

Faculty of Computer and  
Information Science  
University of Ljubljana  
Survey of Activities in 2007

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Prof. Dr. Franc Solina

## Foreword

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

Due to the high demand for graduates in the area of Computer and Information Science in Slovenia the Faculty has avoided the trend of declining enrolment as in some other engineering and science disciplines. However, since the younger generations in Slovenia are smaller in size we have to attract promising students to our educational and research programs in the future from a larger geographical area. We have prepared new study programs designed according to the Bologna principles will have a wider appeal and should help to make the exchange of students even easier. We will start with the new Bologna programs in the academic year 2009/2010.

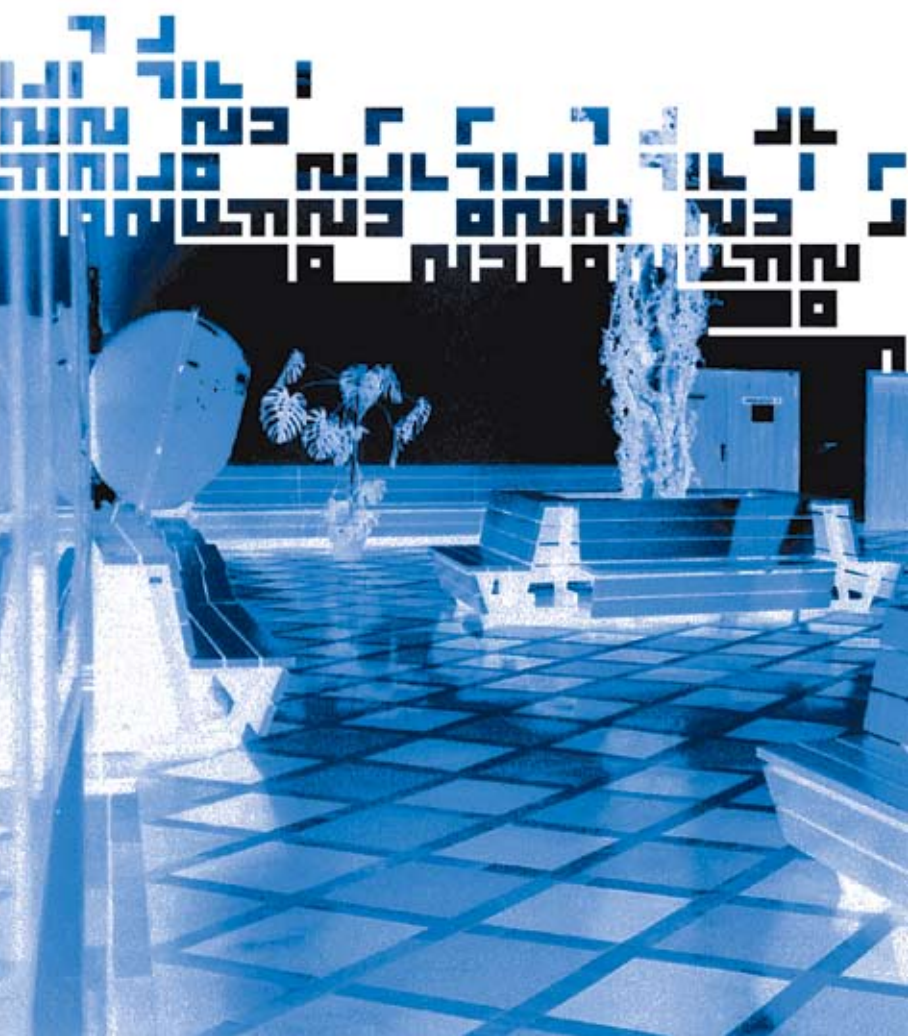
In the age of globalization the Faculty faces increasing competition in all areas. We have to expand our research competence to a wider spectrum of promising technical areas. In 2007 we established a new Laboratory for e-media headed by the leading Slovenian researcher for managing information systems security and privacy. We plan to expand and strengthen the Faculty in the near future also in some other research areas by attracting experienced researchers. This expansion will be possible only when the Faculty's most pressing problem will be solved – the shortage of space. The location and architectural plans for the new Faculty building are already approved and construction is expected to begin in late in 2008.

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

*Franc Solina*

*Professor of Computer and Information Science and Dean*

# About FRI



# General Information

Dean **Prof. Dr. Franc Solina**

Associate Dean for Education **Prof. Dr. Radko Osredkar**

Associate Dean for Research **Prof. Dr. Blaž Zupan**

Associate Dean for Development **Prof. Dr. Nikolaj Zimic**

Head of administration **Lan Vošnjak, Ivan Malešič** (from 11. 2. 2008)

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**FRI**

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

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

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

# How to Reach Ljubljana

## BY AIR

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

## BY PASSENGER CAR

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

## BY AIR AND RAIL

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

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

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

*Via Italy:* By plane to Venice or Trieste and by train or car to Ljubljana



Figure 1: Slovenia in Europe

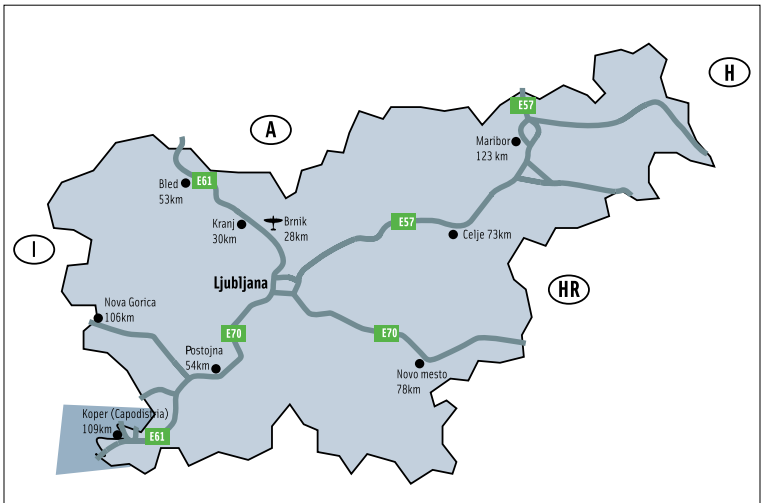


Figure 2: Map of Slovenia

**BY RAIL**

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



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



## LOCATION OF FRI IN LJUBLJANA

FRI is located in the South-West of Ljubljana (Figure 3) within walking distance of most hotels in the center of Ljubljana. To reach the Faculty from the center take bus lines 1 (direction “Mestni log”) or 6 (direction “Dolgi most”). How to reach FRI by car and where to park your car is shown in Figure 4.

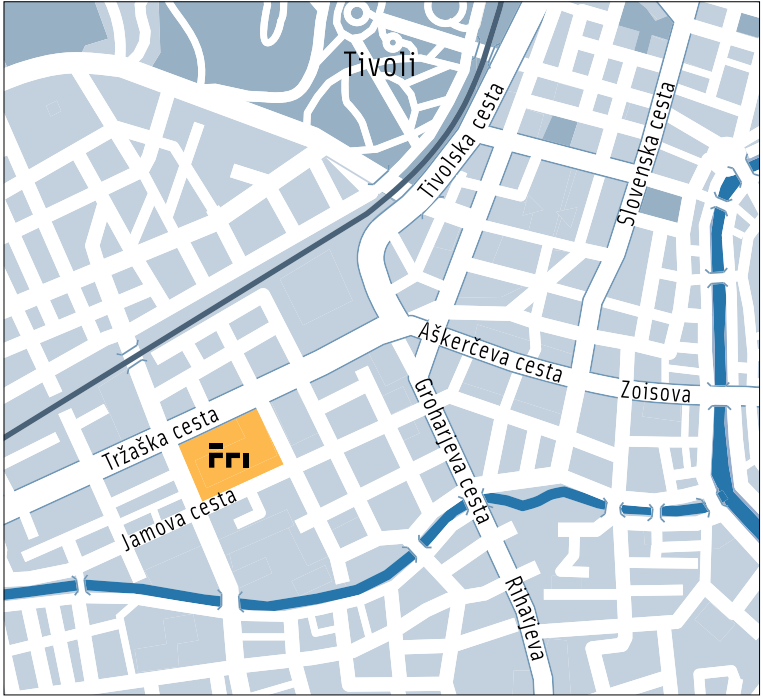


Figure 4: Detailed map of Ljubljana – the location of the Faculty is indicated by the highlighted yellow square

# Educational Programs



The academic year at the University of Ljubljana consists of fall and spring semesters. The courses in the fall semester begin on October 1st and end on January 15th. The spring semester courses start on February 15th and end on May 30th. There are three examination periods: winter (January 15th to February 15th), spring (June) and fall (September). Courses consist of lectures, problem solving classes (tutorials), and laboratory work. The weekly numbers of hours for each course shown in the following tables correspond to lectures, problem solving classes, and laboratory work, respectively. The average weekly course load for undergraduate students is cumulatively 25 hours. In the 2004/05 academic year an updated curriculum of the 8-semester (so called “university”) programs is starting and the data refers to that program.

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

## **UNDERGRADUATE PROGRAMS**

FRI offers three undergraduate educational programs:

*A four-year undergraduate program* (six semesters of lectures, 15 weeks of work in industry, 6 months of Diploma thesis work), which leads to the degree “Dipl. Ing. of Computer and Information Science”,

*A four-year “university” program* (eight semesters of lectures, 6 months of Diploma thesis work), which leads to the degree “University Dipl. Ing. of Computer and Information Science”, and

*A four year interdisciplinary “university” program* (eight semesters of lectures, 6 months of Diploma thesis work), which leads to the degree “University Dipl. Ing. of Computer Science and Mathematics”.



The entry requirement for the three-year program is completion of a four-year secondary education. For the four-year “university” programs the national secondary school baccalaureate is mandatory. The three-year program is application oriented, while the four-year program offers more extensive and in depth theoretical knowledge. Only graduates of the four-year program can continue their education at the postgraduate level.

The first two undergraduate programs consist of a core-curriculum, which contains mainly mathematics and theoretical foundations of computer and information science courses, and three elective modules, entitled,

*Information Science,*

*Computer Systems, and*

*Computer Software.*

Students must choose one of the three modules after the first year in the three-year program and after the second year in the four-year “university” program.

## **POSTGRADUATE PROGRAMS**

Postgraduate programs at the Faculty of Computer and Information Science consist of four semesters, followed by a Masters thesis, leading to a M.Sc. degree and subsequently by a Doctoral thesis leading to a Ph.D. degree in Computer and Information Science. Under specified conditions students can proceed from the required postgraduate courses to working directly on their Doctoral thesis, thus bypassing the Masters thesis. The Faculty offers two postgraduate programs:

*Computer and Information Science,*

*Information Systems and Decision Making.*

# Four-Year Undergraduate Program

## FIRST YEAR

| General Courses                          | Fall      |          |           | Spring    |          |          | Credits   |
|--|-----------|----------|-----------|-----------|----------|----------|-----------|
| Discrete Mathematics                     | 3         | 3        | 0         | 3         | 3        | 0        | 14.5      |
| Introduction to Programming I            | 3         | 0        | 3         | -         | -        | -        | 7         |
| Introduction to Computer Architecture I  | 3         | 0        | 3         | -         | -        | -        | 7         |
| Application Software                     | 1         | 0        | 4         | -         | -        | -        | 5.5       |
| Foreign Language (English)               | 0         | 3        | 0         | -         | -        | -        | 3.5       |
| Calculus I                               | -         | -        | -         | 3         | 1        | 2        | 7.5       |
| Introduction to Programming II           | -         | -        | -         | 3         | 0        | 3        | 7.5       |
| Introduction to Computer Architecture II | -         | -        | -         | 3         | 0        | 3        | 7.5       |
| <b>Total</b>                             | <b>10</b> | <b>6</b> | <b>10</b> | <b>12</b> | <b>4</b> | <b>8</b> | <b>60</b> |

## SECOND YEAR

| General Courses                                   | Fall     |          |          | Spring   |          |          | Credits     |
|---|----------|----------|----------|----------|----------|----------|-------------|
| Calculus II                                       | 3        | 3        | 0        | -        | -        | -        | 7.5         |
| Introduction to Algorithms and Data Structures I  | 3        | 1        | 2        | -        | -        | -        | 7.5         |
| Introduction to Algorithms and Data Structures II | -        | -        | -        | 3        | 1        | 2        | 7           |
| Business Economics                                | -        | -        | -        | 2        | 2        | 0        | 4.5         |
| <b>Total</b>                                      | <b>6</b> | <b>4</b> | <b>2</b> | <b>5</b> | <b>3</b> | <b>2</b> | <b>26.5</b> |

| Courses in Information Science | Fall     |          |          | Spring   |          |          | Credits     |
|--------------------------------|----------|----------|----------|----------|----------|----------|-------------|
| Information Systems            | 3        | 0        | 3        | -        | -        | -        | 7.5         |
| Databases I                    | 3        | 0        | 3        | -        | -        | -        | 7.5         |
| Databases II                   | -        | -        | -        | 3        | 0        | 3        | 7           |
| Statistics and Data Analysis   | -        | -        | -        | 2        | 2        | 0        | 4.5         |
| Information Systems Design     | -        | -        | -        | 3        | 0        | 3        | 7           |
| <b>Total</b>                   | <b>6</b> | <b>0</b> | <b>6</b> | <b>8</b> | <b>2</b> | <b>6</b> | <b>33.5</b> |

| Courses in Computer Logic and Systems | Fall     |          |          | Spring   |          |          | Credits     |
|---------------------------------------|----------|----------|----------|----------|----------|----------|-------------|
| Logic Structures and Systems I        | 3        | 0        | 3        | -        | -        | -        | 7.5         |
| Digital Electronics I                 | 3        | 1        | 2        | -        | -        | -        | 7.5         |
| Digital Electronics II                | -        | -        | -        | 3        | 1        | 2        | 7           |
| Input-Output Devices                  | -        | -        | -        | 3        | 1        | 2        | 7           |
| Computer Systems Organization         | -        | -        | -        | 2        | 2        | 0        | 4.5         |
| <b>Total</b>                          | <b>6</b> | <b>1</b> | <b>5</b> | <b>8</b> | <b>4</b> | <b>4</b> | <b>33.5</b> |

| <b>Courses in Computer Software</b>        | <b>Fall</b> |          | <b>Spring</b> |          |          | <b>Credits</b> |             |
|--|-------------|----------|---------------|----------|----------|----------------|-------------|
| Programming Languages                      | 3           | 1        | 2             | -        | -        | -              | 7.5         |
| Introduction to Databases                  | 3           | 0        | 3             | -        | -        | -              | 7.5         |
| Introduction to Information Systems        | -           | -        | -             | 3        | 0        | 3              | 7           |
| Introduction to Probability and Statistics | -           | -        | -             | 2        | 2        | 0              | 4.5         |
| User Interfaces                            | -           | -        | -             | 3        | 0        | 3              | 7           |
| <b>Total</b>                               | <b>6</b>    | <b>1</b> | <b>5</b>      | <b>8</b> | <b>2</b> | <b>6</b>       | <b>33.5</b> |

**THIRD YEAR**

| <b>General Courses</b>  | <b>Fall</b> |          | <b>Spring</b> |          |          | <b>Credits</b> |           |
|-------------------------|-------------|----------|---------------|----------|----------|----------------|-----------|
| System Software         | 3           | 0        | 2             | -        | -        | -              | 6         |
| Business Functions      | 2           | 2        | 0             | -        | -        | -              | 5         |
| Computer Communications | -           | -        | -             | 3        | 0        | 3              | 7         |
| <b>Total</b>            | <b>5</b>    | <b>2</b> | <b>2</b>      | <b>3</b> | <b>0</b> | <b>3</b>       | <b>18</b> |

| <b>Courses in Information Science</b>               | <b>Fall</b> |          | <b>Spring</b> |           |          | <b>Credits</b> |           |
|---|-------------|----------|---------------|-----------|----------|----------------|-----------|
| Organization Theory                                 | 2           | 2        | 0             | -         | -        | -              | 5         |
| Accounting  | 2           | 2        | 0             | -         | -        | -              | 5         |
| Application Development                             |             |          |               |           |          |                |           |
| Tools and Techniques                                | 3           | 1        | 2             | -         | -        | -              | 6.5       |
| Legal and Social Aspects of Informatics             | 2           | 0        | 0             | -         | -        | -              | 2.5       |
| Project Management<br>and Organiz. of Inform. Syst. | -           | -        | -             | 3         | 1        | 2              | 7         |
| Inform. Syst. Standards<br>and Quality Assurance    | -           | -        | -             | 2         | 0        | 1              | 4         |
| Communication Methods                               | -           | -        | -             | 2         | 2        | 0              | 5         |
| Decision Systems                                    | -           | -        | -             | 3         | 0        | 3              | 7         |
| <b>Total</b>  | <b>9</b>    | <b>5</b> | <b>2</b>      | <b>10</b> | <b>3</b> | <b>6</b>       | <b>42</b> |

| <b>Courses in Computer Logic and Systems</b> | <b>Fall</b> |          | <b>Spring</b> |           |          | <b>Credits</b> |           |
|--|-------------|----------|---------------|-----------|----------|----------------|-----------|
| Introduction to Computer Graphics            | 2           | 0        | 2             | -         | -        | -              | 5         |
| Introduction to Modelling and Simulation     | 3           | 0        | 3             | -         | -        | -              | 7         |
| Digital Signal Processing                    | 3           | 1        | 2             |           |          |                | 7         |
| Real Time Systems                            |             |          |               | 3         | 0        | 3              | 7         |
| Logic Structures and Systems II              |             |          |               | 3         | 0        | 3              | 7         |
| Computer Equipment Evaluation                | -           | -        | -             | 2         | 1        | 1              | 5         |
| Distributed Structures                       | -           | -        | -             | 2         | 0        | 1              | 4         |
| <b>Total</b>                                 | <b>8</b>    | <b>1</b> | <b>7</b>      | <b>10</b> | <b>1</b> | <b>8</b>       | <b>42</b> |

| <b>Courses in Computer Software</b>      | <b>Fall</b> |          | <b>Spring</b> |          |          | <b>Credits</b> |           |
|--|-------------|----------|---------------|----------|----------|----------------|-----------|
| Numerical Methods                        | 3           | 2        | 0             | -        | -        | -              | 6         |
| Introduction to Modelling and Simulation | 3           | 0        | 3             | -        | -        | -              | 7         |
| Programming Systems Design I             | 3           | 0        | 2             | -        | -        | -              | 6         |
| Programming Systems Design II            | -           | -        | -             | 3        | 1        | 2              | 7         |
| Introduction to Computer Graphics        | -           | -        | -             | 2        | 0        | 2              | 5         |
| Applications Development                 | -           | -        | -             | 1        | 0        | 2              | 4         |
| Methods of Artificial Intelligence       | -           | -        | -             | 3        | 0        | 3              | 7         |
| <b>Total</b>                             | <b>9</b>    | <b>2</b> | <b>5</b>      | <b>9</b> | <b>1</b> | <b>9</b>       | <b>42</b> |

## FOURTH YEAR

| <b>General Courses</b> | <b>Fall</b> | <b>Spring</b>   |
|------------------------|-------------|-----------------|
| Practice               | 15 weeks    |                 |
| Diploma Thesis         |             | 6 months        |
| <b>Total</b>           | 15 weeks    | <b>6 months</b> |

# Four-Year “University” Undergraduate Program

## FIRST YEAR

| General Courses                | Fall      |          | Spring   |           |          | Credits  |           |  |
|--------------------------------|-----------|----------|----------|-----------|----------|----------|-----------|--|
| Calculus I                     | 3         | 3        | 0        | -         | -        | -        | 6.5       |  |
| User Application Software      | 1         | 0        | 3        | -         | -        | -        | 4.5       |  |
| Discrete Structures            | 3         | 2        | 0        | -         | -        | -        | 5.5       |  |
| Physics                        | 3         | 3        | 0        | -         | -        | -        | 6,5       |  |
| Programming I                  | 3         | 0        | 3        | -         | -        | -        | 7         |  |
| Calculus II                    | -         | -        | -        | 3         | 3        | 0        | 6.5       |  |
| Computer Technologies          | -         | -        | -        | 3         | 2        | 0        | 5.5       |  |
| Linear Algebra                 | -         | -        | -        | 2         | 2        | 0        | 4.5       |  |
| Programming II                 | -         | -        | -        | 3         | 0        | 3        | 7         |  |
| Switching Circuits and Systems | -         | -        | -        | 3         | 0        | 3        | 6.5       |  |
| <b>Total</b>                   | <b>13</b> | <b>8</b> | <b>6</b> | <b>14</b> | <b>7</b> | <b>6</b> | <b>60</b> |  |

## SECOND YEAR

| General Courses                      | Fall      |          | Spring   |           |          | Credits   |           |  |
|--------------------------------------|-----------|----------|----------|-----------|----------|-----------|-----------|--|
| Algorithms and Data Structures I     | 3         | 0        | 3        | -         | -        | -         | 7         |  |
| Computer Systems Architecture I      | 3         | 0        | 3        | -         | -        | -         | 7.5       |  |
| Foreign Language (English)           | 0         | 3        | 0        | -         | -        | -         | 3.5       |  |
| Introduction to Information Theory   | 3         | 2        | 0        | -         | -        | -         | 6         |  |
| Probability Theory and Statistics    | 3         | 2        | 0        | -         | -        | -         | 6         |  |
| Algorithms and Data Structures II    | -         | -        | -        | 3         | 0        | 3         | 6.5       |  |
| Computer Systems Architecture II     | -         | -        | -        | 3         | 0        | 3         | 6.5       |  |
| Computer Communications and Networks | -         | -        | -        | 3         | 0        | 2         | 5         |  |
| Modeling and Simulation              | -         | -        | -        | 3         | 0        | 3         | 6         |  |
| Numerical Methods                    | -         | -        | -        | 3         | 0        | 3         | 6         |  |
| <b>Total</b>                         | <b>12</b> | <b>7</b> | <b>6</b> | <b>15</b> | <b>0</b> | <b>14</b> | <b>60</b> |  |

## THIRD YEAR

| Common Courses     | Fall     |          | Spring   |          |          | Credits  |            |  |
|--------------------|----------|----------|----------|----------|----------|----------|------------|--|
| Business Economics | 2        | 1        | 0        | -        | -        | -        | 3.5        |  |
| <b>Total</b>       | <b>2</b> | <b>1</b> | <b>0</b> | <b>-</b> | <b>-</b> | <b>-</b> | <b>3.5</b> |  |



| Information Science Module                             | Fall      |          | Spring   |           | Credits  |          |             |
|--|-----------|----------|----------|-----------|----------|----------|-------------|
| Databases I  | 3         | 1        | 2        | -         | -        | -        | 6.5         |
| Information Systems                                    | 3         | 1        | 2        | -         | -        | -        | 7           |
| Operating Systems Fundamentals<br>Software Development | 3         | 0        | 3        | -         | -        | -        | 6.5         |
| Project Management                                     | 3         | 1        | 2        | -         | -        | -        | 6.5         |
| Information Systems Development                        | -         | -        | -        | 3         | 1        | 2        | 6           |
| Decision Models and Systems                            | -         | -        | -        | 3         | 3        | 0        | 6           |
| Operations Research                                    | -         | -        | -        | 2         | 0        | 2        | 4.5         |
| Multimedia Systems                                     | -         | -        | -        | 2         | 0        | 1        | 3.5         |
| Theory of Organization                                 | -         | -        | -        | 2         | 0        | 0        | 4.5         |
| Databases II   | -         | -        | -        | 3         | 1        | 2        | 6.5         |
| <b>Total</b>   | <b>12</b> | <b>3</b> | <b>9</b> | <b>15</b> | <b>5</b> | <b>7</b> | <b>57.5</b> |

| Computer Systems Module              | Fall      |          | Spring    |           | Credits  |           |             |
|--------------------------------------|-----------|----------|-----------|-----------|----------|-----------|-------------|
| Graphic Techniques and Procedures    | 3         | 0        | 3         | -         | -        | -         | 6.5         |
| Logic Design Methods                 | 3         | 0        | 3         | -         | -        | -         | 7           |
| Computer Organization                | 3         | 0        | 3         | -         | -        | -         | 6.5         |
| Operating Systems                    | 3         | 0        | 3         | -         | -        | -         | 6.5         |
| Digital Electronics                  | -         | -        | -         | 3         | 0        | 3         | 6.5         |
| Distributed Systems and Technologies | -         | -        | -         | 3         | 1        | 2         | 7           |
| Input-Output Devices and Systems     | -         | -        | -         | 3         | 0        | 3         | 6.5         |
| Fundamentals of Information Systems  | -         | -        | -         | 2         | 0        | 1         | 3.5         |
| System Software                      | -         | -        | -         | 3         | 0        | 3         | 6.5         |
| <b>Total</b>                         | <b>12</b> | <b>0</b> | <b>12</b> | <b>14</b> | <b>1</b> | <b>12</b> | <b>56.5</b> |

| Computer Software Module  | Fall      |          | Spring   |           | Credits  |          |             |
|---|-----------|----------|----------|-----------|----------|----------|-------------|
| Operating Systems I   | 3         | 0        | 3        | -         | -        | -        | 6.5         |
| Fundamentals of Databases                                       | 3         | 1        | 2        | -         | -        | -        | 6.5         |
| Theoretical Fundamentals<br>of Computer Science I               | 3         | 3        | 0        | -         | -        | -        | 7           |
| Project Management  | 3         | 1        | 2        | -         | -        | -        | 6.5         |
| Operating Systems II  | -         | -        | -        | 3         | 0        | 3        | 6.5         |
| Principles of Programming Languages<br>and Symbolic Programming | -         | -        | -        | 3         | 3        | 0        | 7           |
| Computer Graphics   | -         | -        | -        | 3         | 0        | 3        | 6.5         |
| Fundamentals of Information Systems                             | -         | -        | -        | 2         | 0        | 1        | 3.5         |
| Theoretical Fundamentals<br>of Computer Science II              | -         | -        | -        | 3         | 3        | 0        | 6.5         |
| <b>Total</b>  | <b>12</b> | <b>5</b> | <b>7</b> | <b>14</b> | <b>6</b> | <b>7</b> | <b>56.7</b> |

**FOURTH YEAR**

| <b>Common Courses</b>                       | <b>Fall</b> |          | <b>Spring</b> |          | <b>Credits</b> |          |           |
|---|-------------|----------|---------------|----------|----------------|----------|-----------|
| Computer Systems Performance and Evaluation | 3           | 0        | 3             | -        | -              | -        | 6.5       |
| Business Functions                          | -           | -        | -             | 2        | 1              | 0        | 3.5       |
| <b>Total</b>                                | <b>3</b>    | <b>0</b> | <b>3</b>      | <b>2</b> | <b>1</b>       | <b>0</b> | <b>10</b> |

| <b>Information Science Module</b>                                     | <b>Fall</b> |          | <b>Spring</b> |           | <b>Credits</b> |          |           |
|---|-------------|----------|---------------|-----------|----------------|----------|-----------|
| Methods of Communication Design and Management of Information Systems | 3           | 0        | 3             | -         | -              | -        | 6.5       |
| Business Analysis   | 3           | 1        | 2             | -         | -              | -        | 6.5       |
| Electronic Business   | 2           | 0        | 2             | -         | -              | -        | 4         |
| Distributed Information Systems                                       | 3           | 0        | 3             | -         | -              | -        | 6.5       |
| Information Systems Technology  | -           | -        | -             | 3         | 0              | 3        | 7         |
| Artificial Intelligence   | -           | -        | -             | 3         | 0              | 3        | 7         |
| Information Society   | -           | -        | -             | 3         | 2              | 1        | 7         |
| <b>Total</b>  | <b>11</b>   | <b>1</b> | <b>10</b>     | <b>12</b> | <b>2</b>       | <b>9</b> | <b>50</b> |

| <b>Computer Systems Module</b>                           | <b>Fall</b> |          | <b>Spring</b> |           | <b>Credits</b> |          |           |
|--|-------------|----------|---------------|-----------|----------------|----------|-----------|
| Soft Computing Methods                                   | 3           | 3        | 0             | -         | -              | -        | 6.5       |
| Optical- and Nanotechnologies- Digital Signal Processing | 3           | 0        | 3             | -         | -              | -        | 6.5       |
| Seminar  | 3           | 0        | 3             | -         | -              | -        | 7         |
| Parallel Architecture of Computers                       | 0           | 0        | 3             | -         | -              | -        | 3.5       |
| Process Informatics                                      | -           | -        | -             | 3         | 0              | 3        | 7         |
| Computer Reliability and Diagnostics                     | -           | -        | -             | 3         | 0              | 3        | 6.5       |
| Telematics   | -           | -        | -             | 3         | 3              | 0        | 6.5       |
| <b>Total</b>   | <b>9</b>    | <b>3</b> | <b>9</b>      | <b>12</b> | <b>3</b>       | <b>9</b> | <b>50</b> |

| <b>Computer Software Module</b>               | <b>Fall</b> |          | <b>Spring</b> |           | <b>Credits</b> |          |           |
|---|-------------|----------|---------------|-----------|----------------|----------|-----------|
| Digital Signal Processing                     | 3           | 0        | 3             | -         | -              | -        | 6         |
| Machine Perception                            | 3           | 0        | 3             | -         | -              | -        | 6         |
| Artificial Intelligence I                     | 3           | 2        | 1             | -         | -              | -        | 6         |
| Compilers                                     | 3           | 0        | 2             | -         | -              | -        | 5.5       |
| Intelligent Distributed Software Technologies | -           | -        | -             | 3         | 0              | 3        | 7.5       |
| Software Technology                           | -           | -        | -             | 3         | 0              | 3        | 7         |
| Knowledge Engineering                         | -           | -        | -             | 3         | 2              | 0        | 6         |
| Artificial Intelligence II                    | -           | -        | -             | 3         | 1              | 1        | 6         |
| <b>Total</b>                                  | <b>12</b>   | <b>2</b> | <b>9</b>      | <b>12</b> | <b>3</b>       | <b>7</b> | <b>50</b> |

# Four-Year “University” Interdisciplinary Program “Computer Science and Mathematics”

## FIRST YEAR

| Course                        | Fall     |          | Spring   |           | Credits  |          |           |
|-------------------------------|----------|----------|----------|-----------|----------|----------|-----------|
|                               |          |          |          |           |          |          |           |
| Calculus 1                    | 3        | 3        | 0        | -         | -        | -        | 8         |
| Discrete Mathematics 1        | 3        | 2        | 0        | -         | -        | -        | 7         |
| Computer Lab                  | 1        | 0        | 3        | -         | -        | -        | 6         |
| Introduction to Programming 1 | 2        | 0        | 2        | -         | -        | -        | 6         |
| Calculus 2                    | -        | -        | -        | 3         | 3        | 0        | 8         |
| Discrete Mathematics 2        | -        | -        | -        | 3         | 3        | 0        | 8         |
| Introduction to Programming 2 | -        | -        | -        | 2         | 0        | 2        | 6         |
| Linear Algebra 1              | -        | -        | -        | 2         | 2        | 0        | 6         |
| Tutorial                      | 0        | 0        | 2        | 0         | 0        | 2        | 5         |
| <b>Total</b>                  | <b>9</b> | <b>5</b> | <b>7</b> | <b>10</b> | <b>8</b> | <b>4</b> | <b>60</b> |

## SECOND YEAR

| Course                           | Fall      |          | Spring    |           | Credits  |          |           |
|----------------------------------|-----------|----------|-----------|-----------|----------|----------|-----------|
|                                  |           |          |           |           |          |          |           |
| Linear Algebra 2                 | 2         | 2        | 0         | -         | -        | -        | 5         |
| Numerical Methods 1              | 2         | 0        | 2         | -         | -        | -        | 5         |
| Algorithms and Data Structures 1 | 3         | 0        | 3         | -         | -        | -        | 7         |
| Computer Architectures 1         | 3         | 0        | 3         | -         | -        | -        | 7         |
| Theory of Programming Languages  | 2         | 0        | 2         | -         | -        | -        | 5         |
| Algorithms and Data Structures 2 | -         | -        | -         | 3         | 0        | 3        | 7         |
| Calculus 3                       | -         | -        | -         | 3         | 3        | 0        | 7         |
| Combinatorics                    | -         | -        | -         | 3         | 3        | 0        | 7         |
| Numerical Methods 2              | -         | -        | -         | 2         | 0        | 2        | 5         |
| Declarative Programming          | -         | -        | -         | 2         | 0        | 2        | 5         |
| <b>Total</b>                     | <b>12</b> | <b>2</b> | <b>10</b> | <b>13</b> | <b>6</b> | <b>7</b> | <b>60</b> |

**THIRD YEAR**

| <b>Course</b>              | <b>Fall</b> |          | <b>Spring</b> |           |          | <b>Credits</b> |           |
|----------------------------|-------------|----------|---------------|-----------|----------|----------------|-----------|
| Introduction to Data Bases | 3           | 1        | 2             | -         | -        | -              | 6         |
| Probability and Statistics | 3           | 3        | 0             | -         | -        | -              | 7         |
| Computability Theory       | 3           | 3        | 0             | -         | -        | -              | 7         |
| Operating Systems          | 3           | 0        | 3             | -         | -        | -              | 7         |
| Optimization               | -           | -        | -             | 3         | 0        | 3              | 7         |
| Computational Complexity   | -           | -        | -             | 3         | 3        | 0              | 7         |
| Computational Geometry     | -           | -        | -             | 3         | 0        | 3              | 7         |
| Computer Graphics          | -           | -        | -             | 3         | 0        | 3              | 7         |
| Elective*                  | -           | -        | -             | 2         | 2        | 0              | 5         |
| <b>Total</b>               | <b>12</b>   | <b>7</b> | <b>5</b>      | <b>14</b> | <b>5</b> | <b>9</b>       | <b>60</b> |

**FOURTH YEAR**

| <b>Course</b>                     | <b>Fall</b> |           | <b>Spring</b> |           |           | <b>Credits</b> |           |
|-----------------------------------|-------------|-----------|---------------|-----------|-----------|----------------|-----------|
| Cryptography and Coding Theory 1  | 2           | 2         | 0             | -         | -         | -              | 5         |
| Artificial Intelligence 1         | 3           | 2         | 1             | -         | -         | -              | 6         |
| Communication Theory              | 2           | 2         | 0             | -         | -         | -              | 4.5       |
| Elective*                         | 6           | 6         | 0             | -         | -         | -              | 15        |
| Cryptography and Coding Theory 2  | -           | -         | -             | 2         | 2         | 0              | 5         |
| Artificial Intelligence 2         | -           | -         | -             | 3         | 1         | 1              | 5         |
| Alternative Models of Computation | -           | -         | -             | 2         | 2         | 0              | 4.5       |
| Elective*                         | -           | -         | -             | 6         | 6         | 0              | 15        |
| <b>Total</b>                      | <b>13</b>   | <b>12</b> | <b>1</b>      | <b>13</b> | <b>11</b> | <b>1</b>       | <b>60</b> |

**ELECTIVE COURSES**

| <b>Course</b>                                      | <b>Fall</b> |   | <b>Spring</b> |   | <b>Credits</b> |   |   |
|--|-------------|---|---------------|---|----------------|---|---|
| Symbolic Computing                                 | 2           | 0 | 2             | - | -              | - | 5 |
| Algorithms for Discrete Structures                 | 2           | 0 | 2             | - | -              | - | 5 |
| Topics in Data Analysis                            | 2           | 0 | 2             | - | -              | - | 5 |
| Logic in Computer Science                          | 2           | 2 | 0             | - | -              | - | 5 |
| Scientific Communication                           | 2           | 2 | 0             | - | -              | - | 5 |
| Computer Perception                                | 2           | 0 | 2             | - | -              | - | 5 |
| Real Time Systems                                  | 2           | 0 | 2             | - | -              | - | 5 |
| Soft Computing                                     | 2           | 2 | 0             | - | -              | - | 5 |
| System Performance Analysis                        | 2           | 0 | 2             | - | -              | - | 5 |
| Case Studies in Data Mining                        | 2           | 0 | 2             | - | -              | - | 5 |
| Approximative Algorithms                           | -           | - | -             | 2 | 2              | 0 | 5 |
| Graph Theory                                       | -           | - | -             | 2 | 2              | 0 | 5 |
| Operational Research                               | -           | - | -             | 2 | 0              | 2 | 5 |
| Dynamical Systems                                  | -           | - | -             | 2 | 2              | 0 | 5 |
| Topics in Data Structures                          | -           | - | -             | 2 | 0              | 2 | 5 |
| Computer Architectures 2                           | -           | - | -             | 2 | 0              | 2 | 5 |
| Machine Learning                                   | -           | - | -             | 2 | 2              | 0 | 5 |
| Pattern Recognition                                | -           | - | -             | 2 | 0              | 2 | 5 |
| Computer Vision                                    | -           | - | -             | 2 | 0              | 2 | 5 |
| Human Machine Interaction                          | -           | - | -             | 2 | 2              | 0 | 5 |
| Modeling and Simulation                            | -           | - | -             | 2 | 0              | 2 | 5 |
| Fault Tolerance<br>and Computer System Diagnostics | -           | - | -             | 2 | 2              | 0 | 5 |
| Distributed Systems and Technologies               | -           | - | -             | 2 | 0              | 2 | 5 |
| Distributed Information Systems                    | -           | - | -             | 2 | 0              | 2 | 5 |

# Computer and Information Science Postgraduate Program

The postgraduate curriculum in Computer and Information Science is comprised of:

*six required courses (30 hours, 6 ECTS each),*

*four elective courses (30 hours, 6 ECTS each),*

*two seminars (75 hours, 15 ECTS each).*

The total postgraduate course work consists of 450 hours.

## FIRST YEAR

| Courses  | Fall     | Spring   |
|--|----------|----------|
| Selected Topics in Symbolic Computation and Computer Arithmetics | 30 hours |          |
| Analysis of Algorithms   | 30 hours |          |
| Theory of Computer Languages                                     |          | 30 hours |
| Theory of Computational Procedures                               |          | 30 hour  |
| Elective Course  | 30 hours |          |
| Elective Course  |          | 30 hours |

## SECOND YEAR

| Courses                                    | Fall     | Spring   |
|--|----------|----------|
| Architecture and Organization of Computers | 30 hours |          |
| Theory of Information Systems              |          | 30 hours |
| Elective Course                            | 30 hours |          |
| Elective Course                            |          | 30 hours |
| Seminar                                    | 75 hours | 75 hours |

## ELECTIVE COURSES (30 HOURS, 6 ECTS EACH)

Selected Topics in Computer Architecture

Reliability of Computer Systems

Multiprocessor Architectures and Parallel Algorithms

Artificial Intelligence Methods

Digital Signal Processing

Cellular Automata and Parallel Processing

Neural Networks

Integrated Computer Support of Manufacturing  
Databases  
Concepts for Modeling of Visual Information  
Special Course in Information Science  
Special Course in Operations Research  
Special Course in Programming Technology  
Methods of Applied Mathematics  
Selected Topics in Combinatorial Mathematics  
Machine Learning  
Logic  
Approximation and Randomized Algorithms  
Cryptography and Computer Security  
Differential and Computational Geometry  
System Methods  
Distributed and Decentralized Information Systems  
Decision Systems  
Interpersonal Relations and Communication  
Information Systems Development Tools  
Project Management  
Multimedia Techniques  
Selected Topics of Economics  
Automation of New Public Management  
Information Systems in Natural Sciences and Technology  
Information Systems and Public Administration  
Reengineering of Business Processes  
Information Systems Quality and Standardization  
Information Systems Sociology – Information Society  
Statistical Information Systems  
Reliability of Computer Systems  
Visual Information Handling  
Operational Research in Information Science  
Fuzzy Logic Based Decision Making  
Portfolio Management  
Macroeconomics Modeling  
Computer Networks with Services

Computer Supported Cooperative Work

Data Mining and Knowledge Discovery in Databases

Evolutionary Computing

Intelligent Agents

Electronic Business

Computer Structures and Nanotechnologies

Embedded Systems

Numerical Linear Algebra

Topology in Computer Science

One- and Multi-Dimensional Biomedical Signal Processing



# Information Systems and Decision Making Postgraduate Program

The program (a total of 450 hours) is comprised of the following: two required courses (60 hours, 12 *ECTS* each),

*a combination of three to five elective courses* (Main elective courses of 60 hours, 12 *ECTS* each, other elective courses 30 hours, 6 *ECTS* each),

*seminar* (150 hours, 30 *ECTS*).

| Semester | Courses  |
|----------|--|
| 1        | Functions and Decision Making (Required course)<br>Elective courses  |
| 2        | Information Systems (Required course)<br>Elective courses  |
| 3        | Information Systems Development (Main elective course)<br>Management and Theory of Organization (Main elective course)<br>Information Systems Management in Business Systems (Main elective course)<br>Elective courses<br>Seminar |
| 4        | Master's thesis (30 <i>ECTS</i> )  |

## **ELECTIVE COURSES (30 HOURS EACH)**

Elective courses (see page 24) are common to both postgraduate programs, i.e., Computer and Information Science and Information Systems and Decision Making.

# Research



Research activities (as well as most Diploma, Master, and Doctoral theses research) at FRI are performed in seventeen research laboratories which are organized in six groups.

The main sources of research funding are Slovenian Research Agency, the Ministry of Higher Education, Science and Technology, Ministry of Defense, European Union programs (6<sup>th</sup> and 7<sup>th</sup> FP, COST) and various bilateral programs: USA-Slovenian, French-Slovenian (Proteus), Austrian-Slovenian, Czech-Slovenian, Norwegian-Slovenian, Portuguese-Slovenian, and UK-Slovenian (ALINK). The Ministry of Higher Education, Science and Technology, 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 companies.

For more information consult the Web pages of individual laboratories which are all accessible from the Faculty's home page (<http://www.fri.uni-lj.si/en/laboratories/>).

### **SOFTWARE GROUP**

Laboratory for Computer Graphics and Multimedia

Laboratory for Biomedical Computer Systems and Imaging

### **COMPUTER LOGIC, SYSTEMS AND NETWORKS GROUP**

Laboratory for Adaptive Systems and Parallel Processing

Laboratory for Computer Architecture

Computer Communications Laboratory

Computer Structures and Systems Laboratory

### **INFORMATICS GROUP**

Information Systems Laboratory

Laboratory for e-Media

### **THEORETICAL COMPUTER SCIENCE GROUP**

Laboratory for Algorithms and Data Structures

Laboratory for Architecture and Signal Processing

Software Engineering Laboratory

### **ARTIFICIAL INTELLIGENCE GROUP**

Computer Vision Laboratory

Visual Cognitive Systems Laboratory

Artificial Intelligence Laboratory

Laboratory for Cognitive Modeling

### **MATHEMATICS AND PHYSICS GROUP**

Laboratory for Mathematical Methods in Computer and Information Sciences

Laboratory for Cryptography and Computer Security

# Laboratory for Computer Graphics and Multimedia

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## RESEARCH ACTIVITIES

Laboratory of Computer Graphics and Multimedia is involved in activities related to multimedia technologies, computer-based education and learning, human-computer interaction, 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 laboratory also cooperates with Microsoft in introducing new software technologies.

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

- digital libraries and multimedia information retrieval,
- educational metadata creation, retrieval and exchange,
- folksonomy and social tagging,
- development of interactive educational content,
- e-learning environments.

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

Therefore, 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.

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

## RESEARCH PROJECTS

MELT - a Metadata Ecology for Learning and Teaching (ECP-2005-EDU-038103), eContentplus Programme, European Commission (2006 – 2008).

ETHNOMUSE: multimedia digital archive of Slovenian folk music and folk dance culture (V2-0216), CRP Project, Slovenian Research Agency (2006 – 2008).

ERI: e-materials for computer science and informatics (3311-06-297038), Ministry of Education and Sport, and European Social Fund (2006 – 2007).

e-VIZUS: Informatization of learning and training in Slovenian Armed Forces (M5-0164), CRP Project, Slovenian Research Agency (2006 – 2007).

Second Click on Slovene - a multimedia CD for learning Slovene as a foreign language, project funded by American Embassy in Ljubljana (2006 – 2008).

Digital archive of Slovenian folk songs, project with Science Research Centre of the Slovenian Academy of Sciences and Arts (2006 – 2007).

## INVITED TALKS AND LECTURES

Matija Marolt: Performing Query-by-Melody on Audio Collections, 29. 11. 2007, an invited talk at 154th Meeting of Acoustical Society of America, New Orleans, USA.

## SELECTED PUBLICATIONS

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



Augmented reality in action

- M. Privošnik. Scalability in evolved multi-agent systems. *Proceedings of CEC 2007: 2007 Congress on Evolutionary Computation*, 25 - 28 September 2007, Singapore, pp. 1091-1096. 2007.
- G. Strle, M. Marolt M. Conceptualizing the Ethnomuse: Application of CIDOC CRM and FRBR. *Proceedings of CIDOC2007*, Vienna, Austria. 2007.
- S. Divjak. Interactive courseware for computer science teaching and learning. *HSCI 2007: Proceedings of the 4th International Conference on Hands-on Science, Development, Diversity and Inclusion in Science Education*, July 23-27, 2007, Universidade dos Açores, Ponta Delgada, Portugal. H-Sci, cop. 2007, str. 99-101. 2007.
- A. Kavčič, J. Južna, S. Divjak. Effective use of existing e-learning materials. *Proceedings of International Conference Enabling education and research with ICT, SIRIKT 2007*, Kranjska Gora, 19 - 21 April 2007, pp. 355-359. 2007.
- J. F. Vratinar. Detekcija šumnih dogodkov v glasbenih posnetkih. *Zbornik posvetovanja Dnevi Slovenske Informatike*, Proceedings. 2007.
- C. Wolfgang, M. Belloni, S. Divjak. Fizika s fizleti: interaktivne predstavitve in raziskave za uvod v fiziko. 1. natis. Ljubljana: Zavod Republike Slovenije za šolstvo: Ministrstvo za šolstvo in šport. 2006.
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- S. Divjak. Conceptual learning of science and 3D simulations. *Hands-on science: science in a changing education: HSci2005*, 2nd international conference, 13-16 July 2005, Greece. pp. 87-90. 2005.
- R. Dorn, F. Jager. Semia: semi-automatic interactive graphic editing tool to annotate ambulatory ECG records. *Comput. methods programs biomedicine*, Vol. 75, no. 3, pp. 235-249. 2004.
- A. Kavčič. Fuzzy User Modeling for Adaptation in Educational Hypermedia. *IEEE Transactions on Systems, Man, and Cybernetics*, Part C, November 2004, Vol. 34, No. 4, pp. 439-449. 2004.
- M. Marolt. A Connectionist Approach to Transcription of Polyphonic Piano Music. *IEEE Transactions on Multimedia*, June 2004, Vol.6, Issue 3, pp. 439- 449. 2004.
- M. Marolt. Networks of Adaptive Oscillators for Partial Tracking and Transcription of Music Recordings. *Journal of New Music Research*, Vol. 33, No. 1. 2004.

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

The principal research topic currently underway is the development and evaluation of recognition algorithms for accurate detecting of transient ischaemic events in biomedical data using the LTST DB (Long-Term ST Database).

The second research topic is maintaining, updating and distribution of standardized international reference-annotated ECG database LTST DB. The database is result of a multinational research effort and contains 86

24-hour ambulatory recordings with a number of human-annotated transient ischaemic and non-ischaemic ST events. The database is intended to serve as a reference set in evaluating the performance of ST analyzers, and as a reference set to study physiologic mechanisms responsible for ischaemia. 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://lbcsi.fri.uni-lj.si/database/>.

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

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

Another important contribution of the laboratory to the world community is interactive graphic tool EVAL\_ST to evaluate performance and robustness of ischaemia analysers. The tool is under GNU General Public Licence and is available from [http://www.physionet.org/physiotools/eval\\_st/](http://www.physionet.org/physiotools/eval_st/).

Another topic concerns the investigation and assessment of effective methods for monitoring patients affected by cardiovascular diseases, outside the specialized cardiac units, through computer analysis and the interpretation of non-invasive bio-signal data, with the ultimate goal of cardiac telemonitoring via the Internet.

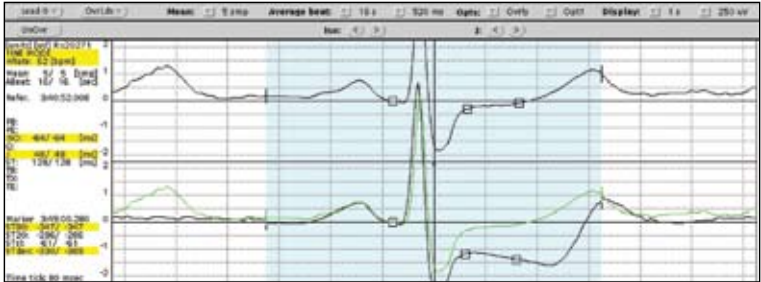
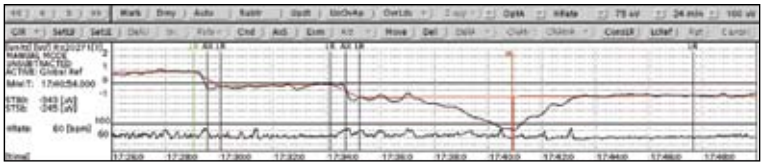
The Laboratory supports a Web mirror site (<http://physionet.fri.uni-lj.si>) for a part of Europe to the PhysioNet Web site (<http://www.physionet.org>) which is located at the Massachusetts Institute of Technology in Cambridge, USA. Maintaining of the PhysioNet Web site is supported by the U.S. National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

## RESEARCH PROJECTS

Maintaining, updating and distribution of the Long Term ST Database (LTST DB); research partners: Beth Israel Deaconess Medical Center, Boston, USA, and CNR Institute of Clinical Physiology, Pisa, Italy; (Database is available from: Laboratory of Biomedical Computer Systems and Imaging, Faculty of Computer and Information Science, Ljubljana, contact: Dr. Franc Jager); Samples of the database are available from <http://www.physionet.org/physiobank/database/ltstadb/> (2002–2007).

Metabolic and inborn factors of reproductive health, birth (P3-0124), Research programme funded by Slovenian Research Agency (2004–2009).





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

## LABORATORY GUESTS

Gari Clifford: Division of Health Sciences and technology, Massachusetts Institute of technology, Cambridge, USA, 24. 6. - 30. 6. 2007. Work on joint research topics.

## RESEARCH VISITS

Franc Jager: Division of Health Sciences and technology, Massachusetts Institute of technology, Cambridge, USA, 25. 9. - 30. 9. 2007. Work on joint research topics.

## SELECTED PUBLICATIONS

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

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: Feature Extraction and Shape Representation of Ambulatory ECG using the Karhunen Loeve Transform. *Electrotechnical Review*, 69(2):83–89, 2002.

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

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

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

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

Miha Amon, F, Jager. Comparison of Protocols ro Annotate Ischaemic Electrocardiogam Episodes in the Reference ESC DB and LTST DB databases. *Electrotechnical Review*. 72(4):183-188, 2005.

A. Mincholé, B. Skarp, F. Jager and P. Laguna. Ischemia Detector on the Long-Term ST Database with Body Position Cancellation. *Proc. Computers in Cardiology*, pp. 853-856, Lyon, France, 2005.

Ales Smrdel, Franc 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.

# Laboratory of Adaptive Systems and Parallel Processing

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## RESEARCH ACTIVITIES

Main research activities are concentrated around the following topics:

- Neural networks in data mining, prediction, recognition and control problems,
- Evolutionary algorithms in optimization problems,
- Identification of dynamic systems with Recurrent neural networks,
- Fuzzy and Neuro-Fuzzy controllers,
- Process Informatics and Programmable Technologies,
- Cellular structures and Complex Systems,
- Modeling of nonlinear dynamic systems with information-theoretic learning,
- Parallel processing/programming in GRID environments.

## RESEARCH PROJECTS

Development and realization of on-line regulation of compound mixer with soft computing methods (IPMT-001/2006/FRI-LASPP-001), Industry-Funded Project, Savatech. d.o.o., Kranj (2006–2008).

Global GRID for data mining with soft computing on large data bases (BI-PT/06-07-008), Bilateral Collaboration Project, Slovenian Research Agency (2006–2007).

Data mining of combined bases of mixing recipes and compound testing with soft computing methods (L2-6460), Basic Research and Application Project, Slovenian Research Agency and Savatech, d.o.o., Kranj (2004-2007).

Relating the Physical Properties of Polymeric Materials by Parallel Implementation of Soft Computing Methods, (L2-6143), Basic Research and Application Project, Slovenian Research Agency (2004-2007).

## LABORATORY GUESTS

Prof. dr. Bernardete Ribeiro, University of Coimbra, Portugal, 19. 5. – 24. 5. 2007. Research collaboration on “Intelligent data mining in GRID technology”.

Catarina Silva, University of Coimbra, Portugal, 21. 5. – 26. 5. 2007. Research collaboration on “Intelligent data mining in GRID technology”.

## RESEARCH VISITS

Branko Šter: CISUC – Department of Informatics Engineering, University of Coimbra, Portugal, 1. 7. – 1. 8. 2007, Research collaboration on “Intelligent data mining in GRID technology”.

Uroš Lotrič: CISUC – Department of Informatics Engineering, University of Coimbra, Portugal, 28. 10. – 3. 11. 2007, Collaboration on development of data-mining algorithms in distributed environments.

## SELECTED PUBLICATIONS

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

M. Trebar, Z. Šušterič, U. Lotrič. Predicting mechanical properties of elastomers with neural networks, *Polymer*, 48: 5340-5347, 2007

Branko Šter, Ivan Gabrijel, Andrej Dobnikar. Impact of Learning on the Structural Properties of Neural Networks, *Lecture notes in computer science*, Springer, part 2, LNCS 4432: 63-71, 2007

Mira Trebar, Uroš Lotrič: Predicting Mechanical Properties of Rubber Compounds with Neural Networks and Support Vector Machines, *Lecture notes on computer science*, Springer, part 2, LNCS 4432: 254-262, 2007



Fuzzy control system based on video-cameras



Computing cluster

I. Jeras, A. Dobnikar. Cellular automata preimages: count and list algorithm. *Lecture notes in computer science*, Springer, part 3, LNCS 3993: 345-352, 2006.

B. Šter, A. Dobnikar. Modelling the environment of a mobile robot with the embedded flow state machine. *J. intell. Robot syst.*, 46(2): 182-199, 2006.

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

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

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

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

# Laboratory for Computer Architecture

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| Retired professor <b>Dr. Ljubo Pipan</b>      |                              |      |

## RESEARCH ACTIVITIES

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

The main research work is dedicated to short SIMD processing and the integration of these new processing facilities into high-level programming languages. Currently, the most significant activities are development of syntax and semantics extensions to the ANSI C in such a way that we could use short SIMD processing facilities in C programming language and development of its vectorizing compiler which is capable to automatically extract short SIMD parallelism from loops. We call it MMC (multimedia C) language. We have also introduced a new data-dependence test for array references with linear subscripts. We have named this test the D-test. It is appropriate for the vectorization for modern SIMD microprocessors and is more accurate than existing tests. The test takes into account the architectural properties of modern SIMD microprocessors and allows the existence of those data dependences in the loops that do not prohibit the vectorization for the SIMD microprocessors.

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

## RESEARCH PROJECTS

Relating the physical properties of polymeric materials by parallel implementation of soft computing methods (L2-6143), Basic Research and Application Project, Slovenian Research Agency (2004–2007).

**SELECTED PUBLICATIONS**

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

P. Bulic, V. Gustin, On the use of the MMC language to utilize SIMD instruction set, *VECPAR 2006. 7th International Conference on High Performance Computing for Computational Science: Revised Selected Papers and Invited Talks, to appear in Lecture Notes in Computer Science*, 2007.

P. Bulic, V. Gustin, E. Durakovic, Exploiting multimedia extensions with a data parallel language, *14th Euromicro International Conference on Parallel, Distributed, and Network-Based Processing : proceedings : 15-17 February 2006, Montbéliard-Sochaux, France*, IEEE Computer Society, 2006.

P. Bulic, V. Guštin, An efficient way to filter out data dependences with a sufficiently large distance between memory references, *ACM SIGPLAN Notices*, No. 4, Vol. 40, 2005

P. Bulic, V. Gustin, On Dependence Analysis for SIMD Enhanced Processors, *VECPAR 2004. 6th International Conference on High Performance Computing for Computational Science: Revised Selected Papers and Invited Talks, Lecture Notes in Computer Science, LNCS 3402*, 2005.

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

# Computer Communications Laboratory

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## RESEARCH ACTIVITIES

Main research interests of laboratory members are distributed systems design and development – especially grid architectures, communication security and policies and other security issues, formal validation and testing techniques of communication protocols and distributed processes, computer networks design, content networks and peer-to-peer systems, mobile computing, agile methodologies in development of software and information systems and service oriented architecture with related technologies.

In 2007, we have researched most actively the following areas:

- In the area of grid systems we were researching protocol analysis methods.
- In the area of software development methodologies, we were researching the properties of agile methodologies, especially test-driven development.
- In the area of distribute systems architecture, we studied the system integration techniques using Service Oriented Architecture principles. We have also studied usability of these architectures in relation to digital identity management systems.
- In the area of communication networks we have researched advanced options of IPv6 protocol and its implementations, together with strategies for migration IPv4 to IPv6.
- In the area of information systems security and security policies, we have suggested implementation of the so-called security knowledge cycle, process of continuous education for information systems users in large companies. We have also researched its prototype support implementations and this research continues also in 2008.



## EQUIPMENT

Besides the typical office equipment, Computer Communications Laboratory is equipped with a few pieces of advanced networking / distributed systems hardware and software equipment. Hardware: a 20 Gb/s Infiniband network switch, two 24-port Gigabit Switches, Dell Power Vault NAS 745 (4 x 250 GB + 6 x 400 GB), 6 Dell Power Edge Servers, IBM eServer xSeries 336, Wireless WiFi and BlueTooth Access Points, various mobile devices, ActiveCard SmartCard readers and smart cards.

*Software:* network management tools and utilities, Oracle 10g and PostgreSQL database and development tools, SharePoint Portal Server, Microsoft development tools and utilities; several open-source Java development tools and utilities including Mobile Phone development utilities, ...

## RESEARCH PROJECTS

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

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

Relating the physical properties of polymeric materials by parallel implementation of soft computing methods (L2-6143), Basic Research and Application Project, Slovenian Research Agency (2004–2007).

Formal analysis of advanced GRID infrastructure protocols (BI-HR/06-07-029), Bilateral Collaboration Project, Slovenian Research Agency (2006–2007).

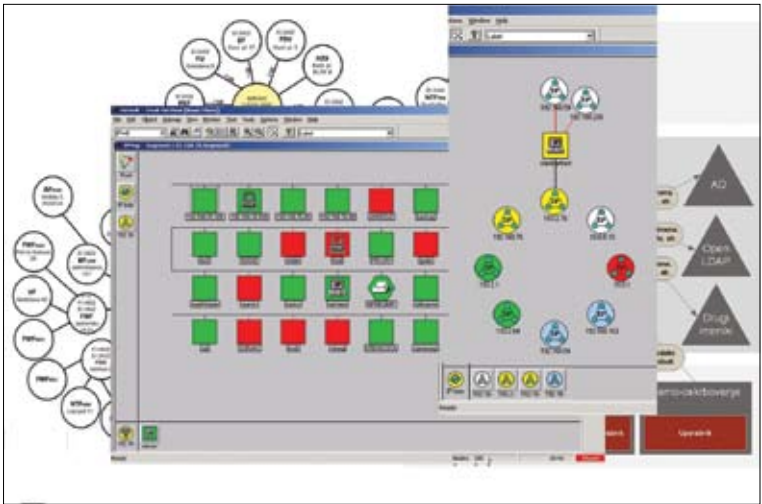
Raising Security Awareness in the Cimos company, Industry-Funded Project, Cimos d.d. (2007–2007).

## LABORATORY GUESTS

Marina Bagić, University of Zagreb, Faculty of of Electrical Engineering and Computing. Croatia. 22.12.2006 - 12.01.2007 Research collaboration on “Formal Analysis of Advanced Grid Infrastructure



Interconnecting four servers in a cluster via 20 Gbps low latency Infiniband links



Network management (Tivoli Netview and other tools)

Protocols”.

Marina Bagić, University of Zagreb, Faculty of of Electrical Engineering and Computing. Croatia. 1.12.2007 - 30.12.2007 Research collaboration on “Formal Analysis of Advanced Grid Infrastructure Protocols”.

## SELECTED PUBLICATIONS

M. Bagić, M. Ciglarič. Modelling epistemic properties for specification and verification of a multi-agent system. V: ARABNIA, Hamid R. (ur.). SERP 2007 : proceedings of the 2007 *International Conference on Software Engineering Research & Practice, June 25-28, 2007, Las Vegas Nevada, USA*. Vol. 1. CSREA Press, 2007, pp.197-202.

M. Ciglarič. Varno obnašanje uporabnikov v omrežnem okolju. V: PINTERIČ, Uroš (ur.), SVETE, Uroš (ur.). *Elektronsko upravljanje in poslovanje v službi uporabnika*. Ljubljana: Fakulteta za družbene vede, 2007, pp.177-191.

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

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

A. Krevl, T. Vidmar [et. al.]: A Framework for Developing Mobile Location Based Applications, in *Dynamic Communications Management* (pp. 1-1 – 1-10), *Meeting Proceedings RTO-MP-IST-062*. Neuilly-sur-Seine, France: RTO. 2006.

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

M. Ciglarič, T. Vidmar. Problematika nestrukturiranih sistemov enak

z enakim (Problems in unstructured P2P Systems). *Electrotech. Review*, 2005, Vol. 72, No. 4, pp 164-170.

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

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

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

# Computer Structures and Systems Laboratory

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## RESEARCH ACTIVITIES

The principal scientific research directions of the Computer Structures and Systems Laboratory are fuzzy logic applied to distributed processing and processing platforms of the future. With respect to these the most recent research is dedicated to the modelling of the dynamics of organized groups of moving entities (e.g. flocking birds) and to the design of the ternary quantum-dot cell.

One of the past research studies in fuzzy logic based modelling and simulation was the design and development of a software application for computer assisted prediction of wind-driven wild-land fire for the Slovenian Ministry of Defence. Lately, however, the members of the laboratory have been using fuzzy logic for modelling bird flocks and applying it to logistic problems. They have recently published an article in the Journal of Theoretical Biology that presents a highly believable bird flocking model that is based on simple linguistic descriptions. Indeed, the simulations performed by using their model show that when performing turns, the simulated birds change position so that a bird at the head of a flock will be in the rear of the flock if the latter turns 180 degrees, which is a behaviour that can typically be observed in pigeon flocks.

Lately a substantial amount of time is being devoted to the design of the ternary quantum-dot cell, an extension of the binary quantum-dot cell that allows for the construction of quantum-dot cellular automata capable of performing ternary logic operations. The obtained results have been published in some of the most renowned journals in the field, such as IOP's Nanotechnology, Elsevier's Microelectronic Engineering, OCP's International Journal of Unconventional Computing as well as accepted for publication in the Japanese Journal of Applied Physics.

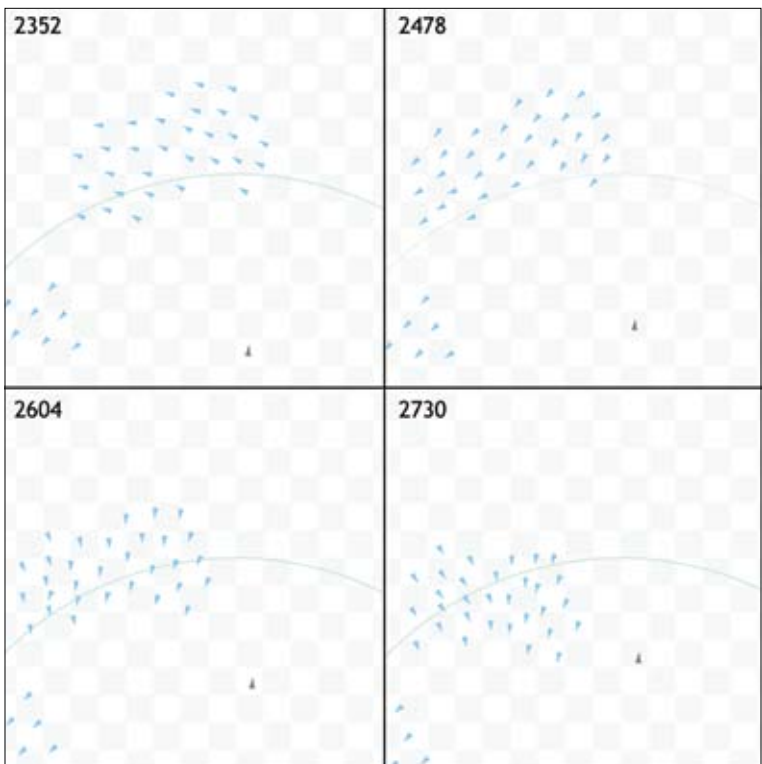
In addition to the scientific research the members of the laboratory actively cooperate with different industrial partners (Iskratele d.o.o, OurSpace, d.o.o, etc.), usually on projects related to wireless computer networks, performance evaluation or reliability diagnostics. Recently they have been cooperating with the FH Joanneum GmbH, Austria and the Department of Intensive Internal Medicine of the General Hospital “dr. Franc Derganc”, Nova Gorica through a joint project named Mobile Medical Monitoring; a Bluetooth based system designed to diminish the insecurity when patients are transferred from the intensive care to ordinary ward units. Currently the system is undergoing extensive live-testing in the General Hospital “dr. Franc Derganc”.

## RESEARCH PROJECTS

Wireless communication platforms, Industry-Funded Project, funded by European Structural Funds and Iskra Sistemi d.o.o., Slovenia (2005–2007).

Specification of wireless communication protocols for medical applications (L2-6272), Slovene Government-Funded R&D Project, funded by Slovene Research Agency and OurSpace d.o.o. (2004–2007).

Optimization of resiliency and fast convergence in the Ethernet network environment Project (03/FRI-IT/ES-2006), Industry-Funded Project, funded by Iskratele d.o.o. (2006–2008).



Fuzzy logic based bird flocking simulation displaying behaviour typical for pigeon flocks, where birds, while performing turns, change their position in the flock

Introduction of fuzzy logic into the process of defence systems management (M2-0170), A Science for Peace and Security Target Research Project, funded by Slovene Research Agency (2006–2010).

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

Randomness verification and irregularity analysis of a mechanical random generator that is to be part of a game machine, Industry-Funded Project, Elektrina d.o.o. (2008–2008).

## LABORATORY GUESTS

Ass. Prof. Ovid Azaria Farhi, Ass. Prof. Petar Dimitrov Petrov, Ass. Prof. Yordan Tsonev Chervenkov, Technical University of Varna, Varna, Bulgaria 27. 6. – 5. 7. 2007. Research visit in the framework of the SOCRATES/Erasmus Bilateral Agreement.

## RESEARCH VISITS

Miha Mraz, Nikolaj Zimic: National Technical University of Kharkov, 7. 6. – 10. 6. 2007, Preparation of Bilateral projects.

Invited Talks and Lectures

Miha Mraz, Nikolaj Zimic, Iztok Lebar Bajec: Information Systems Breakdowns, 10. – 11. 1. 2008, an invited talk at the First RISC (Rare Incidents with Strong Social Consequences) Workshop, University of Ljubljana, Ljubljana, Slovenia.

Iztok Lebar Bajec: Fuzzy Logic and Bird Flocking Simulations 15. 4. 2005, an invited lecture at University of Rhode Island (Department of Biological Sciences), Kingston, Rhode Island, USA.

## SELECTED PUBLICATIONS

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

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

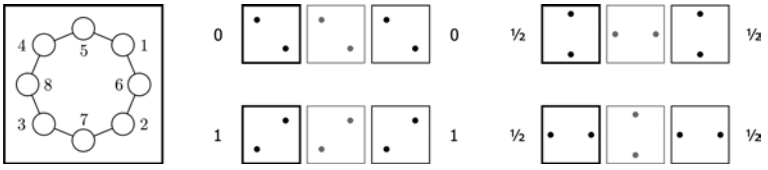
A. Jazbec, M. Mraz, I. Lebar Bajec, N. Zimic. Towards automated cooking process. *Food Research International*, 40(6):733–741, 2007.

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

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

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

I. Lebar Bajec, N. Zimic and M. Mraz. Simulating flocks on the wing:



The ternary quantum-dot cell and ternary wire, where the mechanism of transferring logic values 0, 1/2 or 1 no longer requires electric current but takes advantage of inter-electron Coulomb repulsion

the fuzzy approach. *Journal of Theoretical Biology*, 233(2):199–220, 2005.

I. Lebar Bajec, P. Trunk, D. Oseli and N. Zimic. Virtual coronary cineangiography. *Computers in Biology and Medicine*, 33(3):293–302, 2003.

I. Lebar Bajec, D. Oseli, M. Mraz, M. Klemenc and N. Zimic. PICAMS – Post intensive care monitoring system. *Informatica Medica Slovenica*, 8(1):20–27, 2003.

M. Mraz, N. Zimic, J. Virant and J. Ficzkó. Fuzzy cellular automata and fuzzy sequential circuits, C.T. Leondes (ed.) *Intelligent Systems: Technology and Applications*, pp. II-211–II-256, Boca Raton, FL: CRC Press, 2003.

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

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

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

J. Virant and N. Zimic. Attention to time in fuzzy logic. *Fuzzy Sets and Systems*, 82:39–49, 1996.

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

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| Young Researcher <b>Štefan Furlan, B.Sc.</b>    | stefan.furlan@fri.uni-lj.si   | 186  |
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| Assistant Professor <b>Dr. Marko Colnar</b>     | marko.colnar@gov.si           |      |

## RESEARCH ACTIVITIES

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

*Software Development Methodologies (SDM).* Based on the *collaborative practice research* we strive to define the methodology and supporting tools for designing new or adapting existing SDMs. Specifically, we focus on the methodology socio-technical suitability to both organisation and project-specific requirements. From the topic two PhD theses have been developed. An approach for reengineering methodologies (Agile methodology framework) and supporting tools (Agile Methodology Toolset - AMT, see figure below) present the most important results of this research.

*IT/IS Strategy Planning.* The strategy planning is one of the research areas that have been traditionally present in the Information systems laboratory since its existence. In the period from 2004 to 2007 we published several methodologies that focus on how to build strategic plans for information systems. The methodologies are based on many years of practical experiences in developing strategic plans for a range of organisations. In the context of IT/IS planning we focus our research on: IS/IT architectures, information systems reengineering, business process reengineering, electronic business, and COBIT and other standards.

*Contemporary approaches to software development.* In collaboration with software companies we do research on the maturity level



of the new approaches to software development. Recently we have been focusing on: “Model-driven development”, “Business-rule approach”, and “Method engineering”.

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

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

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

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

## RESEARCH PROJECTS

The Information systems laboratory has been involved in many research and applied projects. The selection of recent project is listed below.

The development of a prototype for Revenue Assurance in telecommunications, Industry-Funded Project , funded by Marand, d.o.o. (2007–2008).

The development of a fraud detection system for health insurance companies, Industry-Funded Project, funded by TRIGLAV, Zdravstvena zavarovalnica d.d. (2007–2008).

The development of a prototype system for billing in telecommunications, Industry-Funded Project, funded by Marand, d.o.o. (2006–2007).

Analysis of IT processes based on CobIT framework – First Phase, Industry-Funded Project funded by Informatika d.d.(2006-2007).

Analysis of IT processes based on CobIT framework – Second Phase Industry-Funded Project funded by Informatika d.d. (2006-2007).

## RESEARCH VISITS

Ana Šaša: KNEIP Communication S.A., Luksemburg, 20.11.2006 - 15.12.2006. Collaboration on development of SOA (service-oriented architecture) maturity model.

## INVITED TALKS AND LECTURES

Marko Bajec: Method Engineering, 2006, ERASMUS lecturer exchange, Vilnius Gediminas Technical University, Litva

Marjan Krisper: Method Engineering, 2006, ERASMUS lecturer exchange, Vilnius Gediminas Technical University, Litva

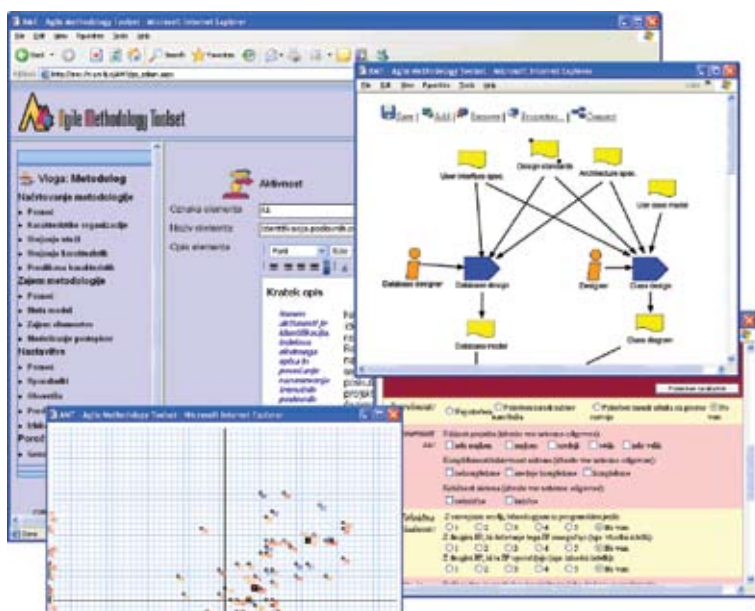
## SELECTED PUBLICATIONS

M. Bajec and M. Krisper. A methodology and tool support for business rule management in organisations. *Information Systems*, 30(2005): 423–443, 2005.

M. Bajec, D. Vavpotič and M. Krisper, Practice-driven approach for creating project-specific software development methods, *Information and Software Technology*, Article in Press.

R. Rupnik, M. Krisper and M. Bajec. A new application model for mobile technologies. *International Journal of Information Technology and Management*, 3(2/3/4): 282-291, 2004.

R. Rupnik, M. Kukar and M. Krisper. Integrating data mining and decision support through data mining based decision support system. *Journal of Computer Information Systems*, Article in press.



Screenshot of the AMT system

- M. Bajec, V. Mahnič. Portal as a key component in an integrated, user-centric university information system. *Systems integration*, 10(2): 7-20, 2003.
- D. Kodek and M. Krisper. Optimal algorithm for minimizing production cycle time of a printed circuit board assembly line. *Int. J. Prod. Res.*, 42(23): 5031-5048, 2004.
- M. Bajec. Educational portals: a way to get an integrated, user-centric university information system. In: A. Tatnall (ed.). *Web portals : the new gateways to Internet information and services*. Hershey (PA): Idea Group Publishing, cop. 2005, pp. 252-269.
- R. Rupnik and M. Krisper. Context-aware mobile application model. *Electrotechnical Review*, 71(4): 215-219, 2004.
- M. Bajec, R. Rupnik and M. Krisper. A framework for reengineering software development methods. International conference on software engineering advances (ICSEA 2006. Piscataway: IEEE, 2006.
- M. Krisper and A. Rožanec. Obvladovanje informatike v poslovnih sistemih : pomen strategije in arhitekture. *Uporab. inform.* (Ljubl.), 2005, letn. 13, št. 4, str. 185-198.
- A. Zrnec, M. Bajec, M. Krisper. Pristop za prilagajanje procesa razvoja programske opreme potrebam konkretnih projektov. Zbornik 16. mednarodne Elektrotehniške in računalniške konference ERK 2007, IEEE Region 8, Slovenska sekcija IEEE, 2007, zv. B, str. 23-26
- M. Bajec, M. Krisper and R. Rupnik. The scenario for constructing flexible, people-focused systems development methodologies. In: T. Leino, T. Saarinen and S. Klein (eds.). *Proc. 12th European conf. on IS*. Turku, Finland, 2004.
- D. Vavpotič, M. Bajec and M. Krisper. Measuring and improving software development methodology value by considering technical and social suitability of its constituent elements. In: O. Vasilecas, J. Zupančič (eds.). *Advances in theory, practice and education: Proc. 13th Intern. Conf. on IS Development*, pp. 228-238, Vilnius, Lithuania, 2004.
- D. Lavbič, A. Šaša, and M. Krisper. Knowledge management in multi-agent systems. *Proceedings of the First International Conference for New Trends in Knowledge Management*, Maribor, June 13-14, 2006. Maribor: Faculty of Electrical Engineering and Computer Science, Institute of informatics, 2006, str. 128-133.
- A. Šaša, M. B. Jurič and M. Krisper. Agents and People Activities in Web-services based Business processes. 2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies (IEEE-DEST 2007).
- M. B. Jurič, M. Heričko, T. Welzer, I. Rozman, A. Šaša and M. Krisper. Web Services and Java Middleware Functional and Performance Analysis for SOA. 2007 Inaugural IEEE International Conference on Digital Ecosystems and Technologies (IEEE-DEST 2007).
- D. Vavpotič and M. Krisper. An approach for rapid creation of a virtual software development team. V: *Managing Worldwide Operations and Communications with Information Technology (IRMA 2007 Proceedings)*, Vancouver, 2007.

D. Vavpotič, M. Bajec and M. Krisper. Scenarios for improvement of software development methodologies. *Advances in information systems development*. Vol. 1, Bridging the gap between academia and industry. New York: Springer, cop. 2006.

D. Lavbič. Povezava rezultatov iskanja spletnega inteligentnega agenta s podatki pomembnimi za poslovne odločitve. In: A. Novakovič, N. Schlamberger, M. Indihar Stemberger, M. Učak and J. Drole (eds.). *Management in informatika: Conf. Proc.*, pp. 670-675, Dnevi slovenske informatike, Portorož, 2004.

M. Bajec, D. Vavpotič and M. Krisper. An approach for creating project-specific software development methodologies. In: Khalid S. (ed.). *Internet and information technology in modern organizations: challenges & answers: Proc. 5th Intern. Business Information Management Association Conf.*, pp. 1082-1091, Cairo Egypt, 2005.

# Laboratory for e-media

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## RESEARCH ACTIVITIES

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

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

## RESEARCH PROJECTS

Advanced technologies for digital forensics (BI-NO/07-09-0003), Bilateral Collaboration Project funded by Slovenian Research Agency (2007–2009).

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

Lightweight services for security, privacy and trust management (J2-9649), Basic Research and Application Project (2008–2009).

## LABORATORY GUESTS

Habtmu Abie Ph.D., Norwegian Computing Center, Oslo, Norway. 3. 12. - 7. 12. 2007.

Advanced Technologies for Digital Forensics (Bilateral Collaboration, BI-NO/07-09-0003, 2007–2009).

## RESEARCH VISITS

Assoc. Prof. Denis Trček: Norwegian Computing Center, Oslo, Norway, 27. 8. - 31. 8. 2007, Research work on project Advanced Technologies for Digital Forensics (Bilateral Collaboration, BI-NO/07-09-0003, 2007–2009).

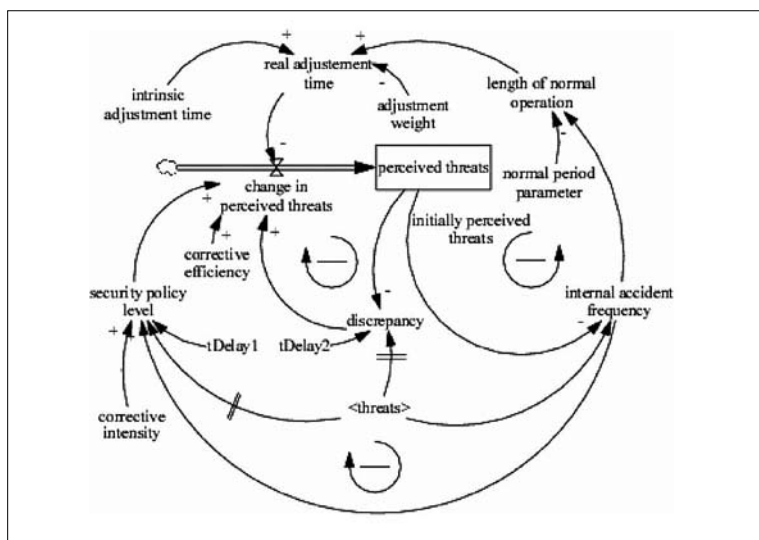
## SELECTED PUBLICATIONS

D. Trček, R. Trobec, N. Pavešić, T. F. Jurij. Information systems security and human behaviour. *Behav. inf. technol.* 26(2): 113-118, 2007.

D. Trček. System dynamics based approach to risk management for security in informatin systems. In Proceedings of 11th WSEAS Int. Conf. on Circuits (ICC'07), *Agios Nikolaos, Crete Island, Greece, July 23-28,2007*. Athens: World Scientific and Engineering Academy and Society, 2007, pages 347-350.

D. Trček. Services deployment methodologies for weak processing devices : an analysis. In Proceedings of 11th WSEAS Int. Conf. on Circuits (ICC'07), *Agios Nikolaos, Crete Island, Greece, July 23-28,2007*. Athens: World Scientific and Engineering Academy and Society, 2007, pages 357-360.

D. Kovač, D. Trček. Metode in modeli zaupanja v porazdeljenih sistemih. In B. Zajc, T. Andrej (eds.). *Zbornik šestnajste mednarodne Elektrotehniške in računalniške konference ERK 2007*, zv. B, pages 7-10, 24. - 26. september 2007, Portorož, Slovenija.



Modelling IS security with emphasis on human behaviour (system dynamics model)

# Laboratory for Algorithms and Data Structures

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## RESEARCH ACTIVITIES

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

## EQUIPMENT

Equipment consists of a network of PCs running under Linux and Windows XP, and Apple Macs running OS X Tiger. Two HP ProLiant DL320 G4 servers are used by PlanetLab. Additionally, miscellaneous items of computer infrastructure offer adequate computational support for the staff and students performing thesis work, as well as occasional guests.

## RESEARCH PROJECTS

“Exact and non-exact Algorithms and Techniques”(J2-6688-1539-05), Basic Research and Application Project funded by the Ministry of Higher Education, Science and Technology and Slovenian Research Agency (2004-2007).

”MetaService – Semantic coupling of GRID Services” (V2 0215) jointly with Jozef Stefan Institute and the company XLAB, Ltd., funded by the Ministry of Higher Education, Science and Technology, and Slovenian Research Agency (2006-2008).

”Computational GRID Technologies for more efficient usage of computer resources in companies” (V2 0214) jointly with Jozef Stefan Institute and the company XLAB, Ltd., funded by the Ministry of Higher Education, Science and Technology, and Slovenian Research Agency (2006-2008).

”Crisis Management Simulator” (M2-0217), Slovene Government-Funded R&D Project (2007–2009).

## SELECTED PUBLICATIONS

A. Sulistio, U. Čibej, S. Venugopal, R. Buyya, B. Robič. A toolkit for modelling and simulation of Data Grids: An extension to GridSim, *Concurrency and Computation: Practice and Experience* (accepted for publ.)

U. Jovanovič, B. Slivnik. Using ant colony optimization for searching in (dynamic) distributed datasets. *WSEAS Transactions on Computing* 6(1):119-126, 2007.

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 & Hall / CRC, 2006.

T. Dobravec, J. Žerovnik, B. Robič. An optimal message routing algorithm for circulant networks. *Journal of Systems Architecture* 52:298-306, 2006.

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

J. Mihelič, B. Robič. Solving the k-center problem efficiently with a dominating set algorithm. *Journal of Computing and Information Technology* 13(3):225-233, 2005.

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

M. Šterk, B. Robič, R. Trobec. Mesh free method applied to diffusion equation. Proc. *Parallel Numerics PARNUM* 05, p.204-214.

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

U. Čibej, B. Robič. Locating copies of data in grid computing environment: a formal model and heuristics. Proc. *EWGLA 2004*, September 5-8, Saarbrücken, Germany.

A. Mahjoub, J. Mihelič, C. Rapine, B. Robič. k-Center problem with uncertainty: flexible approach. Proc. 2nd Int’l Workshop DOM-2004 Discrete Optimization Methods in Production and Logistics, July 20-27, 2004, Omsk - Irkutsk, Russia, pp.75-80.

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



- T. Dobravec, B. Robič, J. Žerovnik. Permutation routing in double-loop networks : design and empirical evaluation. *Journal of Systems Architecture* 48:387–402, 2003.
- J. Močnik, R. Trobec, B. Robič. Integration of load balancing in COR-BA environment. *Parallel Algorithms and Applications* 18:99–105, 2003.
- T. Ungerer, B. Robič, J. Silc. Multithreaded Processors. *Computer Journal* 45(3):320–348, 2002.
- J. Mihelič, B. Robič. The flexible-attribute problems. *Computational Optimization and Applications* (to appear).
- R. Trobec, M. Šterk, B. Robič. Computational complexity of the parallel meshless local Petrov-Galerkin method. *Computers and Structures* (to appear).

# Laboratory for Architecture and Signal Processing

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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 RISC vs. CISC 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 has been developed during the course of this work. Various applications of DSP processors are studied and implemented. One of them is a low-cost DSP processor based spectrum and vibration analyzer that was developed and is now in production.

3. *In Speech Processing:* Speech recognition over telephone lines. 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 is being implemented and tested.

## RESEARCH PROJECTS

Ex Zone. Control unit for measurements in underground mines. Project for TEVE Varnost Elektronika d.d., Contract 4-25/2006 (2006-2008).

ARM9 microcomputer system - education tool for computer science students. Joint project with Asyst Electronic Ltd. (2007-2008).

VOIP technologies in corporate communication systems. Project for Comutel d.o.o. Contract 6-41/2005 (2005-2007).

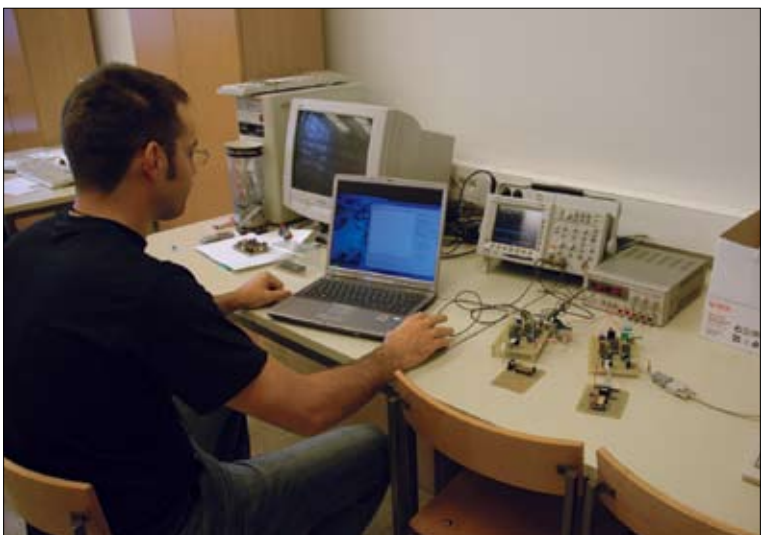
## RESEARCH VISITS

*Research visits related to research projects:* D. M. Kodek: Department of Computer Science, Princeton University, NJ, USA, 24.3. – 5.4. 2007. Development of algorithms for theoretical bounds on finite wordlength minimax approximation.

## SELECTED PUBLICATIONS

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



Student working on a low-cost wireless computer network for embedded industrial applications

- D. M. Kodek. Performance limit of finite wordlength FIR digital filters. *IEEE Transactions on Signal Processing*, vol. 53, no. 7, pp. 2462-2469, Jul. 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 research in the areas of Software Engineering and Information Systems with an emphasis on Software Quality Management, Software Metrics, Information Systems Development, Information Systems Audit and Control, and Data Warehouses. The staff has recently worked on two international projects within the EC TEMPUS and INCO-COPERNICUS programs, as well as on several development projects for the industry. The following areas of research are currently being pursued:

- In Software Quality Management:* Comparative studies of different software quality models (CMMI, ISO 9000 family of standards, SPICE, Bootstrap etc.). Adaptation of CMMI to the needs of small organizations. Personal and Team Software Process.
- In Software Metrics:* Different approaches to software measurements (e.g. GQM, bottom-up). Definition of appropriate metrics for the development of applications in a database environment. Measuring performance of agile software development methods.
- 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.
- 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.

## 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 (2001-2008).

Implementation of the student records information system at the Faculty of Machine Engineering (S-471A), Industry-Funded Project (2003-2007).

International Multi-conference Information Society (S-465), Industry-Funded Project, Microsoft (2006-2007).

## RESEARCH VISITS

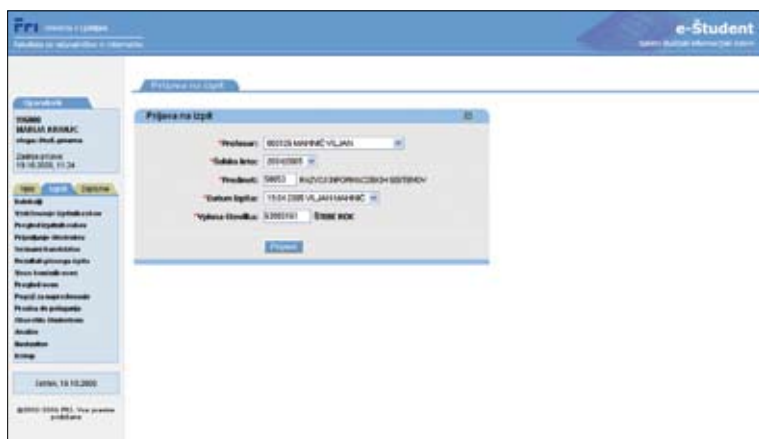
Viljan Mahnič: Department of Information Engineering, Czech University of Life Sciences, Prague, Czech Republic, 1.3. – 31.5.2007. Collaboration on research project MSM 6046070904 “Information and knowledge support of strategic management” funded by the Czech Ministry of Education.

## SELECTED PUBLICATIONS

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

M. Poženel, V. Mahnič. Data Webhouse: A tool for monitoring the use of a Web based information system. *Proceedings of the 13th International Conference of European University Information Systems, EUNIS 2007, 26-29 June 2007, Grenoble, France*.

V. Mahnič, S. Drnovšček. Introducing agile methods in the development of university information systems. In: LILLEMAA, Tiia (ur.).



e-Študent: web-based student records information system

*Proceedings of the 12th International Conference of European University Information Systems, EUNIS 2006, 28-30 June 2006, Tartu, Estonia.* Tartu: University of Tartu, pp. 61-68, 2006.

G. Krajnc, V. Mahnič. Pair programming in high schools. *Organizacija*, 39(8): 539-545, 2006.

M. Ferle, V. Mahnič. Real-time streaming ETL. *Uporabna informatika*, 14(1): 5-14, 2006.

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

V. Mahnič, M. Požnel. The role of data warehousing in university information systems. *Proc. University Information Systems UNINFOS 2005*, pp. 454 -464, 2005.

V. Mahnič, S. Drnovšček. Agile software project management with scrum, *Proc. European University Information Systems EUNIS 2005*, pp. 1-6, Manchester, U.K., 2005.

V. Mahnič, M. Požnel. Data warehousing in university environment: the case of the University of Ljubljana. *Uporabna informatika*, 12(4): 237 -247, 2004.

V. Mahnič. Analyzing educational process through a chain of data marts. *Informatika*, 27(3): 305-311, 2003.

# Computer Vision Laboratory

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## RESEARCH ACTIVITIES

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

Range image interpretation includes range image acquisition, segmentation of range images using the “recover-and-select” paradigm and modeling of shapes using different types of parametric models (i.e. superquadrics, surface patches). Possible applications include automatic creation of CAD models for reverse engineering applications, creation of models for virtual reality applications, part-based object recognition, and next-view planning for intelligent image acquisition. Superquadric models are used also for object tracking in sequences of intensity images.

We generate panoramic images by assembling multiple images captured in sequence by moving the camera using a pan-tilt robotic manipulator. The sequential image acquisition using the robotic manipulator makes possible also the generation of panoramic stereo pairs and panoramic depth images as a consequence. We use panoramic images for mobile robot navigation, for designing efficient user interfaces for remote camera manipulation and for visual surveillance applications.

For human face detection and recognition in difficult illumination conditions we study the use of skin colour and appearance and fusion of different techniques.

Analysis and tracking of objects in video sequences is applied to studies of human locomotion, roulette gaming instruments and golf.

An ongoing collaboration with the New media department of the Academy of Fine Arts at the University of Ljubljana supports the



creation of interactive art installations using the latest information technology. The art projects serve as an excellent frame for testing our research results in practical applications, in particular we applied face detection in the installation “15 seconds of fame”, body position tracking in “Virtual skiing” and locomotion-based person identification in “Coincidence-matrix-dating club” project.

## RESEARCH PROJECTS

Computer vision (P2-0214), a basic research programme funded by the Slovenian Research Agency (2004–2008).

Leonardo EU-NZ (CPT-CPTNZ 1003), A multi-national exploration in interaction design education and research, Pilot program in cooperation between EU and New Zealand (2004–2008).

Lotery On-line, Industry-Funded Project, Loterija SLOvenije, d.d. (2003–2008).

## LABORATORY GUESTS

Shayna Quinn, Wanganui School of Design, Wanganui, New Zealand, 1.2.-1.3.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

Matt White, Wanganui School of Design, Wanganui, New Zealand, 1.2.-1.3.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

Reinhardt Feichtinger, FH Hagenberg Medientechnik und design, Hagenberg, Austria, 2.4.-16.4.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

Colin Holloway, Wanganui School of Design, Wanganui, New Zealand, 13.7.-26.8.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

Dion Schmidt, Wanganui School of Design, Wanganui, New Zealand, 13.7.-26.8.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

Jesse Read, Department of Computer Science, University of Waikato, New Zealand, 19.9.-14.12.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).



Analysis of golf game improves the quality of its training

Masood Masoodian, Department of Computer Science, University of Waikato, New Zealand, 9.10-15.10.2007, Collaboration on project Leonardo EU-NZ (CPT-CPTNZ 1003).

## INVITED TALKS AND LECTURES

Peter Peer: Introduction to the University of Ljubljana, Slovenia, with Focus on the Faculty of Computer and Information Science: the Cooperation Potential, 31.10.2007, an invited talk at TECNUN-CEIT (University of Navarra), San Sebastian, Spain.

Franc Solina: Modeling image contents using superquadric models, 14-16.2.2007, keynote talk at the Fourth IASTED International Conference on Signal Processing, Pattern Recognition, and Applications, Innsbruck, Austria.

## SELECTED PUBLICATIONS

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

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

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



Having fun in front of the "15 seconds of fame" installation

- F. Solina. 15 sekund slave in virtualno smučanje / 15 Seconds of Fame and Virtual Skiing. Exhibition Catalogue. ArtNetLab, Ljubljana, 2005.
- F. Solina. 15 seconds of fame. *Leonardo*, 37(2):105–110+125, 2004.
- J. Krivic, F. Solina. Part-level object recognition using supequadrics. *Computer Vision and Image Understanding*, 95(2):105–126, 2004.
- A. Jaklič, F. Solina. Moments of Superellipsoids and their Application to Range Image Registration. *IEEE Transactions on Society, Man and Cybernetics-Part B: Cybernetics*, 33(4):648–657, 2003.
- P. Peer and F. Solina. Panoramic depth imaging: Single standard camera approach. *International Journal of Computer Vision*, 47(1/2/3):149–160, 2002.
- A. Jaklič, A. Leonardis and F. Solina. Segmentation and Recovery of Superquadrics. Volume 20 of Computational Imaging and Vision. Kluwer, Dordrecht, 2000.
- A. Leonardis, F. Solina and R. Bajcsy, editors. Confluence of Computer Vision and Computer Graphics. Volume 84 of NATO Science Series 3. High Technology. Kluwer, Dordrecht, 2000.
- F. Solina and A. Leonardis, editors. Computer Analysis of Images and Patterns. 8th international conference, CAIP'99, Ljubljana, Slovenia, September 1–3, 1999: proceedings. Lecture Notes in Computer Science, 1689. Springer, Berlin, 1999.
- B. Prihavec and F. Solina. User interface for video observation over the internet. *Journal of Network and Computer Applications*, (21):219–237, 1998.
- F. Solina and A. Leonardis. Proper scale for modeling visual data. *Image and Vision Computing Journal*, 16:89–98, 1998.
- A. Leonardis, A. Jaklič, and F. Solina. Superquadrics for segmentation and modeling range data. *IEEE Transactions on Pattern Recognition and Machine Intelligence*, 19(11):1289–1295, November 1997.
- F. Solina and R. Bajcsy. Recovery of parametric models from range images: The case for superquadrics with global deformations. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 12(2):131–147, 1990.

# Visual Cognitive Systems Laboratory

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## RESEARCH ACTIVITIES

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

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

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

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

Recently, continuous learning has become a major topic of our research; we have been developing a general framework for continuous learning of visual concepts by learning associations between automatically extracted visual features and words describing the scene. Our research has also shifted towards learning scalable representations suitable for recognition and detection of a large number of object categories. Within this framework, we developed an approach which learns a hierarchy of spatially flexible compositions in an unsupervised, statistics-driven manner. Applications include recognition of objects, scenes, and activities in visual cognitive tasks, such as surveillance and smart vision-based positioning using mobile computing devices in urban environments as well as in other applications of cognitive systems.

Our theoretical findings on visual learning and recognition very often ground in a realistic scenario of spatial orientation of mobile robots (specifically, we use in-door and out-door iRobot mobile platforms equipped with omnidirectional and stereo camera setups), which represent a target system for many of the methods developed. In the long run, we aim at developing algorithms for autonomous exploration and building of cognitive maps which can be used by agents for navigation and spatial reasoning in unbounded environments. We are also implementing direct interaction and object manipulation with a Katana HD6M light weighted robot arm with the aim of developing methods for robust and adaptive interaction of the robot with its environment that would enable studying object affordances. Such cognitive agents will ultimately be able to perceive and understand their environment through interaction, to categorise and recognise objects and subjects around them as well as actions they are performing, and will be able to communicate with humans and other agents on a semantical level.

Research in the area of range image interpretation includes range image acquisition (using a structured light range scanner), segmentation of range images using the “recover-and-select” paradigm and modeling of shapes using different types of parametric models. Possible applications include automatic creation of CAD models for reverse engineering applications, creation of models for virtual reality applications, and part-based object recognition.



Mobile robot localization using omnidirectional vision

## RESEARCH PROJECTS

Computer Vision, 1539–0214. A basic research program, Slovenian Ministry of Higher Education, Science and Technology (2004–2008).

COSY - Cognitive Systems for Cognitive Assistants (IST-2002-2.3.2.4 FP6-004250-IP). FP6 IST Programme Project, European Commission (2004-2008).

MOBVIS - Vision Technologies and Intelligent Maps for Mobile Attentive Interfaces in Urban Scenarios (IST-2002-2.3.4.1, FP6-511051-STREP), FP6 IST Programme Project, European Commission (2005-2008).

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

Development of New Techniques for Recognition and Categorization, A Slovenian-Greek Intergovernmental Science and Technology Cooperation Project, Slovene Research Agency (2006-2007).

Mobile Robot Localisation Using Panoramic Images, A Slovenian-Czech Intergovernmental Science and Technology Cooperation Project, Slovene Research Agency (2007-2008).

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

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

## LABORATORY GUESTS

Kristy Sim, Royal Institute of Technology, Stockholm, Sweden, 24. 9. - 30. 9. Research collaboration on project “MOBVIS” (Vision Technologies and Intelligent Maps for Mobile Attentive Interfaces in Urban Scenario).

Maria-Elena Nilsback, University of Oxford, UK, 17. 9. - 12. 10. Research collaboration on project “VISIONTRAIN” (Computational and Cognitive Vision Systems: A Training European Network)

Michal Jancosek, Czech Technical University, Prague, 1.8. - 31.8. Collaboration on the Slovenian-Czech Intergovernmental Science and Technology Cooperation Project.

Hynek Bakstein, Czech Technical University, Prague, 19.11. - 22.11. Collaboration on the Slovenian-Czech Intergovernmental Science and Technology Cooperation Project.

Prof. Dr. Harry Wechsler, George Mason University, USA, 26. 6. - 26. 6. Invited lecture: Reliable Face Recognition Methods - Applied Modern Pattern Recognition.

## RESEARCH VISITS

Aleš Leonardis: York University, Toronto, Canada. 24.1.2007-3.2.2007. Invited talk and collaboration on computational models of biological vision.

Danijel Skočaj: School of Computer Science, University of Birmingham, UK, 9.7.–13.7.2007. Collaboration on CoSy project.

Alen Vrečko: School of Computer Science, University of Birmingham, UK, 9.7.–13.7.2007. Collaboration on CoSy project.

Danijel Skočaj: Deutsches Forschungszentrum für Künstliche Intelligenz, Saarbrücken, Germany, 30.9.-4.10.2007. Integration of different modules of the CoSy system.

Alen Vrečko: Deutsches Forschungszentrum für Künstliche Intelligenz, Saarbrücken, Germany, 30.9.-4.10.2007. Integration of different modules of the CoSy system.

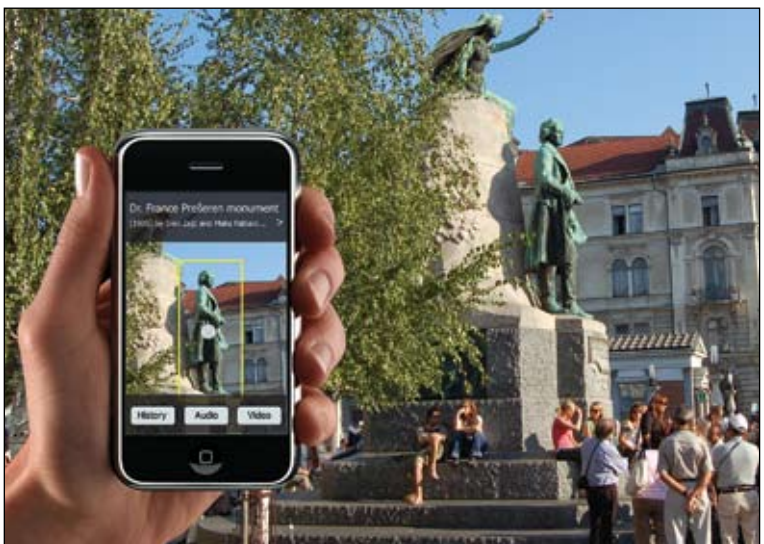
Matjaž Jogan: Democritus University of Thrace, Greece. 11.9.2007-6.10.2007. Collaboration on the Slovenian-Greek Intergovernmental Science and Technology Cooperation Project.

Dušan Omerčević: Czech Technical University, Prague, Czech Republic. -5.11-8.11. Collaboration on the Slovenian-Czech Intergovernmental Science and Technology Cooperation Project.

Dušan Omerčević: TU Darmstadt, Darmstadt, Germany. 15.4 - 19.4. Collaboration on MOBVIS data acquisition, system integration and experimentation on mobile localization.

Roland Perko: TU Darmstadt, Darmstadt, Germany. 15.4 - 19.4. Collaboration on MOBVIS data acquisition, system integration and experimentation on mobile localization.

Roland Perko: Joanneum Institute, Graz, Austria. 8.10.-12.10. Collaboration on MOBVIS demonstrator.



Vision-based positioning and landmark recognition using mobile devices in urban environments

## INVITED TALKS AND LECTURES

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 31.1.2007, an invited talk at York University, Toronto, Canada.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 2.2.2007, an invited talk at University of Toronto, Toronto, Canada.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 21.3.2007, an invited talk at the Visiontrain thematic School “Computational and Neurophysiological Models for Visual Perception”, Les Houches, France.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 4.9.2007, an invited talk at Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 17.9.2007, an invited talk at the CoSy Meeting-of-Mind Workshop, Paris, France.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 1.11.2007, an invited talk at Czech Technical University, Prague, Czech Republic.

Aleš Leonardis: Hierarchically Learned Representations of Object Categories: From Pixels towards Semantic Parts, 6.11.2007, an invited talk at the Significant Advances in Computer Science (Symposium and Celebration “30 Years COMPUTER SCIENCE”), Graz, Austria.

Aleš Leonardis: Learning hierarchical representations of object categories for robot vision, an invited talk at the 13th International Symposium of Robotics Research (ISRR), 2007.

Dušan Omerčević: High-Dimensional Feature Matching: Employing the Concept of Meaningful Nearest Neighbors, 6.11.2007, a CMP lecture at the Czech Technical University, Prague, Czech Republic.

Roland Perko: Context Driven Focus of Attention for Object Detection, an invited talk at the Dagstuhl seminar “Mobile Interfaces Meet Cognitive Technologies”, 9.9. - 14.9., Dagstuhl, Germany.

Dušan Omerčević: High-Dimensional Feature Matching: Employing the Concept of Meaningful Nearest Neighbors, an invited talk at the Dagstuhl seminar “Mobile Interfaces Meet Cognitive Technologies”, 9.9. - 14.9., Dagstuhl, Germany.

## AWARDS

Sanja Fidler: Learning Hierarchical Representations of Object Categories, 11.1.2007, best PhD student presentation award, EU Cognition meeting, Munich, Germany.



## SELECTED PUBLICATIONS

- B. Leibe, A. Leonardis and B. Schiele. Robust Object Detection with Interleaved Categorization and Segmentation. *International Journal of Computer Vision*. In Press, 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
- S. Fidler and A. Leonardis. Towards Scalable Representations of Object Categories: Learning a Hierarchy of Parts. In *Proceedings of IEEE Conference on Computer Vision and Pattern Recognition 2007*.
- A. Leonardis and S. Fidler. Learning hierarchical representations of object categories for robot vision. *13th International Symposium of Robotics Research (ISRR)*, 2007.
- 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.
- A. Leonardis, H. Bischof, and A. Pinz (Editors), 9th European Conference on Computer Vision - ECCV 2006, Proceedings, Parts I-IV, Series: Lecture Notes in Computer Science, Vols. 3951, 3952, 3953, 3954; Springer, 2006.
- 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.
- H. Bischof, H. Wildenauer, A. Leonardis. Illumination insensitive recognition using eigenspaces. *ComputerVision and Image Understanding*, Volume 95, no. 1, pp. 86-104, 2004.
- 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.
- T. Werner, T. Pajdla, V. Hlaváč, A. Leonardis, M. Matoušek. Selection of reference images for image-based scene representations. *Computing*, vol. 68, pp. 163–180, 2002.
- A. Leonardis and H. Bischof. Robust recognition using eigenimages. *Computer Vision and Image Understanding*, 78(1):99–118, 2000.
- A. Jaklič, A. Leonardis and F. Solina. *Segmentation and Recovery of Superquadrics*, volume 20 of Computational imaging and vision. Kluwer, Dordrecht, 2000.

H. Bischof, A. Leonardis and Alexander Selb. MDL principle for robust vector quantisation. *Pattern analysis and applications*, 2(1):59–72, 1999.

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

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

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

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

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

# Artificial Intelligence Laboratory

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## RESEARCH ACTIVITIES

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

Our Research Program “Artificial Intelligence and Intelligent Systems”, carried out in part by this laboratory, was in 2006 listed among the best research programs funded by the Slovenian research agency ARRS. Also in 2006, a former member of this laboratory Aleks Jakulin, received the prestigious best European AI dissertation award, sponsored by ECCAI for his dissertation Attribute Interactions in Machine

Learning. This was already the second ECCAI dissertation award, after Dorian Šuc, received by PhD students who did their work in the Artificial Intelligence Laboratory. In 2007, Ivan Bratko received the national Zois award for outstanding scientific achievements.

The laboratory is also the principal developer of a major open-source data mining package Orange ([www.ailab.si/orange](http://www.ailab.si/orange)), which interfaces with Python and also has an attractive and easy-to-use visual programming interface. Besides being the core development and research tool for the lab, Orange gained its popularity as the principal Python-based data mining tool and has a substantial community of users world-wide. Another popular software product, also developed within the laboratory, is GenePath ([www.genepath.org](http://www.genepath.org)), known to be the only available software package which interactively supports epistasis analysis for gene network reconstruction from mutant-based experimental data. Other notable and recent developments include software packages for chess tutoring, qualitative modeling, and web-based visualization and analysis of whole-genome expression and sequence data sets.

## RESEARCH PROJECTS

Artificial Intelligence and Intelligent Systems. Research Programme funded by Slovenian Research Agency (2004-2008).

ASPIC - Argumentation Service Platform with Integrated Components (IST-002307). FP6 IST Programme project, European Commission (2004-2007).

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

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

STEROLTALK - Functional genomics of complex regulatory networks from yeast to human: cross talk of sterol homeostasis and drug metabolism (FP6-2003-LIFESCIHEALTH-I 512096). Project funded by the EU 6th Framework Programme (2005-2008).

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

QSPAI – Quality Control In The Production Line Of Sandwich Panels With AI Methods. Project funded by the Slovene Ministry of Economy and EUREKA (2005-2007).

Knowledge technologies and decision support in health information portals (V2-0221), Slovene Government-Funded R&D Project (2006-2008).

Knowledge discovery and visualization methods for textual data (PROTEUS 07-08), Bilateral Collaboration Project, funded by Slovenian Research Agency (2007–2008).

Computational Phenomics (J2-9699), Basic Research and Application Project funded by the Slovenian Research Agency (2007–2009).

Preventive effects of antioxidants on development of hyperlipidemia and atherosclerosis in the animal model of obesity (V3-0365), Slovene Government-Funded R&D Project (2006-2008).

## LABORATORY GUESTS

Prof. Dr. Morin Anne, IRISA universit  de Rennes1, Rennes, France. 24.11. - 2.12. Research work on bilateral project 'Data analysis and visualization techniques for text mining'.

Prof. Dr. Chauchat Jean-Hugues, ERIC, Universit  de Lyon2, Lyon, France. 24.11. - 2.12. Research work on project 'Data analysis and visualization techniques for text mining'.

Frane  ari , University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia. 24.10. - 26.10. Development of text mining module for Orange, a data mining system.

Prof. Dr. Gad Shaulsky, Baylor College of Medicine, Houston, TX, USA. 11.10. - 19.10. Development of bioinformatics tools for analysis of experimental data on *D. discoideum*.

Anup Parikh, Baylor College of Medicine, Houston, TX, USA. 21.08. - 21.09. Development of bioinformatics tools for analysis of experimental data on *D. discoideum*.

Matthias Schlemmer, Technical University of Vienna, 13. 9. 2007. Research collaboration within XPERO EU Project.

Ricardo Duarte, Departamento de Biologia, Universidade do Minho, Braga, Portugal. 19.08. - 26.08. Analysis of relation between genotype and phenotype of *S. cerevisiae*.

Frane  ari  and Saša Petrovi , University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia. 2.04.- 06.04. Development of text mining module for Orange, a data mining system.

Erwin Prassler and Timo Henne, University of Applied Sciences Bonn-Rhein-Sieg, 22. 03. - 23. 3. Research collaboration within XPERO EU Project.



Submersible with intelligent and adaptive buoyancy and stability control

Monica Reggiani and Federico di Palma, University of Verona, 22. 03. – 23. 3. Research collaboration within XPERO EU Project.

Aritz Perez Martinez, Intelligent Systems Group at University of San Sebastian, Spain. 12.3.- 29.6. Postgraduate studies - work on supervised classification with Bayesian networks.

## RESEARCH VISITS

Blaž Zupan: University of Pavia, Italy, 9. 9. – 12. 9. 2007, Reconstruction of genetic networks from expression and SNP data.

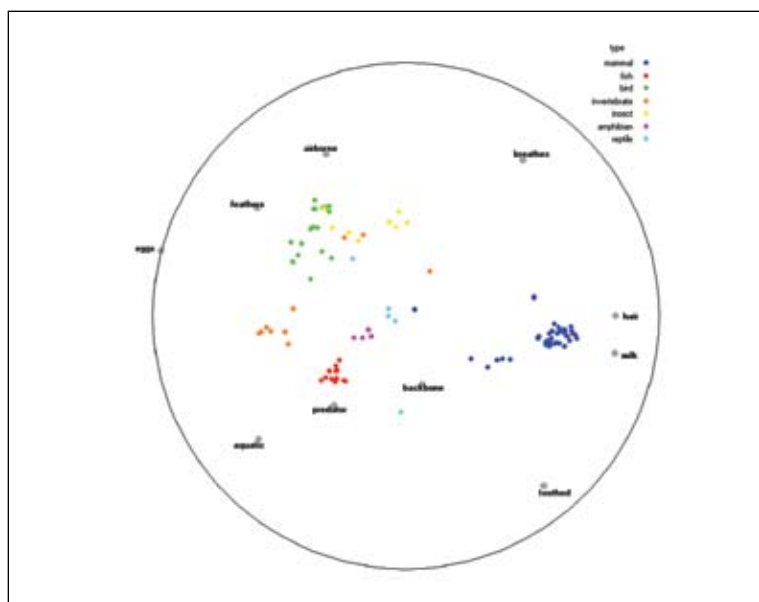
Janez Demšar and Blaž Zupan: The French Research Institute for Research in Computer Science and Control, Rennes, France, 11. 11. – 15. 11. 2007, Text mining and data visualization approaches and implementations within Orange data mining toolbox.

Tomaž Curk: Unitat de Recerca de Reumatologia (URR), Institut de Recerca Hospital Universitari Vall d'Hebron, Barcelona, Spain. 20.1. - 24. 1. 2007, 24. 2. - 24. 3. 2007. Collaboration on SNP interaction analysis for Whole Genome Association Study (WGAS) in Rheumatoid Arthritis.

## INVITED TALKS AND LECTURES

Ivan Bratko: Pessimistic Heuristics Better than Optimistic in Real-Time Search, 14. 6. 2007, Univ. of Klagenfurt, Austria.

Blaž Zupan: Epistasis and Inference of Genetic Network Topology, 4. 3. 2007, ESF/LESC-PESC Exploratory Workshop: Phenomics - Advancing High-Resolution Genome-Wide Phenotyping in Yeast, Göteborg, Sweden.



FreeViz - an intelligent visualization approach for class-labeled multidimensional data sets

Blaž Zupan: Knowledge discovery methods in functional genomics, 9. 3. 2007, Workshop on “DNA Microarray, Proteomics, Metabolomics: looking at inside the cells”, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy.

Blaž Zupan: Inference of gene regulatory relations from mutant-based phenotypes, 23. 7. 2007, ISMB/ECCB’s Special Session on Genetic interaction networks: Using combinatorial perturbations to determine pathway structure, Vienna, Austria.

Janez Demšar and Blaž Zupan: Data mining with Orange, 13. 11. 2007, The French Research Institute for Research in Computer Science and Control, Rennes, France.

## SELECTED PUBLICATIONS

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

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

J. Demšar, G. Leban, B. Zupan. FreeViz – an intelligent multivariate visualization approach to explorative analysis of biomedical data. *Journal of Biomedical Informatics* 40(6): 661-671, 2007.

R. Bellazzi, B. Zupan. Towards knowledge-based gene expression data mining. *Journal of Biomedical Informatics* 40(6): 787-802, 2007.

M. Guid, I. Bratko. Factors affecting diminishing returns for searching deeper. *ICGA Journal* 30(2): 75-84, 2007.

D. Vladušič, B. Kompare, I. Bratko. Use of qualitative constraints in modelling of the Lake Glumsø. *Int. Journal Environmental Pollution* 31(1/2): 107-124, 2007.

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

G. Leban, B. Zupan, G. Vidmar, I. Bratko. VizRank : data visualization guided by machine learning. *Data Mining and Knowledge Discovery* 13(2): 119-136, 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. Demšar. Statistical comparisons of classifiers over multiple data sets. *Journal of Machine Learning Research* 7: 1-30, 2006.

M. Možina, J. Žabkar, T. Bench-Capon, I. Bratko. Argument based machine learning applied to law. *Artificial Intelligence and Law* 13: 53-73, 2006.

- J. Žabkar, R. Žabkar, D. Vladušič, D. Čemas, D. Šuc, I. Bratko. Q<sup>2</sup> Prediction of ozone concentrations. *Ecological Modelling*, 191(1): 68-82, 2006.
- A. Sadikov, I. Bratko, I. Kononenko. Bias and pathology in minimax search. *Theoretical Computer Science*, 349(2): 268-281, 2005.
- 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.
- T. Curk, J. Demšar, Q. Xu, G. Leban, U. Petrovič, I. Bratko, G. Shaulsky, B. Zupan. Microarray data mining with visual programming. *Bioinformatics*, 21(3): 396-398, 2005.
- 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.
- D. Šuc, D. Vladušič, I. Bratko. Qualitatively faithful quantitative prediction. *Artificial Intelligence*, 158(2): 189-214, 2004.
- B. Zupan, J. Demšar J, I. Bratko, P. Juvan, J. A. Halter, A. Kuspa, G. Shaulsky. GenePath: a system for automated construction of genetic networks from mutant data. *Bioinformatics*, 19(3): 383-389, 2003.
- I. Bratko. *Prolog Programming for Artificial Intelligence, third edition*. Addison-Wesley/Pearson Education 2001; previous editions also translated into German, Italian, French, Slovene, Japanese, and Russian.



# Laboratory for Cognitive Modeling

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## RESEARCH ACTIVITIES

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

## RESEARCH PROJECTS

Reliable and Comprehensible Machine Learning Approaches with Applications to Medical Diagnostics and Bioinformatics. Bilateral project funded by Slovenian and Greek Ministry of science (2005-2007).

Machine Learning of Probabilities with Applications to Web Portals and Medical Diagnostics (BI-PT/06-07-004). Bilateral project funded by Slovenian and Portuguese Ministry of science (2006-2007).

Artificial intelligence and intelligent systems (P2-0209). Research Program funded by Slovenian Research Agency (2004-2008).

## LABORATORY GUESTS

Pedro Pereira Rodrigues and Cláudia Camila Dias, University of Porto, Portugal, 5. 10. - 13. 10. 2007, work on joint project Machine Learning of Probabilities with Applications to Web Portals and Medical Diagnostics.

Raul Fidalgo Merino, University of Málaga, Spain, 20. 08. – 21 .11. 2007, research collaboration on Artificial intelligence and intelligent systems.

Aristidis Likas, University of Ioannina, 5. - 9. 9. 2007, work on joint project: Reliable and Comprehensible Machine Learning Approaches with Applications to Medical Diagnostics and Bioinformatics.

Jose del Campo Avilla, University of Malaga, 5. - 12. 9. 2007. Research collaboration on Artificial intelligence and intelligent systems.

## RESEARCH VISITS

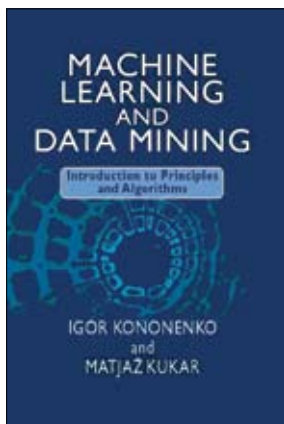
Matjaž Kukar and Zoran Bosnić, University of Porto, Portugal, 24. 09. - 28. 09. 2007, work on joint project Machine Learning of Probabilities with Applications to Web Portals and Medical Diagnostics.

Marko Robnik Šikonja and Zoran Bosnić, University of Ioannina, Greece, 12. 3. – 16. 3. 2007, work on joint project Reliable and Comprehensible Machine Learning Approaches with Applications to Medical Diagnostics and Bioinformatics.

## INVITED TALKS AND LECTURES

M. Kukar: Multi-resolution image parametrization in stepwise diagnostics of Coronary Artery Disease: some results and open problems, invited talk at University of Porto, 27. 9. 2007

I. Kononenko: Objective science and subjective spirituality are complementary. Invited lecture. In: I. Kononenko (ed.). *Proceedings of measuring energy fields : international scientific conference, Kamnik, Tunjice, 13-14 October 2007*. Kamnik: Zavod Zdravilni gaj, 2007, pp. 117-124.



The book by two members of LKM was published by Hoorwood and represents the appreciation of our research work



We collaborate with several Universities and Institutes from Greece, Portugal, Switzerland, Russia and Belgium

## SELECTED PUBLICATIONS

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

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

Luka Šajn, Igor Kononenko, Metka Milčinski: Computerized segmentation and diagnostics of whole-body bone scintigrams. *Comput. med. imaging graph..* 2007, vol. 31, no. 7, pp. 531-541

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

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

M. Kukar. Quality assessment of individual classifications in machine learning and data mining. *Knowledge and information systems*, 2006, vol. 9, no. 3, pages 364-384.

M. Kukar., C. Grošelj. Transductive machine learning for reliable medical diagnostics. *J. med. syst.*, 2005, vol. 29, no. 1, pages 13-32.

M. Robnik-Šikonja, I. Kononenko. Reliable feature evaluation in classification and regression. V: LIU, John X. (ur.). *Control and Learning in Robotic Systems*. New York: Nova Science Publishers, cop. 2005, str. 281-319

L. Šajn, M. Kukar, I. Kononenko, M. Milcinski. Computerized segmentation of whole-body bone scintigrams and its use in automated diagnostics. *Comput. Methods and Programs in Biomedicine*, 80(1)47-55, 2005.

I. Kononenko, I. Jerman (eds.). Mind-body studies : proceedings of 6th International Conference on Cognitive Science, Ljubljana, 13-17th October 2003. Ljubljana: Institut "Josef Stefan" (190 pages).

M. Kukar. Transductive reliability estimation for medical diagnosis. *Artificial Intelligence in Medicine*, 29:81-106, 2003.

M. Robnik-Šikonja, D. Cukjati, I. Kononenko. Comprehensible evaluation of prognostic factors and prediction of wound healing. *Artificial Intelligence in Medicine*, 29: 25-38, 2003.

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

D. Cukjati, M. Robnik-Šikonja, S. Reberšek, I. Kononenko, D. Miklavčič. Prognostic factors, prediction of chronic wound healing and electrical stimulation. *Medical & Biological Engineering & Computing*, 39:542-550, 2001.

I. Kononenko: Machine learning for medical diagnosis: History, state of the art and perspective, Invited paper, *Artificial Intelligence in Medicine*, 23(1):89-109, 2001.

# Laboratory for Mathematical Methods in Computer and Information Science

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| Associate Professor <b>Dr. Bojan Orel</b>        | bojan.orel@fri.uni-lj.si       | 870  |
| Assistant Professor <b>Dr. Gašper Fijavž</b>     | gasper.fijavz@fri.uni-lj.si    | 871  |
| Assistant <b>Dr. Marko Boben</b>                 | marko.boben@fri.uni-lj.si      | 871  |
| Assistant <b>Sanja Fidler, B.Sc.</b>             | sanja.fidler@fri.uni-lj.si     | 866  |
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| Assistant <b>Peter Kink, M.Sc.</b>               | peter.kink@fri.uni-lj.si       | 184  |
| Assistant <b>Dr. Andrej Vodopivec</b>            | andrej.vodopivec@fri.uni-lj.si | 883  |
| Assistant <b>Martin Vuk, M.Sc.</b>               | martin.vuk@fri.uni-lj.si       | 883  |
| Assistant <b>Damjan Vrenčur, B.Sc.</b>           | damjan.vrencur@fri.uni-lj.si   | 184  |

## RESEARCH ACTIVITIES

The research activities of the laboratory involve various fields of mathematics with special emphasis on applications to computer and information science. The following areas of mathematics are studied:

- scientific computing and numerical solutions of differential equations, in particular, methods for geometric integration of differential equations,
- graph theory, mostly topological and structural properties of graphs, vertex colorings of graphs and weighted graphs as a natural generalization of the channel assignment problem,
- algebraic topology, in particular cohomology of topological spaces with group actions, applications of topology to computer science, and computational topology,
- nonlinear dynamical systems and their application in geometry, physics and mechanics,
- linear and nonlinear mathematical techniques in image analysis and their application to computer vision (in cooperation with the Visual Cognitive Systems Laboratory),
- 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,
- in the area of incidence structures we study problems related to combinatorial and geometric configurations (the study of combina-

torial properties of configurations via their incidence graphs, and the study of possibility of the realization of configurations in other incidence structures).

- algebraic combinatorics (discrete structures and algebraic methods: coding theory, design theory and statistical design, theory of orthogonal polynomials and covering spaces, finite geometries and group theory, theory of association schemes and graph theory, in particular distance-regular graphs)

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

Several members of the lab are also members of research groups of the Institute of Mathematics, Physics, and Mechanics. Members of the lab are involved in joint research work with other research groups at the Faculty of Computer and Information Science and the Faculty of Electrical Engineering and with the following institutions: NTNU Trondheim, Norway, and University in Bergen, Norway, University of Hamburg, Germany, P.J.Šafarik University in Košice, Slovakia, and others.

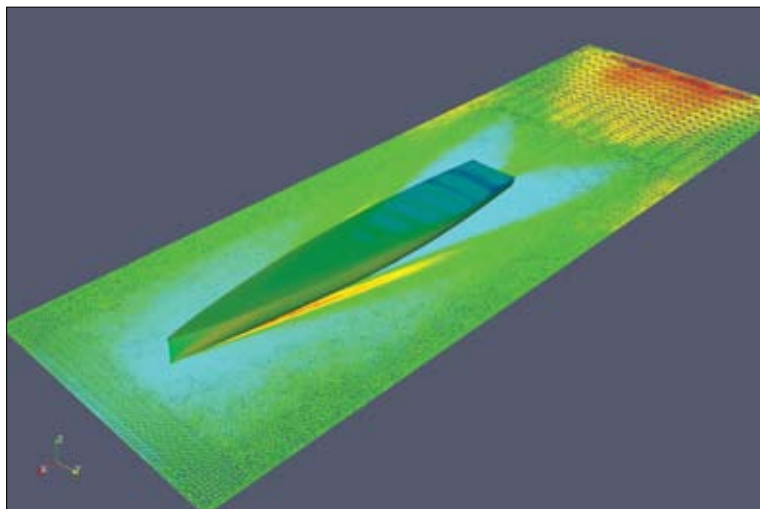
## RESEARCH PROJECTS

Optimization of the shape of yacht hulls, Industry-Funded Project, Seaway group, d.o.o. (2007–2008).

Randomness verification and irregularity analysis of a mechanical random generator that is to be part of a game machine, Industry-Funded Project, Elektrina d.o.o. (2008–2008).

## LABORATORY GUESTS

Dr. Eva Trenklerova, J.P. Šafarik University, Košice, Slovakia. 20.05. - 02.06. Research work on the topic of discrete and computational topology with Neža Mramor Kosta.



The pressure field of a simulated sailing boat

Roman Kozlov, University in Bergen, Norway, 13.9. - 15. 9. Joint research on geometric integration with Bojan Orel.

## RESEARCH VISITS

Sanja Fidler, York University, Toronto, Canada, 24.1.2007 – 9.2.2007. Collaboration on computational models of biological vision.

Gašper Fijavž, University of Hamburg, 1. 4. 2007 - 30. 6. 2007. Joint research work with prof. Reinhard Diestel on graphs on surfaces

Neža Mramor Kosta, J.P. Šafarik University in Košice, Slovakia, 6. 12. - 15. 12. Research on basic sets in the digital plane.

## INVITED TALKS AND LECTURES

Sanja Fidler: Learning Hierarchical Representations of Object Categories, 11.1.2007, best PhD student presentation award, EU Cognition meeting, Munich, Germany.

Gašper Fijavž: K6-minors and realizability of triangulations of the Möbius band, April 2007, an invited lecture at the Department of Mathematics, University of Hamburg, Germany.

## SELECTED PUBLICATIONS

Marko Boben. Irreducible ( $v_3$ ) configurations and graphs. *Discrete Math.*, 2007, vol. 307, iss. 3-5, str. 331-344.

G. Fijavž. Contractions of 6-connected toroidal graphs. *J. Comb. Theory, Ser. B*, 2007, vol. 97, no. 4, str. 553-570.

G. Fijavž. Hadwiger's conjecture for circular colorings of edge-weighted graphs. *Discrete Mathematics* 307, (2007) 402-408.

S. Fidler and A. Leonardis. Towards Scalable Representations of Object Categories: Learning a Hierarchy of Parts. *Proc. of IEEE Conference on Computer Vision and Pattern Recognition 2007*.

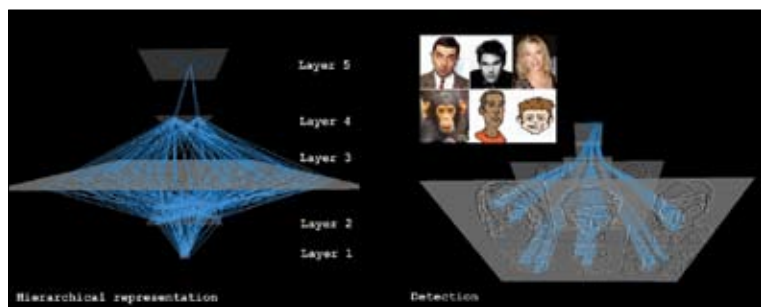
S. Gojak, I. Gutman, S. Radenković, A. Vodopivec. Relating resonance energy with Zhang-Zhang polynomial. *J. Serb. Chem. Soc.* 72 (2007) 673-679.

A. Turković, B. Orel, M. Lučić-Lavčević, P. Dubček, M. Pavlović, Z. Crnjak Orel, S. Bernstorff. GISAXS study of temperature evolution in nanostructured  $\text{CeVO}_4$  films. *Sol. energy mater. sol. cells*. [Printed ed.], 2007, vol. 91, no. 14, str. 1299-1304.

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 (3), March 2006, pp. 337 - 350.

M. Boben, B. Grünbaum, T. Pisanski, A. Žitnik. Small triangle-free configurations of points and lines. *Discrete comput. geom.*, 2006, vol. 35, no. 3, str. 405-427.

S. Bokal, G. Fijavž and B. Mohar, The minor crossing number. *SIAM j. discrete math.*, 2006, vol. 20, no. 2, str. 344-356.



A hierarchical method for recognizing object categories in images

H. King, K. Knudson, N. Mramor Kosta. Generating discrete Morse functions from point data. *Experimental Math.* 14 (2005), 441--450.

M. Vilfan, M. Vuk, Nuclear spin relaxation of mesogenic fluids in spherical microcavities, *J. Chem. Phys.*, 2004, vol. 120, 8638-8644.

E. Celledoni, A. Iserles, S.P. Norsett, B. Orel. Complexity Theory for Lie Group Solvers, *J. of Complexity* 18 (2002), 242–286.



# 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



Smart cards enable us to securely store private keys.

on elliptic curves, algorithmic number theory, applications of finite fields and coding theory.

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

## RESEARCH PROJECTS

Certification agency with ECC(M1-0139), Target Research Programmes funded by Slovenian Research Agency (2006-2008).

Database anonymization (L1-9659), Applied Research Project funded by Slovenian Research Agency and Ministry of Health (2007-2009).

Elliptic curve cryptosystems over prime fields and smart cards (M2-0206), Target Research Programmes funded by Slovenian Research Agency (2006-2008).

## LABORATORY GUESTS

Prof. Dr. Paul Terwilliger, Department of Mathematics, University of Wisconsin-Madison, USA, 20. 6. – 1. 7. 2007. Scientific research collaboration between Slovenia and USA.



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

Prof. Dr. Andries Brouwer, Eindhoven University of Technology, Eindhoven, Netherlands, 19. 6. – 24. 6. 2007.

Prof. Dr. William Martin, Worcester Polytechnic Institute, Worcester, MA, USA, 23. 6. – 4. 7. 2007. Scientific research collaboration between Slovenia and USA and lecture on random number generators.

Prof. Dr. Chris Godsil, Department of Combinatorics and Optimization, University of Waterloo, Waterloo, Canada, 24. 6. – 1. 7. 2007.

Prof. Dr. Arnold Neumaier, University of Vienna, Vienna, Austria, 24. 6. – 26. 6. 2007.

## RESEARCH VISITS

Aleksandar Jurišić: Combinatorial and Computational Mathematics Center, PosTech, Pohang, Korea, 23. 1. - 12. 2. 2007.

Aleksandar Jurišić: Department of Mathematics, Sir Wilfred Grenfell College, Memorial University of Newfoundland, Canada, 23. 9. - 3. 10. 2007.

## INVITED TALKS AND LECTURES

Aleksandar Jurišić: A diameter 5 family of triangle-free distance-regular graphs with an eigenvalue multiplicity equal to the valency, Feb. 1, 2007, an invited lecture at the Combinatorial and Computational Mathematics Center, PosTech, Pohang, Korea.

Aleksandar Jurišić: Distance-regular graphs with complete multipartite subgraphs, Feb. 10, 2007, an invited lecture at the Koreja-Japan Workshop in Algebra and Combinatorics, Pusan National University, Busan, Korea.

Aleksandar Jurišić: Inequalities for distance-regular graphs and the structure of primitive idempotents, June 25, 2007, an invited lecture at 6th Slovenian International Conference on Graph Theory, Minisymposia on Algebraic Combinatorics, Bled, Slovenia.

Aleksandar Jurišić: From symmetric to public cryptography, Sept. 28, 2007, an invited lecture at the Department of Mathematics, Sir Wilfred Grenfell College, Memorial University of Newfoundland, Canada.

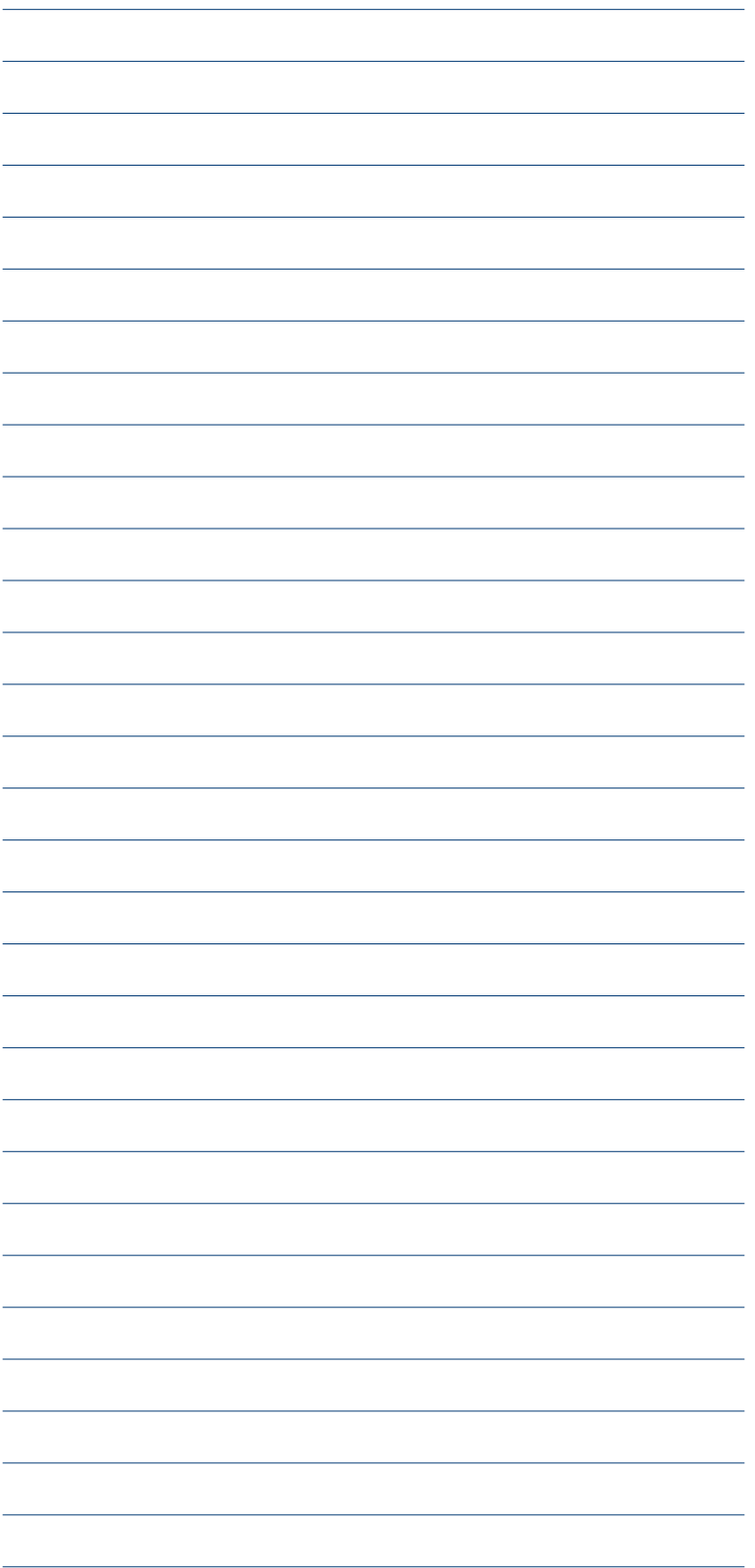
Aleksandar Jurišić, A characterization of  $Q$ -polynomial triangle-free distance-regular graphs with an eigenvalue multiplicity equal to the valency, Oct. 5, 2007, an invited lecture at the AMS meeting in Chicago, IL, USA.

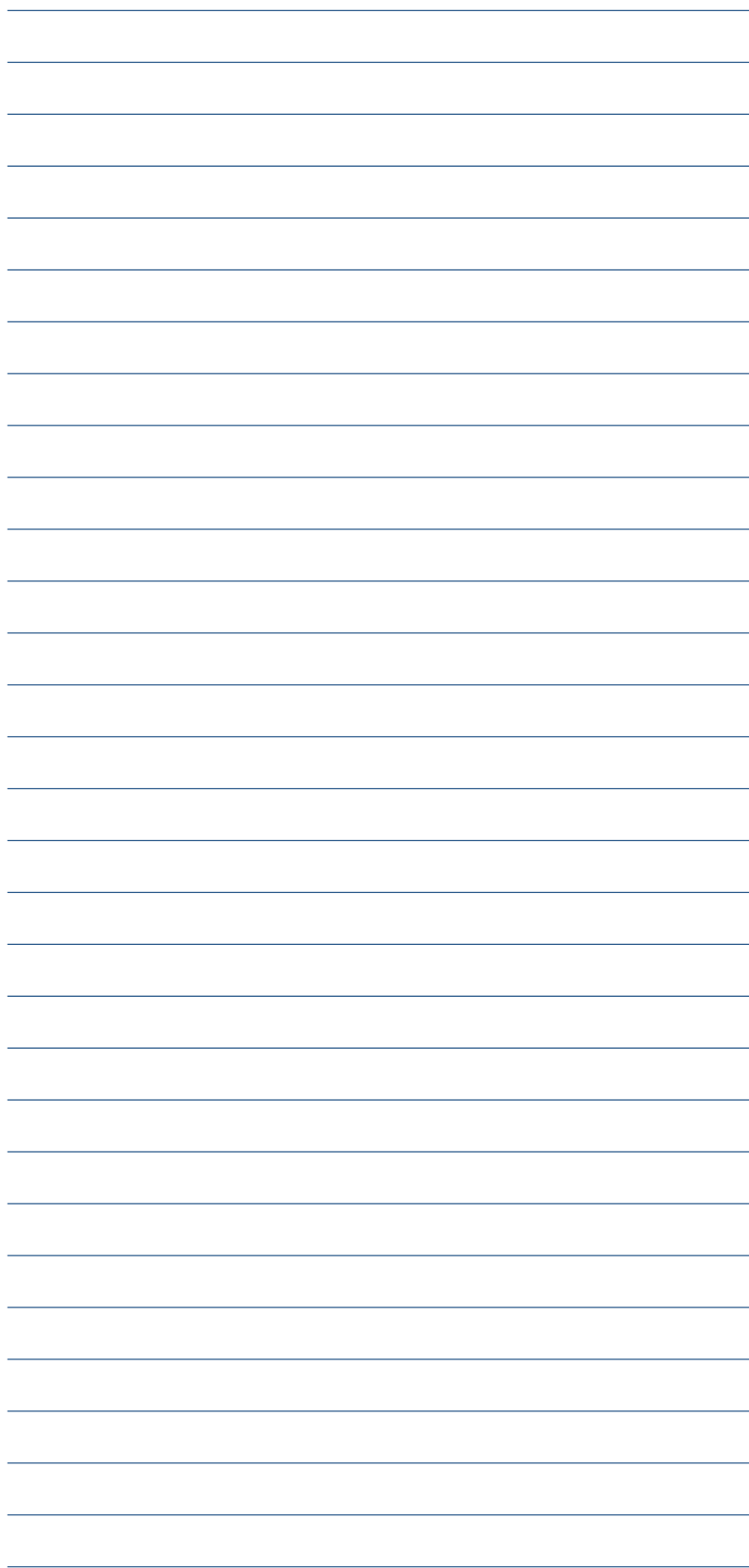
## SELECTED PUBLICATIONS

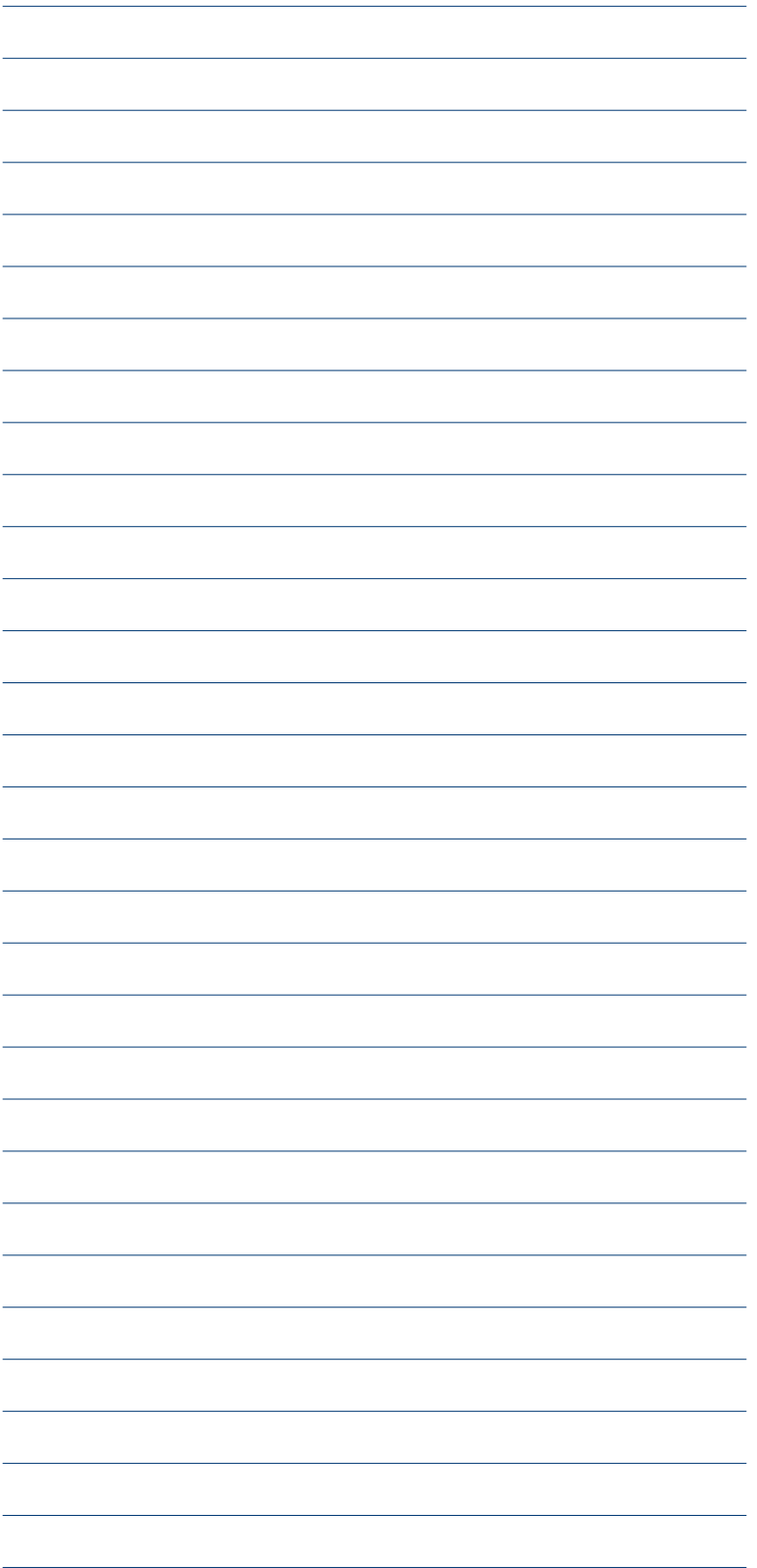
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