T. Žbonta. *Mnemonic mirrors = mnemonična zrcala*. Zagreb: Galerija SC, 22. 5. - 2. 6. 2012.

SELECTED PUBLICATIONS

R. Ravnik, F. Solina. Interactive and audience adaptive digital signage using real-time computer vision.

Accepted for publication in *International Journal of Advanced Robotic Systems*, December 2012.

R. Ravnik, F. Solina. Audience measurement of digital signage: Quantitative study in real-world environment using computer vision,

Accepted for publication in *Interacting with Computers*, December 2012.

N. Bovcon, A. Vaupotič. A network of quotations between print and computer media: a qualitative approach to Gerhard Richter's "Text". *BIT's 1st Annual World Congress of Emerging InfoTech-2012*, August 28-30, 2012, Dalian, China. *InfoTech*, 2012, p. 259.

D. Pogačnik, R. Ravnik, N. Bovcon, F. Solina. Evaluating photo aesthetics using machine learning. *Zbornik 15. mednarodne multikonference Informacijska družba - IS 2012, Ljubljana, Slovenia: volume A*, (Informacijska družba). Ljubljana: Institut Jožef Stefan, 2012, pp. 197-200.

J. Bule, P. Peer. Izboljšava kvalitete slike prstnega odtisa. *Zbornik enaindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2012, Portorož, Slovenija*, Ljubljana: IEEE Region 8, Slovenska sekcija IEEE, 2012, zv. B, pp. 87-90.

B. Klemenc, P. Ciuha, F. Solina. Educational possibilities of the project Colour visualization of music. *Organizacija (Kranj)*, 2011, vol. 44, no. 3, pp. 67-75.

A. Ikica, P. Peer. CVL OCR DB, an annotated image database of text in natural scenes, and its usability. *Inf. MIDEEM*, 2011, vol. 41, no. 2, pp. 150-154.

T. Pristovnik, P. Peer, T. Hodnik Čadež. Reševanje problemov iz verjetnosti ob uporabi e-gradiva v četrtem razredu. *Didactica Slovenica / Pedagoš. obz.*, 2011, letn. 26, št. 1/2, str. 102-119.

N. Bovcon, A. Vaupotič. Curating New Media by Focusing on the Recipient's Attitude: Immateriality and Entertainment. *Acta graph.*, 2011, vol. 22, no. 1-2, pp. 33-38.

A. Jaklič, A. Leonardis, F. Solina. *Segmentation and Recovery of Superquadrics*. Volume 20 of Computational Imaging and Vision. Kluwer, Dordrecht, 2010.

L. Šajn, M. Kukar. Image processing and machine learning for fully automated probabilistic evaluation of medical images. *Comput. methods programs biomed.*, 2010, doi: doi:10.1016/j.cmpb.2010.06.021.

P. Ciuha, B. Klemenc, F. Solina. Visualization of concurrent tones in music with colours. *ACM MM 2010 & co-located workshops*, New York, pp. 1667-1680.

N. Bovcon. *Umetnost v svetu pametnih strojev: novomedijska umetnost Sreča Dragana, Jake Železnikarja in Marka Peljhana*. Raziskovalni inštitut Akademije za likovno umetnost in oblikovanje, Ljubljana, 2009.

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

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

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.

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

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

F. Solina, 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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* Until June 2012. Danijel Skočaj from July 2012.

** From July 2012 with the University of Birmingham, School of Computer Science, Centre for Computational Neuroscience and Cognitive Robotics, and 10 \square with FRI.

*** Also with the Machine Vision Laboratory at the Faculty of Electrical Engineering.

**** Also with the 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 categorization. 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 both, low-level incremental learning methods (based on mixture models), as well as a high-level general framework for continuous learning of categorical knowledge. 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, in simulation as well as on real robots. 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. Visual tracking has also been very important research topic recently. We developed a novel coupled-layer visual model that combines the target's global and local appearance, leading to a more robust tracking through significant appearance changes. 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.

EQUIPMENT

Our theoretical findings on visual tracking, 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 monocular, omnidirectional, stereo, and RGBD camera setups. We are also implementing direct interaction and object manipulation with a Katana HD6M light weighted robot arm. The laboratory is also equipped

with several low cost robotic mobile platforms such as TurteBots and AR.Drone quadcopters. 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 categorize and recognize 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).

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 (J2-2221). Basic Research Project, Slovenian Research Agency (2009–2012).

Learning a large number of visual object categories for content-based retrieval in image and video databases (J2-3607). Basic Research Project, Slovenian Research Agency (2010-2013).

Learning, analysis, and detection of motion in the framework of a hierarchical compositional visual architecture (J2-4284). Basic Research Project, Slovenian Research Agency (2011-2014).

LABORATORY GUESTS

Michael Zillich, Kai Zhou, Technische Universität Wien, Vienna, Austria. 23. – 26. 4. 2012. Collaboration on the CogX project.

Thomas Keller, Albert-Ludwigs-Universität, Freiburg, Germany. 23. – 26. 4. 2012. Collaboration on the CogX project.

Miroslav Janiček, Deutsches Forschungszentrum für Künstliche Intelligenz, DFKI, Saarbrücken, Germany. 23. – 26. 4. 2012. Collaboration on the CogX project.

RESEARCH VISITS

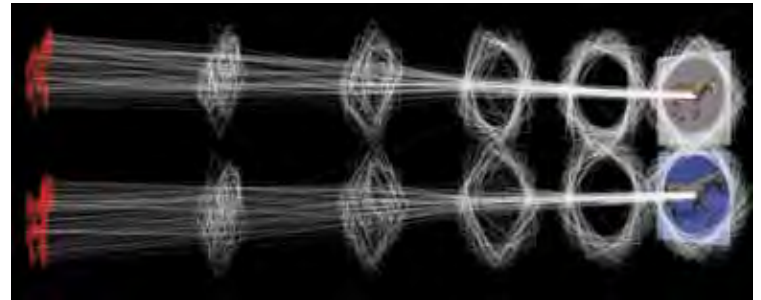
Danijel Skočaj, Marko Mahnič, Alen Vrečko: Technische Universität Wien, Vienna, Austria, 27. – 29. 6. 2012. Collaboration on the CogX project.

Danijel Skočaj: University of Birmingham, School of Computer Science, Birmingham, UK, 7. 10. – 31. 12. 2012. Research collaboration.

INVITED TALKS AND LECTURES

Aleš Leonardis: Combining compositional shape hierarchy and multi-class object taxonomy for efficient object categorization, an invited talk at Imperial College London, United Kingdom, March 2012.

Aleš Leonardis: Combining compositional shape hierarchy and multi-class object taxonomy for efficient object categorization, an invited talk



Object categorization by hierarchical matching to a prototype

at Upper Austria University of Applied Sciences Media Technology and Design / Digital Media, Linz, Austria, May 2012.

Aleš Leonardis: Compositional representations of object structure, Tutorial on Stochastic Image Grammars for Object, Scene and Event Understanding (in conjunction with CVPR 2012), Providence, Rhode Island, USA, June 2012.

Aleš Leonardis: Vision, Learning and Cognition, invited lectures at Summer school in Beijing, National Lab of Pattern recognition at Chinese Academy of Science, August 2012.

Aleš Leonardis: Robust Visual Tracking Using an Adaptive Coupled-layer Visual Model, an invited talk at Area Chair Workshop of the Asian Conference on Computer Vision, Daejeon, Korea, September 2012.

Matej Kristan: Introduction to computer vision -- What can a computer do and what it cannot, invited talk at winter school "Support technologies in kinesiology and sports training", Faculty of sports sciences, University of Ljubljana, Slovenia, October 2012.

Aleš Leonardis: Hierarchical Compositional Representations of Object Structure, an invited talk at Joint IAPR International Workshops on Structural and Syntactic Pattern Recognition (SSPR 2012) and Statistical Techniques in Pattern Recognition (SPR 2012), Miyajima-Itsukushima, Hiroshima, Japan, November 2012.

Aleš Leonardis: Robust Visual Tracking using an Adaptive Coupled-layer Visual Model, an invited talk at Chiba University, Japan, November 2012.

Aleš Leonardis: Visual perception in robotic systems, Conference on robotics (Posvet o robotiki), Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia, November 2012.

Danijel Skočaj: Knowledge gap detection for interactive continuous learning of categorical knowledge, an invited talk at University of Birmingham, School of Computer Science, Birmingham, UK, December 2012.

Aleš Leonardis: Hierarchical Compositional Representations of Object Structure, Frankfurt Institute of Advanced Studies, J.W. Goethe University, Frankfurt, Germany, December 2012.



Visual tracking of an articulated target

SELECTED PUBLICATIONS

L. Čehovin, M. Kristan, A. Leonardis. Robust Visual Tracking using an Adaptive Coupled-layer Visual Model. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. pre-published. 2012.

M. Kristan, A. Leonardis, D. Skočaj. Multivariate online kernel density estimation with Gaussian kernels, *Pattern recogn*, 2011, pp. 2630-2642

J. L. Wyatt, A. Aydemir, M. Brenner, M. Hanheide, N. Hawes, P. Jensfelt, M. Kristan, G. J. Kruijff, P. Lison, A. Pronobis, K. Sjöo, A. Vrečko, H. Zender, M. Zillich, D. Skočaj, Self-Understanding and Self-Extension: A Systems and Representational Approach. *IEEE Transactions on Autonomous Mental Development*, Vol. 2, no. 4, pp. 282 - 303, 2010.

O. Drbohlav, A. Leonardis. Towards correct and informative evaluation methodology for texture classification under varying viewpoint and illumination. *Comput. vis. image underst.*, 2010, vol. 114, no. 4, pp. 439-449.

R. Perko, A. Leonardis. A framework for visual-context-aware object detection in still images. *Comput. vis. image underst.* 2010, vol. 114, no. 6, pp. 700-711.

S. Fidler, M. Boben, A. Leonardis. Learning Hierarchical Compositional Representations of Object Structure. In: *Object Categorization: Computer and Human Vision Perspectives*, Editors: S. Dickinson, A. Leonardis, B. Schiele and M. J. Tarr, Cambridge University Press, 2009.

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.

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-motionbased probabilistic model for visual tracking. *Pattern Recognition*, Vol. 42, No. 9, pp. 2160-2168, 2009.

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.

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.

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.

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.

Artificial Intelligence Laboratory

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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 intelligent tutoring systems. A notable aspect of much of this research is its application to problems in medicine, systems control, game playing and analysis, ecological modeling, reconstruction of human control skill, robotics, and intelligent tutoring systems.

In 2009, the laboratory's demo on autonomous robot learning by experimentation (<http://www.ailab.si/xpero/>, part of the XPERO project) was awarded the first prize at the European Exhibition in Future Emergent Technologies, Prague, April 2009. 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. Two former members of



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

this laboratory Aleks Jakulin and Dorian Šuc received the prestigious best European AI dissertation awards, sponsored by ECCAI (European Coord. Committee in AI). In 2007, Ivan Bratko received the national Zois award for outstanding scientific achievements. Aleksander Sadikov was elected by students as best lecturer in the faculty's study programs in Computer Sc. and Mathematics in 2008, 2010 and 2011.

EQUIPMENT

The laboratory owns a NAO humanoid robot by Aldebaran Robotics and a motion capturing sensor suit Animazoo IGS-190.

RESEARCH PROJECTS

Artificial Intelligence and Intelligent Systems (P2-0209). Research Program, Slovenian Research Agency (2009-2014).

Machine Learning in Building Intelligent Tutoring Systems (J2-4222). Basic Research Project, Slovenian Research Agency (2011-2014).

Molecular and other prognosticators of lung cancer and mesothelioma (J3-4076). Basic Research Project, Slovenian Research Agency (2011-2014).

Towards Multi-Agent Intelligent Systems with Ability of Incremental Learning (BI-SK/11-12-008), Bilateral Collaboration Project, Slovenian Research Agency (2011-2012).



Computer analysis of human movement with a motion-sensing suit

ParkinsCheck: timely detection and monitoring of Parkinson's disease. Structural Funds Project, Ministry of education, science, culture and sports (2012-2013).

Warehouse scheduling system. Application project, 3R.TIM d.o.o. (2011-2012).

LABORATORY GUESTS

Prof. Eduardo F. Morales, National Institute of Astrophysics, Optics and Electronics, Mexico. 28. 3. 2012 - 2. 4. 2012. Lecture at the faculty seminar.

Prof. Claude Sammut, University of New South Wales, Australia. 19. 9. 2012 - 12. 10. 2012. Invited talk at the conference 100 Years of Turing and 40 Years of SLAIS, and work on joint research.

Martin Pala, Technical University of Košice, Slovakia. 6. 11. 2012 - 15. 11. 2012. Research visit within bilateral collaboration project.

Martina Tarhanicova, Technical University of Košice, Slovakia. 6. 11. 2012 - 15. 11. 2012. Research visit within bilateral collaboration project.

RESEARCH VISITS

Jure Žabkar: Intelligent Robotics Lab, University of Birmingham, 1. 2. 2012 - 1. 5. 2012. Collaboration on development of sensorymotor representation of a robot.

ORGANIZATION OF CONFERENCES

Ivan Bratko: Robotics Symposium. Slovenian Academy of Sciences and Arts. 27. 11. 2012.

Ivan Bratko: 100 Years of Turing and 40 Years of SLAIS, Ljubljana. 11. 10. 2012.

SELECTED PUBLICATIONS

BRATKO, Ivan. Prolog programming for artificial intelligence. 4th ed. Harlow (England): Addison-Wesley / Pearson, cop. 2012. XXI + 673 pp.; previous editions also translated into German, Italian, French, Slovene, Japanese, and Russian.

GROZNIK, Vida, GUID, Matej, SADIKOV, Aleksander, MOŽINA, Martin, GEORGIEV, Dejan, KRAGELJ, Veronika, RIBARIČ, Samo, PIRTOŠEK, Zvezdan, BRATKO, Ivan. Elicitation of neurological knowledge with argument-based machine learning. *Artif. Intell. in Medicine*, 2012

KOŠMERLJ, Aljaž, BRATKO, Ivan, ŽABKAR, Jure. Embodied concept discovery through qualitative action models. *Int. j. uncertain. fuzziness knowl.-based syst.*, 2011, vol. 19, no. 3, pp. 453-475.

ŽABKAR, Jure, MOŽINA, Martin, BRATKO, Ivan, DEMŠAR, Janez. Learning qualitative models from numerical data. *Artif. intell.* [Print ed.], 2011, vol. 175, no. 9/10, str. 1604-1619, ilustr.

GUID, Matej, BRATKO, Ivan. Using heuristic-search based engines for estimating human skill at chess. *ICGA journal*, 2011, vol. 34, no. 2, str. 71-81, ilustr.

BRATKO, Ivan. Autonomous discovery of abstract concepts by a robot. *Lect. notes comput. sci.*, part 1, str. 1-11, ilustr.

GROZNIK, Vida, GUID, Matej, SADIKOV, Aleksander, MOŽINA, Martin, GEORGIEV, Dejan, KRAGELJ, Veronika, RIBARIČ, Samo, PIRTOŠEK, Zvezdan, BRATKO, Ivan. Elicitation of neurological knowledge with ABML. *Lect. notes comput. sci.*, str. 14-23.

OBLAK, Andrej, BRATKO, Ivan. Learning from noisy data using a non-covering ILP algorithm. *Lect. notes comput. sci.*, str. 190-197, ilustr.

D. S. Nau, M. Luštrek, A. Parker, I. Bratko, M. Gams. When is it better not to look ahead? *Artificial Intelligence* 174 (2010) 1323-1338.

I. Bratko. Comparison of Machine Learning for Autonomous Robot Discovery. In book: *Advances in Machine Learning I: Dedicated to the Memory of Professor Ryszard S. Michalski (Studies in Computational Intelligence)* edited by Jacek Koronacki, Zbigniew W. Ras, Sławomir T. Wierzbachon, and Janusz Kacprzyk, Springer 2010, pp. 451-456

I. Bratko, J. Žabkar, M. Možina. Argument Base Machine Learning. In book *Argumentation in Artificial Intelligence*, Edited by Iyad Rahwan, Guillermo Simari, Springer Verlag 2009, pp. 463-482.

A. Sadikov, I. Bratko. LRTA* works much better with pessimistic heuristics. *Proceedings of the Eighteenth European Conference on Artificial Intelligence (ECAI 2008)*, pp. 897-898, 2008.

M. Možina, J. Žabkar, I. Bratko. Argument based machine learning. *Artificial Intelligence Journal* 171(10): 922-937, 2007.

M. Luštrek, M. Gams, I. Bratko. Is real-valued minimax pathological? *Artificial Intelligence* 170: 620-642, 2006.

M. Guid, I. Bratko. Computer analysis of world chess champions. *ICGA Journal* 29(2): 65-73, 2006.

D. Vladušič, D. Šuc, I. Bratko, W. Rulka. Q2 learning and its application to car modeling. *Applied Artificial Intelligence* 20(8): 675-701, 2006.

A. Sadikov, I. Bratko. Learning long-term chess strategies from databases. *Machine Learning* 63(3): 329-340, 2006.

J. Žabkar, R. Žabkar, D. Vladušič, D. Čemas, D. Šuc, I. Bratko. Q2 Prediction of ozone concentrations. *Ecological Modelling*, 191(1): 6882, 2006.

G. Leban, I. Bratko, U. Petrovič, T. Curk, B. Zupan. VizRank: finding informative data projections in functional genomics by machine learning. *Bioinformatics*, 21(3): 413-414, 2005.

D. Šuc, D. Vladušič, I. Bratko. Qualitatively faithful quantitative prediction. *Artificial Intelligence*, 158(2): 189-214, 2004.

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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 evaluating the utility of ordinal attributes, evaluating the reliability of single models' predictions in classification and regression, evaluating the reliability of clustering, explaining single predictions by arbitrary classification and regression model, efficient parameterization of images using a subset of possible

image resolutions, text summarization using symbolic graphs, analyzing of sport data, user profiling by mining the web-logs, learning of imbalanced classification problems, applying evolutionary computation to data mining focused on using ant colony optimization, prediction intervals which represent the distribution of individual future points in a more informative manner, spatial data mining with multi-level directed graphs, employing background knowledge analysis for search space reduction in inductive logic programming, detection of (non)-ischemic episodes in ECG signals, heuristic search methods in clickstream mining and mining of data streams. A notable aspect of much of this research is its application to problems in image analysis, medical diagnosis, ecological modeling, marketing and financial modeling.

RESEARCH PROJECTS

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

Reliability estimation of drug interactions in pharmaceutical industry. Industry-Funded Project, AZ (2011-2012).

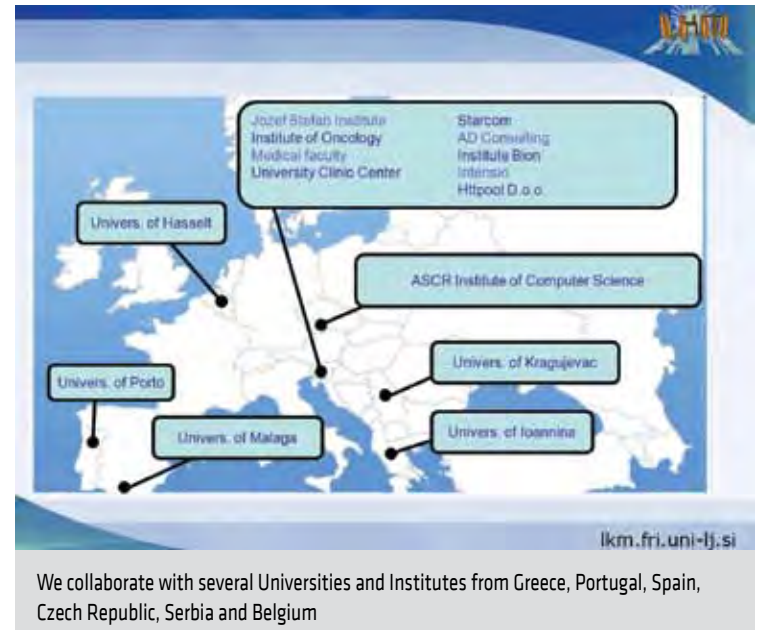
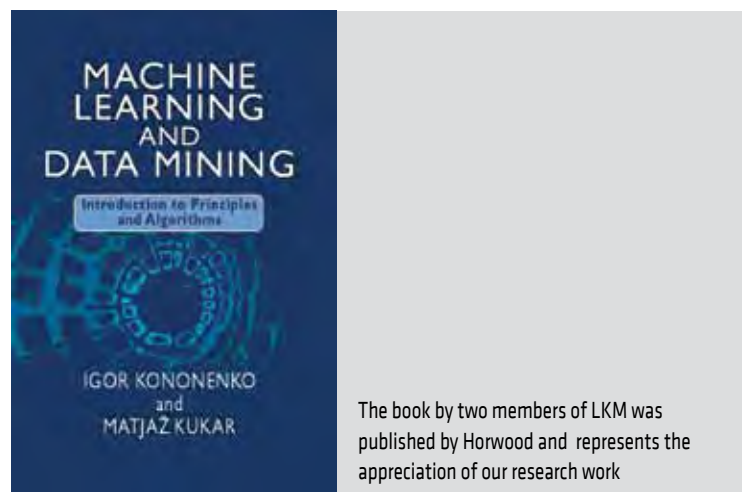
A component for intelligent analysis of data streams. Industry-Funded Project, Optilab (2012-2013).

LABORATORY GUESTS

Ercan Canhas, MSc, University of Prizren, Kosovo. 15. 3. 2012 - 25. 3. 2012. Research collaboration on multidocument summarization based on multilayered graphs.

Prof. Dr. Joao Gama, University of Porto, Portugal, 4. 10. 2012 - 10. 10. 2012. Research collaboration on data streams mining.

Prof. Dr. Tatjana Zrimec, Univerza na Primorskem, Koper, 3. 6. 2012 - 17. 6. 2012. Research collaboration on machine learning from medical image data.



SELECTED PUBLICATIONS

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

Z. Bosnić, P.Vračar, M. Radović, G. Devedžić, N. Filipović., I. Kononenko. Mining data from hemodynamic simulations for generating prediction and explanation models. *IEEE trans. inf. technol. biomed.* Mar. 2012, vol. 16, no. 2, pp. 248-254, 1A1

M. Robnik-Šikonja, I. Kononenko, E. Štrumbelj. Quality of classification explanations with PRBF. *Neurocomputing*, Nov. 2012, vol. 96, pp. 37-46, 1A2

E. Štrumbelj, P.Vračar. Simulating a basketball match with a homogeneous Markov model and forecasting the outcome. *Int. j. forecast.* 2012, vol. 28, no. 2, pp. 532-542. 1A1

M. Kukar, I. Kononenko, C. Grošelj. Modern parameterization and explanation techniques in diagnostic decision support system : a case study in diagnostics of coronary artery disease. *Artif. intell. med.* Jun. 2011, vol. 52, no. 2, pp. 77-90, 1A2

E. Štrumbelj, M. Robnik-Šikonja. Online bookmakers' odds as forecasts : the case of European soccer leagues. *Int. j. forecast.* 2010, vol. 26, no. 3, pp. 482-488. 1A1

E. Štrumbelj, I. Kononenko: An efficient explanation of individual classifications using game theory. *J. Mach. Learn. Res.* 2010, 11[1]:1-18. 1A1

Z. Bosnić, I. Kononenko: Automatic selection of reliability estimates for individual regression predictions. *Knowl. eng. rev.*, 25(1)27-47, 2010. 1A3

E. Štrumbelj, Z. Bosnić, I. Kononenko, B. Zakotnik, C. Grašič-Kuhar: Explanation and reliability of prediction models: the case of breast cancer

recurrence. Knowledge and information systems, 24(2)305-324, 2010. 1A1

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. 1A2

I. Kononenko. Natural and Machine Learning, Intelligence and Consciousness, In: E. Žerovnik et al. (eds.) Philosophical Insights about Modern Science, NY: Nova Science publ., 239-258, 2009.

M. Robnik-Šikonja, I. Kononenko: Explaining classifications for individual instances. IEEE Trans. Knowl. Data Eng., 2008, 20:589-600. 1A1

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. 1A3

Z. Bosnić and I. Kononenko. Comparison of approaches for estimating reliability of individual regression predictions. Data & Knowledge Engineering, 67 (3)504-516, 2008. 1A2

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RESEARCH ACTIVITIES

Bioinformatics Laboratory performs research in data mining and data visualization. We apply our methods and algorithms to problems from molecular and system biology, functional genomics, chemo genomics and medicine. The lab maintains a major open-source data mining package Orange (<http://www.aillab.si/orange>) with an attractive and easy-to-use visual programming interface. Orange gained its popularity as the principal Python-based data mining tool and has a substantial

community of users. In collaboration with spin-off company Ainda we are working towards turning Orange into a cloud service with appealing web interface. This will borrow from our already successful interactive web-applications, such as dictyExpress (<http://www.ailab.si/dictyexpress>), a popular interactive exploratory data analytics tool that provides access to over 1,000 gene expression experiments on social amoeba *Dictyostelium discoideum*. The application was developed in collaboration with Baylor College of Medicine. Our first web-based application is GenePath (<http://www.genepath.org>) that supports interactive epistasis analysis and gene network reconstruction from mutant-based experimental data. GenePath is nearly 10 years old but still in frequent use in scholar institutions. In collaboration with MRC Laboratory of Molecular Biology in Cambridge we are also developing a computational pipeline for comprehensive analysis of next-generation high-throughput sequencing data (RNA-Seq and iCLIP) with the aim of modeling and understanding the molecular mechanisms associated with neurodegenerative diseases.

RESEARCH PROJECTS

AXLE: Analytics for Xtremely Large European Data (FP7-318633). European Project (FP7), European Commission (2012-2015).

CARE-MI: Cardio Repair European Multidisciplinary Initiative (FP7-242038). EU FP7-HEALTH Programme project, European Commission (2010-2015).

Artificial intelligence and intelligent systems (P2-0209). Research Programme, Slovenian Research Agency (2009-2014).

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

CLIP: Mapping functional protein-RNA interactions to identify new targets for oligonucleotide-based therapy (ERC 206726 CLIP). ERC Project, European Research Council (2008-2013).

Modeling the transcriptome (Z7-3665). Basic Research Project, Slovenian Research Agency (2010-2012).

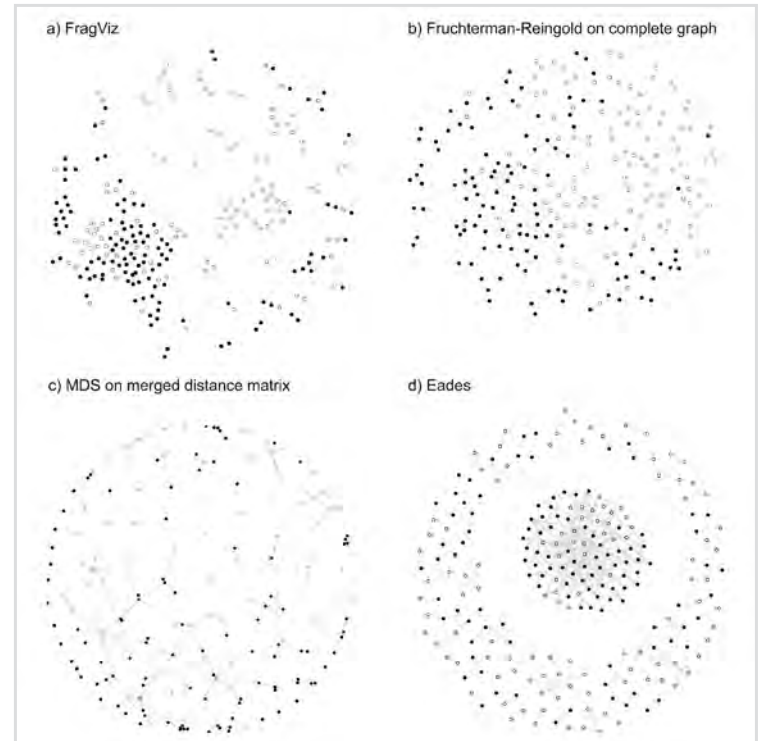
FightingDrugFailure (PITN-GA-2009-238132). European Project (FP7) (2010-2013).

Growth and defense trade-offs in multitrophic interaction between potato and its two major pests (J4-4165). Basic Research and Application Project, Slovenian Research Agency (2011-2014).

Evaluation of neuro-muscular trunk stabilization functions and development of exercise programs for lower back pain prevention (L5-4293).

Basic Research and Application Project, Slovenian Research Agency (2011-2014).

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



The leukemia gene network optimized with four different algorithms. Regions that contain mostly solid or empty vertices (genes expressed in different types of leukemia) pop out in (a) and (b), where our proposed heuristic approach FragViz performs substantially faster than standard Fruchterman-Reingold optimization. Alternative methods (c) and (d) fail to expose the similarity of gene expression within each leukemia type

Combination of next generation sequencing and metagenomic analysis in the diagnostics of severe hop stunting (J4-4153). Basic Research and Application Project (2011-2014).

Functional genomics of cholesterol homeostasis: the role of lanosterol 14alpha-demethylase in development of metabolic disorders (J7-4053).

Basic Research and Application Project, Slovenian Research Agency (2011-2014).

A next-generation analytics toolbox for integrated high-throughput genomic data analysis (BI-US/11-12-020). Bilateral Collaboration Project, Slovenian Research Agency (2011-2012).

Functional genomics of potato-PVY interactions (J1-4268). Basic Research and Application Project, Slovenian Research Agency (2011-2014).

LABORATORY GUESTS

Francesca Mulas, University of Pavia, Italy. 25.6.2012 - 25.7.2012. Collaboration in bilateral project.

RESEARCH VISITS

Tomaž Curk: International Centre for Genetic Engineering and Biotechnology (ICGEB), Trieste, Italy, 26. 3. 2012 - 30. 4. 2012. Analysis of TDP43-RNA interaction in alternative splicing.

Tomaž Curk: MRC Laboratory of Molecular Biology, Cambridge, UK, 6. 5. 2012 - 6. 7. 2012. Development of pipeline for pA-seq data analysis.

Tomaž Curk: European Molecular Biology Laboratory (EMBL), Heidelberg, Germany, 1. 9. 2012 - 30. 6. 2013. Visiting Scientist, development of methods and software for genome-wide protein-RNA interaction analysis.

Lan Žagar: University College London, Computer Science Department, London, UK, 14. 2. 2012 - 10. 5. 2012. PASCAL research visit, development of methods and software for multi-task and multiple kernel learning.

Marko Toplak: Department of Molecular and Human Biology, Baylor College of Medicine, Houston, USA, 4. 6. 2012 - 22. 6. 2012: Analysis of high-throughput sequencing data on ABC transporter mutants.

Gregor Rot: Department of Molecular and Human Biology, Baylor College of Medicine, Houston, USA, UK, 1. 4. 2011 - 31. 6. 2011. Development of pipeline for pA-seq data analysis.

Marinka Žitnik: Donnelly Centre for Cellular and Biomolecular Research, University of Toronto, Canada, 14. 8. 2012 - 6. 10. 2012. Data analysis of yeast screens.

Marinka Žitnik: Computational Bioinformatics Laboratory, Department of Computing, Imperial College London, UK, 17. 11. 2012 - 27. 11. 2012. Data fusion from heterogeneous data sources for disease classification.

INVITED TALKS AND LECTURES

Tomaž Curk: Discovering protein-RNA interactions with iCLIP, 22. 3. 2012, University of Heidelberg, Center for Molecular Biology of the University of Heidelberg (ZMBH), Heidelberg, Germany.

Marinka Žitnik: A matrix factorization approach for inference of prediction models from heterogeneous data sources, 26. 9. 2012, Donnelly Centre for Cellular and Biomolecular Research, University of Toronto, Toronto, Canada.

Janez Demšar: Slovenian schools should teach computing, 12. 10. 2012, Education in Information Society, Jožef Stefan Institute, Slovenia.

SELECTED PUBLICATIONS

M. Žitnik, B. Zupan. NIMFA: A Python library for nonnegative matrix factorization, *Journal of Machine Learning Research*, 13:849-853, 2012.

M.L. Änkö, M. Müller-McNicoll, H. Brandl, T. Curk, G. Črtomir, I. Henry, J. Ule, K.M. Neugebauer. The RNA-binding landscapes of two SR proteins reveal unique functions and binding to diverse RNA classes. *Genome Biology*, 13(3): R17, 2012.



iCount web server integrates iCLIP data on protein-RNA interaction and pAseq data on polyadenylation site selection to help us understand mechanisms of transcript processing

Y. Sugimoto, J. König, S. Hussain, B. Zupan, T. Curk, M. Frye, J. Ule. Analysis of CLIP and iCLIP methods for nucleotide-resolution studies of protein-RNA interactions. *Genome Biology*, 13(8): R67, 2012.

J. Žabkar, M. Možina, I. Bratko, J. Demšar. Learning qualitative models from numerical data. *Artificial Intelligence*, 175(9/10): 1604-1619, 2011.

L. Žagar, F. Mulas, S. Garagna, Z. Maurizio, R. Bellazzi, B. Zupan. Stage prediction of embryonic stem cell differentiation from genome-wide expression data, *Bioinformatics*, 27(18): 2546-2553, 2011.

L. Umek, B. Zupan. Subgroup discovery in data sets with multi-dimensional responses, Umek L, Zupan B. *Intelligent Data Analysis*, 15(4):533-549, 2011.

J. R. Tollervy, T. Curk, B. Rogelj, M. Briese, M. Cereda, M. Kayikci, J. König, T. Hortobágyi, A. L. Nishimura, V. Župunski, R. Patani, S.

Chandran, G. Rot, B. Zupan, C. E. Shaw, J. Ule. Characterizing the RNA targets and position-dependent splicing regulation by TDP-43. *Nature Neuroscience*, 14(4): 452-459, 2011.

T. Curk, G. Rot, B. Zupan. SNPsyn: detection and exploration of SNP-SNP interactions. *Nucleic Acids Research*, 39(W444-9), 2011.

E. Huang, S. Talukder, T. R. Hughes, T. Curk, B. Zupan, G. Shaulsky, M. Katoh. BzpF is a CREB-like transcription factor that regulates spore maturation and stability in *Dictyostelium*. *Developmental Biology*, 358(1): 137-146, 2011.

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

Z. Wang, M. Kayikci, M. Briese, K. Zarnack, N. M. Luscombe, G. Rot, B. Zupan, T. Curk, J. Ule. ICLIP predicts the dual splicing effects of TIA-RNA interactions. *PLoS Biology*, 8(10), 2010.

J. König, K. Zarnack, G. Rot, T. Curk, M. Kayikci, B. Zupan, D. J. Turner, N. M. Luscombe, J. Ule. iCLIP reveals the function of hnRNP particles in splicing

at individual nucleotide resolution. *Nature Structural and Molecular Biology*, 17(7): 909-916, 2010.

A. Parikh, E. R. Miranda, M. Katoh-Kurasawa, D. Fuller, G. Rot, L. Žagar, T. Curk, R. Sucgang, R. Chen, B. Zupan, W. F. Loomis, A. Kuspa, G. Shaulsky. Conserved developmental transcriptomes in evolutionarily divergent species. *Genome Biology*, 11(3), 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.

M. Štajdohar, M. Mramor, B. Zupan, J. Demšar. FragViz: visualization of fragmented networks. *BMC Bioinformatics*, 11, 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.

G. Rot, A. Parikh, T. Curk, A. Kuspa, G. Shaulsky, B. Zupan: dictyExpress: a *D. discoideum* gene expression database with an explorative data analysis web-based interface. *BMC Bioinformatics*, 10: 265, 2009.

M. Mramor, G. Leban, J. Demšar, B. Zupan. Visualization-based cancer microarray data classification analysis. *Bioinformatics*, 23(16): 2147-2154, 2007.

J. Demšar. Statistical comparisons of classifiers over multiple data sets. *Journal of Machine Learning Research*, 7: 1-30, 2006.

N. Van Driessche, J. Demšar, E.O. Booth, P. Hill, P. Juvan, B. Zupan, A. Kuspa, G. Shaulsky. Epistasis analysis with global transcriptional phenotypes. *Nature Genetics*, 37(5): 471-477, 2005.

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RESEARCH ACTIVITIES

Members of the laboratory are involved in research in various fields of mathematics:

- semi groups and their interaction with automata theory and combinatorics; universal algebra.
- commutative algebra and linear algebra, in particular, studying the variety of commuting nilpotent matrices over algebraically closed fields and certain classes of matrices over semi rings,

- algebraic topology, in particular algebraic invariants of topological spaces with group actions, as well as computational topology and topological data analysis,
- coarse geometry,
- Brownian motion and martingales and their applications to analysis,
- scientific computing and numerical solutions of differential equations, where we study methods for geometric integration of ordinary differential equations, as well as numerical simulations,
- graph theory, topological and structural properties of graphs, and colorings problems of graphs, both in connection with graph symmetries and embedding properties,
- graph representations, connected with problems in computational geometry,
- 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,

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 several institutions from abroad. To mention a few: University of Uppsala, Sweden, NTNU Trondheim, Norway, University of Ulm, Germany, University of Tuebingen, Germany, Moscow State University, Russia, P. J. Šafarik University, Košice, Slovakia, University of Sevilla, Spain, Yokohama National University, Japan, Simon Fraser University, Canada, University of Melbourne, Australia.

RESEARCH PROJECTS

Applied and Computational Algebraic Topology (ACAT). European Science Foundation Project (2011-2015).

LABORATORY GUESTS

Sven Jacobs, TU Graz, Austria, October 2012, 1 month. Visiting professor, lectures: *Formal Methods - Modelling and Reasoning about Systems*.

RESEARCH VISITS

Ganna Kudryavtseva: Uppsala University, Sweden. February 2012, 14 days. Work on properties of multisemigroups.

Gašper Fijavž: Univeritaet Ulm, Ulm, Germany. April-May 2012, 2 months. Research on Chi-binding functions within Institut fuer Diskrete Optimierung.

Gašper Fijavž: University of Tuebingen, Tuebingen, Germany. June-July 2012, 2 months. Work on partial edge representations of graphs in Fachbereich Algorithimik.

Ganna Kudryavtseva: LIAFA (Laboratoire d'Informatique Algorithmique Fondements et Applications), Paris, France. September 2012, 5 days. Research on noncommutative power series.

Ganna Kudryavtseva: CAUL (Centro de Álgebra da Universidade de Lisboa), Lisbon, Portugal. November 2012, 5 days. Research on noncommutative extension of Stone duality.

Žiga Virk: Kobe University, Kobe, Japan. December 2012, 14 days. Giving a course of four lectures on Coarse Geometry.

INVITED TALKS AND LECTURES

Gašper Fijavž: *Minor monotone graph invariants*, April 2012, a colloquim talk at Univeritaet Ulm, Ulm, Germany.

Neža Mramor: a series of invited talks on ACAT Workshop on Computational Topology, May 2012, Bologna, Italy.

Ganna Kudryavtseva: *On non-commutative Stone duality*, September 2012, an invited talk at conference Semigroups and applications, Uppsala, Sweden.

Žiga Virk: *Coarse geometry*, December 2012, an invited talk at Topology Symposium, Kobe City, Japan.

SELECTED PUBLICATIONS

D. Repovš, W. Rosicki, Ž. Virk, and A. Zastrow: *On Minc' sheltered middle path*, *Topology and its Applications* 159(2012), 2609-2620.

G. Kudryavtseva, *A refinement of Stone duality to skew Boolean algebras*, *Algebra Universalis*, 67 (2012), 397--416.

Ž. Virk: *A generalization of the Levin-Rubin-Schapiro factorization theorem*, *Topology and its Applications* 159(2012), 695-703.

A. Franc, *Topological complexity of the telescope*, *Topology and its Applications* 159 (2012), 1357 - 1360.

B. Orel, A. Perne, *Computations with half-range Chebyshev polynomials*, *J. comput. appl. math* 236, (2012), 1753-1765.

D. Franetič, P. Pavešič. H-spaces, semiperfect rings and self-homotopy equivalences. *Proceedings of the Royal Society of Edinburgh: Section A Mathematics* (2011) 141, pp 1263-1277

R. Ayala, J. A. Vilches, G. Jerše, N. Mramor Kosta. Discrete gradient fields on infinite complexes. *Discrete contin. dyn. syst.*, 2011, vol. 30, no. 3, pp. 623-639

K. Cvetko-Vah, D. Kokol Bukovšek, T. Košir, G. Kudryavtseva. Semitransitive subsemigroups of the singular part of the finite symmetric inverse semigroup. *Acta Math. Hungar.* 131 (2011), no. 1-2, pp.1-24.

V. Dujmović, G. Fijavž, G. Joret, T. Sulanke, D. R. Wood. On the maximum number of cliques in a graph embedded in a surface. *Eur. j. comb.*, 2011, vol. 32, no. 8, pp. 1244-1252.

Ž. Virk. Homotopical smallness and closeness. *Topol. appl.* [Print ed.], 2011, vol. 158, iss. 3, pp. 360-378.

G. Kudryavtseva, Ordered semigroups, upper-triangular reflexive relations and semigroups of languages. *Internat. J. Algebra Comput.* 20, (2010), pp. 6, 823-832.

G. Fijavž, D. Wood, Graph Minors and Minimum Degree, *Electron. J. Comb.* (online journal), 2010, vol. 17, no. 1, r151 (30 p).

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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.



Colossus was the first electronic computer, used by British codebreakers during World War II for cryptanalysis of the Lorenz cipher

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 expensive 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).

EQUIPMENT

Xilinx Virtex 6 FPGA Evaluation Kit
VIA Artigo Pico-ITX A1000
VIA Amos-5000
VIA EITX-3000

LABORATORY GUEST

Robert Gallant, Ph.D., Memorial University of Newfoundland, Canada. 3. 8. 2011 – 19. 7. 2012. Sabbatical.

RESEARCH VISITS

Aleksandar Jurišić, Peter Nose, Janoš Vidali, Robert Gallant: Institute of Analysis and Computational Number Theory, Graz University of Technology, Austria, 6. 12. - 12. 12. 2011. Attending lectures on "Finite Fields and Factorization" by prof. Hendrik Lenstra.

Aleksandar Jurišić, Peter Nose, Janoš Vidali, Robert Gallant: EUROCRYPT '12, Cambridge, United Kingdom 15. 4. - 19. 4. 2012. Attending the annual European conference on cryptography.

Aleksandar Jurišić, Janoš Vidali: Department of Combinatorics & Optimization, University of Waterloo, Canada. 25. 9. - 26. 10. 2012. Research visit to prof. Chris Godsil and prof. Alfred Menezes as a part of Aleksandar Jurišić's sabbatical.

Aleksandar Jurišić, Janoš Vidali: Department of Mathematics, Michigan State University, East Lansing MI, USA. 8. 10. - 11. 10. 2012. Research visit to prof. Jonathan Hall as a part of Aleksandar Jurišić's sabbatical.

INVITED TALKS AND LECTURES

Janoš Vidali: Extremal 1-codes in distance-regular graphs of diameter 3, 9. 10. 2012, a talk at the Student Combinatorics Seminar at Department of Mathematics, Michigan State University, East Lansing MI, USA.

Aleksandar Jurišić: Tight graphs with classical parameters, 10. 10. 2012, a talk at the Algebra Seminar at Department of Mathematics, Michigan State University, East Lansing MI, USA.

Aleksandar Jurišić: Tight graphs with classical parameters, 18. 10. 2012, a talk at the Department of Combinatorics & Optimization, University of Waterloo, Canada.

SELECTED PUBLICATIONS

A. Jurišić and J. Vidali: Extremal 1-codes in distance-regular graphs of diameter 3, *Des. Codes Cryptogr.*, 65 (2012), 29-47.

M. Deza, E. Deza and J. Vidali: Cones of Weighted and Partial Metrics, *Algebra 2010 : Advances in Algebraic Structures* (2011), 177-197.

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The Bombe helped the British at Bletchley Park decrypt intercepted messages that had been encrypted using Enigma

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```
er = FILE_1)/includes/check_user.php';
name('FILE_1)/includes/functions.php';
ost Variables:
explode($_S_POST['gal_deletes']);
explode($_S_POST['gal_names']);
explode($_S_POST['gal_folders']);
to any galleries that need it--
[0] => ""
each($deletes as $delete){
//get the server path to the gallery to delete
$dir = realpath($delete);
if(is_dir($dir)){
//delete the gallery
rmdir($dir);
}
}
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= realpath("./menu.xml");
il for new menu.xml
menu->\n";
[0] => ""
each($names as $key => $value){
$xml .= "\t<menu name=\"$key\" value=\"$value\" folder=\"$folders[$key]\"/\n";
}
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