

DEPARTMENT OF INTELLIGENT SYSTEMS

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The Department of Intelligent Systems develops new methods and techniques for intelligent computer systems, with applications in the areas of the information society, computer science and informatics, and network communication systems. The main research areas are ambient intelligence, computational intelligence, agent modeling, and language and speech technologies. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research program "Artificial Intelligence and Intelligent Systems", led by Prof. Ivan Bratko.

Intelligent systems simulate intelligence so that a typical user perceives them as truly intelligent. However, in reality, these systems use complex mechanisms and implement them on digital computers to imitate human behavior as well as possible, exploiting raw, exponentially growing computer power.

Ambient intelligence is an increasingly important research area aiming to introduce the technology into our everyday environment in a friendly way that is undemanding for the user. The two key topics of ambient intelligence we work on are (1) telemedicine and elderly care, and (2) smart buildings. The European telemedicine project CHIRON is concerned with monitoring chronic heart-disease patients at home. Our task is activity recognition and the estimation of the patient's energy expenditure with accelerometers. Additionally, we worked on a decision-support system for the physicians to assess the risk to the patient's health. Since activity recognition is one of the fundamental

tasks of ambient intelligence, we upgraded the activity recognition from the CHIRON project into the TriLAR (three-layer activity recognition) method. Another important task is the detection of unusual and suspicious behavior, which we tackled in a doctoral research project. When analyzing human behavior, it is important to adapt to each individual user. For this purpose we developed a semi-supervised learning method called MCAT (multi-classifier adaptive training). Finally, we worked on the recognition of typical diseases of the elderly and fall detection. In the ELKOV22 project we cooperate with the Elgoline, Kovinoplastika and INTECH-LES razvojni center companies to develop an intelligent door system. In the door we integrated an intelligent system consisting of sensors, actuators, controllers, communication interfaces and mobile applications. The system provides smart functionalities devoted to comfort (voice messages, event monitoring, remote control) and security (detection of movement and banging on the door, alarms with images over e-mail or SMS, etc.). The most advanced functions are the recognition of unusual entries/exits, automatic identification/verification of the entering individuals, a user interface featuring a virtual assistant, and learning the habits of the inhabitants to optimize the energy consumption of the building. In the area of smart buildings we were also developing a multi-agent building-control system with the purpose of performing a multi-objective optimization of comfort and energy consumption.

Computational intelligence is a study of stochastic search, optimization and learning methods, inspired by physical and biological systems. Research in this area at the Department of Intelligent Systems focuses on evolutionary computation methods. We study extensions of evolutionary algorithms for multiobjective optimization and their speedup, and apply these algorithms in engineering design and optimization problems. In doctoral research projects, we develop a method for the visualization of multidimensional fronts of nondominated solutions in multiobjective optimization, an algorithm for the discovery of optimal car-driving strategies with respect to the traveling time and the fuel consumption, and optimization based on surrogate models. In addition, our work is motivated by the optimization of metallurgical production processes, which is a subject of two research projects executed together with the University of Nova Gorica,



Head:
Prof. Matjaž Gams

In the European project CHIRON we monitor chronic heart-disease patients at home. The recognized patient's activity and estimated energy expenditure represent the context for the observation of the patient's heartbeat.



Figure 1: An intelligent door system, developed in cooperation with the INTECH-LES razvojni center and companies Kovinoplastika Lož and Elgoline, was demonstrated at the Ambient furniture fair from 6th to 11th November 2012, and presented in a short interview on RTV Slovenia.

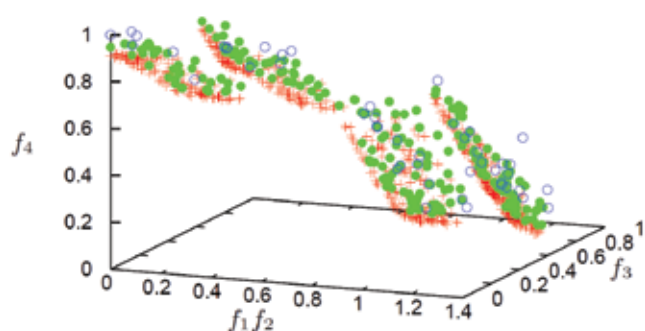


Figure 2: Visualization of three 4D Pareto front approximations in 3D using projections

In the ELKOV22 project we cooperate with industrial partners to develop an intelligent-door system. The project is focused on the security and the detection of unusual events during entrance.



Figure 3: At the 5th International Conference on Bioinspired Optimization Methods and their Applications - BIOMA 2012, held in Bohinj, Slovenia, on 24 and 25 May 2012, 30 papers by 70 (co)authors from 13 countries were presented.

The goal of the 7th Framework Program project MIRABEL is to develop a computer infrastructure to efficiently balance the generation and consumption of electrical energy for an increased amount of energy from renewable sources.

Institute of Metals and Technology, Ljubljana, and the Štore Steel company. A substantial part of our applied research is devoted to energy efficiency. In collaboration with partners from five European countries, we carry out the 7th Framework Program project MIRABEL (originally MIRACLE). Its goal is to develop a computer infrastructure to efficiently balance between the generation and consumption of electrical energy for an increased amount of energy from renewable sources. This infrastructure relies on flexible offers for energy generation and consumption, their aggregation and scheduling. For this project we implemented scheduling algorithms for assigning the time and energy amount to the offers.

In the field of **agent modeling** we are focused on the behavior analysis and cloning of individuals and groups. Most of the work is performed for the EUSAS project, which is funded by the European Defense Agency. The aim is to develop a new approach to mission training for low-level units (security, police force, etc.) facing asymmetric threats in an urban environment. The developed tools can be used to discover the common agent strategy by knowing only low-level agent behavior and possessing basic domain knowledge. The discovered strategic action descriptions are presented to the user in the form of graph paths, agent actions, roles and corresponding rules. The rules, constructed by machine learning, enrich the graphical strategic patterns and describe the conditions under which individual actions present in the pattern occur. Moreover, meaningful behavior patterns are later used during behavior cloning, where software agents reproduce the observed behavior of real operational people. Experiments have shown that the developed approach allows for a high-quality reproduction of behavior.

In the field of **speech and language technologies** we work on speech synthesis, forensic speaker recognition, semantic analysis of text and question answering. Together with the Amebis company, we are developing a new speech synthesizer for Slovene. Special attention is paid to the requirements of elderly, handicapped and visually impaired people. In cooperation with the national television and radio, RTV Slovenia, we recorded a phonetically rich and balanced speech database for corpus-based speech synthesis. In speaker recognition we continue to investigate the correlation between the speech quality in telephony and the performance of automatic speaker verification.

In collaboration with the Department of Computer Systems, we organized the 5th International Conference on Bioinspired Optimization Methods and their Applications - BIOMA 2012, held in Bohinj, Slovenia, on 24 and 25 May 2012, and devoted to theoretical and practical aspects of optimization methods based on the models of biological processes and associations. There were 30 papers by 70 (co)authors from 13 countries presented at the conference. The invited lecturers were Prof. Ágoston E. Eiben from VU University of Amsterdam, and Dr. Xin-She Yang, from the National Physical Laboratory in Teddington, UK.

From 8 to 12 October 2012, the 15th International Multiconference Information Society - IS 2012 took place at the Jožef Stefan Institute. It consisted of ten independent conferences with 215 papers. The special event was the conference "100 Years of Alan Turing and 20 Years of SLAIS" gathering

scientists that had a significant impact on the field of artificial intelligence in the past decades. Four conference awards were given: for exceptional contribution to the development and promotion of the information society, for current achievements in the field of information society, and the information strawberry and lemon for the best and worst public information-society services.

Some outstanding publications in the past year

1. Kaluža, B., Gams, M.: Analysis of daily-living dynamics. *Journal of Ambient Intelligence and Smart Environments*, 2012, 4(5), pp. 403-413

2. Korošec, P., Šilc, J., Filipič, B.: The differential ant-stigmergy algorithm. *Information Sciences*, 2012, 192, pp. 82–97
3. Luštrek, M., Bratko, I., Gams, M.: Independent-valued minimax: Pathological or beneficial? *Theoretical Computer Science*, 2012, 442, pp. 59–77
4. Marinčič, D., Šef, T., Gams, M.: Parsing with clause and intraclausal coordination detection. *Computing and Informatics*, 2012, 31(2), pp. 299–329
5. Piltaver, R., Luštrek, M., Gams, M.: The pathology of heuristic search in the 8-puzzle. *Journal of Experimental & Theoretical Artificial Intelligence*, 2012, 24(1), pp. 65–94
6. Pogorelc, B., Gams, M.: Home-based health monitoring of the elderly through gait recognition. *Journal of Ambient Intelligence and Smart Environments*, 2012, 4(5), pp. 415–428

Organization of conferences, congresses and meetings

1. The 5th International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2012, Bohinj, Slovenia, 24.–25. 5. 2012
2. 4th Jožef Stefan International Postgraduate School Students Conference, Jožef Stefan Institute, Ljubljana, 25. 5. 2012
3. 20th Workshop on Nature-Inspired Algorithms, AVN, Šmarna gora, Slovenia, 20. 9. 2012
4. 15th International Multiconference Information Society, IS 2012, 8.–12. 10. 2012; independent conferences: 100 Years of Alan Turing and 20 Years of SLAIS, Intelligent Systems, Data Mining and Data Warehouses (SiKDD 2012), Collaboration, Software and Services in Information Society, Cognitive Sciences, Robotics, Language Technologies, Education in Information Society, FORSEE – Technological Forecasting in ICT, Facing Demographic Challenges

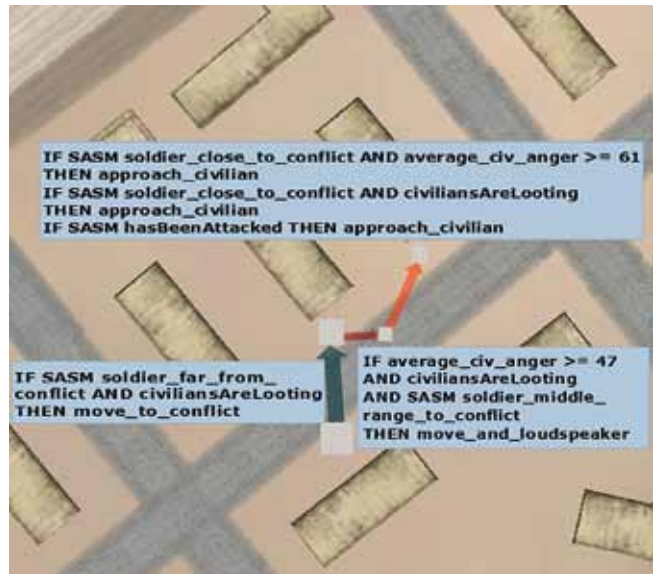


Figure 4: An example of a discovered strategic behavior pattern. The pattern is composed of a graphical (sequences of actions) and symbolic part (rules).

The main goal of the EUSAS project is to develop a new approach to mission analysis and training for low-level units facing asymmetric threats in an urban environment.

INTERNATIONAL PROJECTS

1. 7. FP - MIRACLE, MIRABEL: Micro-request-based aggregation, forecasting and scheduling of energy demand, supply and distribution
European Commission
Prof. Bogdan Filipič
2. 7. FP - Xperience: Robots bootstrapped through learning from experience
European Commission
Prof. Matjaž Gams
3. EUSAS: European urban simulation for asymmetric scenarios
EADS N.V., Defense And Security Systems
Prof. Matjaž Gams
4. Constrained multiobjective optimization based on simulation models
Slovenian Research Agency
Prof. Bogdan Filipič

RESEARCH PROGRAM

1. Artificial intelligence and intelligent systems
Prof. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Advanced modelling and simulation of liquid-solid processes
Prof. Bogdan Filipič

2. Simulation and optimization of casting, rolling and heat treatment processes for competitive production of topmost steels
Prof. Bogdan Filipič
3. The 15th international multiconference Information Society 2012
Prof. Matjaž Gams
4. Open communication platform for service integration
Prof. Matjaž Gams
5. E-Reader in Slovene for the blind and visually impaired
Dr. Tomaž Šef
6. Crowdsourcing support for reassembly of wall painting fragments
Prof. Bogdan Filipič
7. Electronic mobile tourist guide
Dr. Mitja Luštrek
8. Virtual assistant for municipalities and societies
Prof. Matjaž Gams
9. ARTEMIS, CHIRON: Cyclic and person-centric health management: Integrated approach for home, mobile and clinical environments
Dr. Mitja Luštrek

NEW CONTRACTS

1. 2nd project phase: Intelligent surveillance and administration system for wooden residences
Intech - Les, d. o. o.
Prof. Matjaž Gams
2. Development of virtual assistant
Education, Science and Culture Trade Union of Slovenia
Prof. Matjaž Gams

VISITORS FROM ABROAD

1. Prof. Erkki Laitinen, University of Oulu, Department of Mathematical Sciences, Oulu, Finland, 20.-26. 5. 2012
2. Martin Gjoreski, Faculty of Computer Science and Engineering, Univerzitet Sv. Kiril in Metodij, Skopje, Macedonia, 1.-31. 8. 2012
3. Dr. David Krizaj, Department of Ophthalmology and Visual Sciences, University of Utah, Utah, USA, 5.-23. 10. 2012
4. Prof. Adam Przepiorkowski, Institute of Computer Science, Polish Academy of Sciences, Warsaw, Poland, 6.-9. 10. 2012
5. Prof. Liliana Albertazzi, Center for Mind and Brain Sciences, University of Trento, Trento, Italy, 7.-11. 10. 2012
6. Luisa Milic, Ideya Business and Marketing Consultancy, Cambridge, United Kingdom, 7.-11. 10. 2012
7. Dr. Albert Bifet, University of Waikato, Hamilton, New Zealand, 8.-11. 10. 2012
8. Prof. Stephen Muggleton, Imperial College London, London, UK, 8.-12. 10. 2012
9. Prof. Marko Tadić, Faculty of Arts, University of Zagreb, Zagreb, Croatia, 8.-12. 10. 2012
10. Prof. Joao Gama, Laboratory of Artificial Intelligence and Decision Support, Porto, Portugal, 11. 10. 2012
11. Dr. Nataša Milić Frayling, Microsoft Research Cambridge, Cambridge, United Kingdom, 11. 10. 2012
12. Prof. Gerhard Friedrich, Intelligent Systems and Business Informatics, Universität Klagenfurt, Klagenfurt, Austria, 11.-12. 10. 2012
13. Dr. Gerald Steinbauer, Institute for Software Technology, Graz University of Technology, Graz, Austria, 11.-13. 10. 2012
14. Prof. Claude Sammut, University of New South Wales, Kensington, Australia, 16. 10. 2012

STAFF

Researchers

1. Prof. Ivan Bratko*
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9. Dr. Matija Drobnič*
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11. Dr. Aleksander Pivk*
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13. Robert Blatnik, M. Sc.
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15. Erik Dovgan, B. Sc.
16. Boštjan Kaluža, B. Sc.
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18. Simon Kozina, B. Sc.

19. Jana Krivec*, B. Sc.
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26. Tea Tušar, M. Sc.
27. Domen Zupančič**

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29. Gašper Pintarič*, B. Sc.

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30. Dr. France Dacar, retired 29.07.12
31. Vesna Koricki Špetič, B. Sc.
32. Mitja Lasič
33. Liljana Lasič
34. Lana Zemljak

Note:

* part-time JSI member

** postgraduate financed by industry

BIBLIOGRAPHY

ORIGINAL SCIENTIFIC ARTICLE

1. Carlos Cavero Barca *et al.* (14 authors), "Medical expert support tool (MEST): a person-centric approach for healthcare management", In: Impact analysis of solutions for chronic disease prevention and management: proceedings, *Lecture notes in computer science*, vol. 7251, pp. 99-115, 2012.
2. Božidara Cvetković, Boštjan Kaluža, Mitja Luštrek, Matjaž Gams, "Multi-classifier adaptive training: specialising and activity recognition classifier using semi-supervised learning", In: Ambient Intelligence: Third International Joint Conference, Aml 2012, Pisa, Italy, November 13-15, 2012: proceedings, *Lecture notes in computer science*, vol. 7683, pp. 193-207, 2012.
3. Erik Dovgan, Tea Tušar, Matija Javorski, Bogdan Filipič, "Discovering comfortable driving strategies using simulation-based multiobjective optimization", *Informatica (Ljublj.)*, vol. 36, no. 3, pp. 319-326, 2012.
4. Iztok Fister, Marjan Mernik, Bogdan Filipič, "Graph 3-coloring with a hybrid self-adaptive evolutionary algorithm", *Computat. optimiz. appl.*, pp. 1-32, Published online 28 June 2012.
5. Hristijan Gjoreski, Mitja Luštrek, Matjaž Gams, "Context-based fall detection using inertial and location sensors", In: Ambient Intelligence: Third International Joint Conference, Aml 2012, Pisa, Italy, November 13-15, 2012: proceedings, *Lecture notes in computer science*, vol. 7683, pp. 1-16, 2012.
6. Vida Groznic, Matej Guid, Aleksander Sadikov, Martin Možina, Dejan Georgiev, Veronika Kragelj, Samo Ribarič, Zvezdan Pirtošek, Ivan Bratko, "Elicitation of neurological knowledge with argument-based machine learning", *Artif. intell. med.*, vol., iss., pp., 2012.
7. Matej Guid, Ivan Bratko, "Detecting fortresses in chess", *Elektrotehniški vestnik*, vol. 79, no. 1/2, pp. 35-40, 2012.
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13. Mitja Luštrek, Ivan Bratko, Matjaž Gams, "Independent-valued minimax: Pathological or beneficial?", *Theor. comp. sci.*, vol. 422, pp. 59-77, 2012.
14. Domen Marinčič, Tomaž Kompara, Matjaž Gams, "Question classification with active learning", In: Text, speech and dialogue: 15th international conference, TSD 2012, Brno, Czech Republic, September 3-7, 2012: proceedings, *Lecture notes in computer science*, vol. 7499, pp. 673-680, 2012.

15. Domen Marinčič, Tomaž Šef, Matjaž Gams, "Parsing with clause and intraclausal coordination detection", *Comput. inform.*, vol. 31, no. 2, pp. 299-329, 2012.
16. Stephen Muggleton, Luc de Raedt, David Lynton Poole, Ivan Bratko, Peter A. Flach, Katsumi Inoue, Ashwin Srinivasan, "ILP turns 20: biography and future challenges", *Mach. learn.*, vol. 86, no. 1, pp. 3-23, Jan. 2012.
17. Rok Piltaver, Mitja Luštrek, Matjaž Gams, "The pathology of heuristic search in the 8-puzzle", *J. exp. theor. artif. intell.*, vol. 24, no. 1, pp. 65-94, 2012.
18. Bogdan Pogorelc, Zoran Bosnić, Matjaž Gams, "Automatic recognition of gait-related health problems in the elderly using machine learning", *Multimedia tools and applications*, vol. 58, no. 2, pp. 333-354, 2012.
19. Bogdan Pogorelc, Matjaž Gams, "Home-based health monitoring of the elderly through gait recognition", *Journal of ambient intelligence and smart environments*, vol. 4, no. 5, pp. 415-428, 2012.
20. Bogdan Pogorelc, Matjaž Gams, "Recognition of patterns of health problems and falls in the elderly using data mining", In: Progress in pattern recognition, image analysis, computer vision, and applications: 17th Iberoamerican Congress, CIARP 2012, Buenos Aires, Argentina, September 3-6, 2012: proceedings, *Lecture notes in computer science*, vol. 7441, pp. 463-471, 2012.
21. Bogdan Pogorelc, Radu-Daniel Vatavu, Artur Lugmayr, Bjoern Stockleben, Thomas Risse, Juha Kaario, Estefania Constanza Lomonaco, Matjaž Gams, "Semantic ambient media: from ambient advertising to ambient-assisted living", *Multimedia tools and applications*, vol. 58, no. 2, pp. 399-425, 2012.
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6. Erik Dovgan, Matja Javorski, Tea Tušar, Bogdan Filipič, "Dealing with comfort as an objective in multiobjective optimization of driving strategies", In: *Zbornik 15. mednarodne multikonference Informacijska družba - IS 2012, 8.-12. oktober 2012, Ljubljana, Slovenia: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Maja Smrdu, ed., Olga Markič, ed., Zvezdan Pirtošek, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Ljubljana, Institut Jožef Stefan, 2012, zv. A, pp. 103-106.
7. Bogdan Filipič, Ivan Lorencin, "Evolutionary multiobjective design of an alternative energy supply system", In: *2012 IEEE World Congresses on Computational Intelligence*, International Joint Conference on Neural Networks (IJCNN 2012), the IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2012) and the IEEE Congress on Evolutionary Computation (IEEE CEC 2012), June 10-15, Brisbane, Australia, Danvers, IEEE, 2012, pp. 395-400.
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13. Boštjan Kaluža, "Postopek za detekcijo nenavadnega in sumljivega obnašanja iz časovno-prostranskih sledi agenta", In: *Zbornik 15.*

SHORT SCIENTIFIC ARTICLE

1. Matjaž Gams, "Alan M. Turing, izumitelj univerzalnega stroja (1912-1954 in 2012): [vabljen predavanje]", *Organ. znanja (Tisk. izd.)*, vol. 17, zv. 2, pp. 55-59, 2012.

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MENTORING

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