

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 language and speech technologies, agent technologies, the semantic web, evolutionary computing, data mining, search algorithms, decision support, intelligent sensors, distributed supervisory systems and network voice services. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research programme Artificial Intelligence and Intelligent Systems, led by Prof. Ivan Bratko.



Head:
Prof. Matjaž Gams

Intelligent systems simulate intelligence so that a typical user seemingly perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to copy human behaviour as well as possible, and combine them with raw, exponentially growing computer power.

We study **search algorithms** for path-finding and other applications. We explained many cases of the pathological behaviour of these algorithms, i.e., achieving worse results at a greater search depth, and determined in which cases a deeper search is beneficial. It was shown that search algorithms in game trees and single-agent search trees are sensitive to pathology in real-life domains. By analyzing the factors that influence the pathology, it was discovered that pathology can be avoided by using rather simple methods, such as increasing the number of values of the heuristic evaluation function. For path-finding algorithms we are also developing methods for the automatic selection of an optimal search depth and waypoints.

Evolutionary computing is the study of search and optimization techniques that imitate the concepts of Darwinian evolution and genetic variation in the exploration of complex problem spaces. Our research focus was on evolutionary multi-objective optimization, with the algorithm DEMO developed recently at our department. This algorithm is based on single-objective differential evolution, and we showed that on numerical problems it generally outperforms similar multi-objective algorithms that rely on genetic algorithms. Applied studies of evolutionary computation were performed in the process parameter optimization in the continuous casting of steel, marker optimization in textile production, parameter tuning for a PID controller of a laboratory experimental device, and the induction of decision trees to control the process of electrical discharge machining (EDM).

Using **data-mining** techniques, we tackled three different tasks: genre identification, spam filtering and modelling of a tablet-manufacturing process. As part of a doctoral research project in automatic genre classification, we used style-based categorization to identify genres of web pages. Our classifier was tested in a web-search task by specifying genres in combination with keywords. The tests showed a significant improvement in the precision of the retrieved results. We continued our research on sequence classification based on characteristic subsequences of symbols. In addition to previous applications of this method for e-mail filtering, we extended the application domain to include biological sequence analysis. In a preliminary analysis of a pharmaceutical tablet-manufacturing process, we used different classification algorithms to find crucial parameters that influence the quality of the produced tablets.

One of the most promising intelligent approaches is based on **intelligent agents**. Agents have two basic properties: autonomy and sociability. Autonomy denotes the capability of agents to perform actions on their own. The other ability – sociability – makes agents, in principle, potentially stronger than universal Turing machines. Our research includes the learning, modelling and simulation of intelligent agents and multi-agent systems. In 2007, the emphasis was on modelling the strategic multi-agent behaviour

We developed a Multi-Agent Strategy Discovering Algorithm (MASDA), which is able to detect and describe a previously unknown strategy of a team of agents based only on agent trace and low-level domain knowledge. The algorithm was successfully tested on two robot-soccer domains: the RoboCup and the 3vs2 Keepaway.

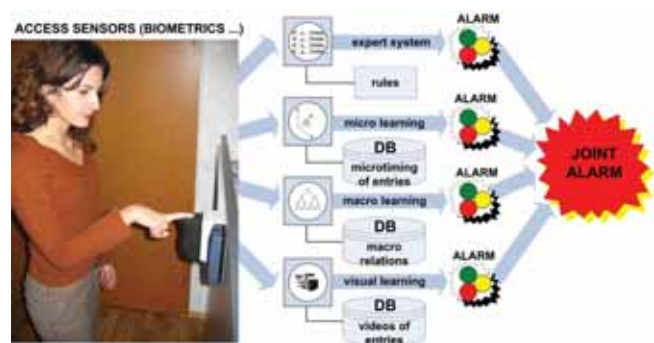


Figure 1: A scheme of the intelligent supervisory system developed by the Department of Intelligent Systems for the Ministry of Defence of the Republic of Slovenia

The Department of Intelligent Systems developed an intelligent event-driven supervisory system for near-real-time and mission-critical operations with a biometric access control and an intelligent expert system (CIVaBiS) for the Slovenian Armed Forces. The project was sponsored by the Ministry of Defence of the Republic of Slovenia.

without prior high-level domain knowledge. We developed a Multi-Agent Strategy Discovering Algorithm (MASDA), which is able to detect and describe the previously unknown strategy of a team of agents based only on the agent trace and a low-level domain knowledge. The algorithm was successfully tested on two robot-soccer domains: the RoboCup and the 3vs2 Keepaway. This research was part of a recent doctoral dissertation from the field of multi-agent system modelling.

In the field of **language technologies** we continued our research on the automatic syntactical parsing of Slovene text. The existing parsers with, currently, the best accuracy for Slovene, were upgraded. We concentrated on complex multi-clausal sentences. The improvement of parsing accuracy

can be achieved by detecting smaller embedded units. We developed an algorithm for intra-clausal coordination detection, which represents a preprocessing stage of the parsing. Our current topics of research are algorithms for clause detection in sentences.

For the Tax Administration of the Republic of Slovenia the Department of Intelligent Systems provided expert advisory support, analyses, consultations and proposed modifications to the Slovenian taxpayers virtual assistant "Vida". Placed on the Tax Administration website, "Vida" answers common taxpayer questions and provides a good alternative tax-related information source as part of the Slovenian e-government services.

The department developed an intelligent event-driven supervisory system for near-real-time and mission-critical operations with biometric access control and an intelligent expert system (CIVaBiS) for the Slovenian Armed Forces. The project was sponsored by the Ministry of Defence of the Republic of Slovenia, and carried out in collaboration with the industrial partner Spica International and with the Faculty of Electrical Engineering, University of Ljubljana.

Within the **Intelligent Home Telekom (IHT)** project for the national telecom operator Telekom Slovenije we developed the functional and technical design of the intelligent home framework for providing a list of the next-generation intelligent home services with the emphasis on ambient intelligence methods and techniques. The current project will be included in a wider project coordinated by the national telecom operator Telekom Slovenije, with partners such as the Faculty of Electrical Engineering, Goap, d.o.o., and Iskratel, d.d. By the integration of the current

triple-play services (TV, telephony and internet) into key service fields, such as home security, home systems intelligent management and telemedicine, we plan to develop next-generation intelligent-home products and broadband services.

Within the working group for Social Alarms of the Technical Committee for electric alarms of the Slovenian Institute for Standardization (SIST) the department participated in the review of the existing DIND VDE 0834 standard for nurse-call systems and helped to conclude that this standard does not

reflect the state of the art in the medical industry and therefore should not be translated into the Slovenian national standard. Therefore, the JSI supported the proposal to form a new Technical Committee for Social Alarms (local to SIST) to address the development of a new standard for this area.

A traditional activity of the Department of Intelligent Systems is the organization of the International Multiconference "Information Society". In October 2007, the 10th multiconference was held in Ljubljana, consisting of six independent conferences.

We participate in the European project WeGo, aimed at promoting e-government services, and Confidence, which deals with ambient-assisted living. Major applied projects are conducted for the Tax Administration of the Republic of Slovenia, Telekom Slovenije, and the Ministry of Defence of the Republic of Slovenia.

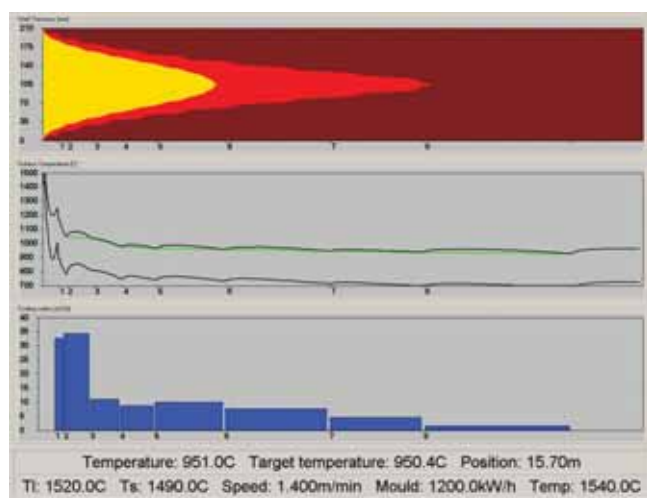


Figure 2: In collaboration with the Department of Mathematical Sciences, University of Oulu, Finland, we are developing a multiobjective optimization methodology for the continuous casting of steel.

Some outstanding publications in the past three years

1. A. Pivk, P. Cimiano, Y. Sure, M. Gams, V. Rajkovič, R. Studer, Transforming arbitrary tables into logical form with TARTAR, *Data & Knowledge Engineering*, 60 (2007), 567–595
2. M. Možina, J. Žabkar, I. Bratko, Argument based machine learning, *Artificial intelligence*, 171 (2007), 922–937
3. A. Bratko, G. V. Cormack, B. Filipič, T. R. Lynam, B. Zupan, Spam filtering using statistical data compression models, *Journal of Machine Learning Research*, 7 (2006), 2673–2698
4. M. Luštrek, M. Gams, I. Bratko, Is real-valued minimax pathological?, *Artificial Intelligence*, 170 (2006), 620–642
5. A. A. Kavalenka, B. Filipič, M. A. Hemminga, J. Štrancar, Speeding up a genetic algorithm for EPR-based spin label characterization of biosystem complexity, *Journal of Chemical Information and Modeling*, 45 (2005), 1628–2635



Figure 3: Academician Prof. Ivan Bratko received an award for his outstanding contribution to the development and promotion of the information society in Slovenia at the 10th International Multiconference Information Society 2007.

Awards and appointments

1. Ivan Bratko: Zois award, Ljubljana, Ministry of Higher Education, Science and Technology, award for top scientific achievements in artificial intelligence

Organization of conferences, congresses and meetings

1. 10th International Multiconference Information Society IS 2007; independent conferences:
 - Cognitive Sciences
 - Collaboration, Software and Services in Information Society
 - Data Mining and Data Warehouses
 - Education in Information Society
 - Intelligent Systems
 - Slovenian Demographic Challenges of the 21st Century
 Jožef Stefan Institute, Ljubljana, Slovenia, 8.–12. 10. 2007
2. 8th Workshop “Nature-Inspired Algorithms”, Jožef Stefan Institute, Ljubljana, Slovenia, 28. 05. 2007

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12. Aleksander Pivk, Philipp Cimiano, York Sure, Matjaž Gams, Vladislav Rajkovič, Rudi Studer
Transforming arbitrary tables into logical form with TARTAR
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13. Uroš Rajkovič, Olga Sušteršič, Vladislav Rajkovič, Darja Cibic
The educational challenges of e-representing the international classification of nursing practice
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2. Olga Šušteršič, Vladislav Rajkovič, Uroš Rajkovič
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INTERNATIONAL PROJECTS

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We-Go, 6. FP; 045472
EC; Dr. Klaus Josef Gschwendtner, ARC Seibersdorf Research GmbH, Vienna, Austria
Prof. Matjaž Gams
2. Superpeer Semantic Search Engine
ALVIS, 6. FP; 002068
EC; Wray Buntine, Complex Systems Computation Group at Helsinki Institute for Information Technology, Helsinki University of Technology, Espoo, Finland
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3. Securing and Optimising Smart Access and Personal Identification Systems with Intelligent Agents
BI-RO/05-06/016
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4. AuID: Audio Visual Identification and Detection of Speaker Creability to Give an Assurance of Secure Communication
dr. Tomaž Šef
5. Commanders right hand
prof.dr. Matjaž Gams
6. Knowledge technology and decision support in medical information portals
prof.dr. Matjaž Gams
7. The role of Lika Koper in logistic support of the Slovenian Armed Forces and allies
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RESEARCH PROGRAM

1. Artificial intelligence and intelligent systems
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R & D GRANTS AND CONTRACTS

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3. CIVaBIS - An integrated security biometrical system
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NEW CONTRACTS

1. Expert counselling for the introduction of tax advisor for Tax Administration of the Republic of Slovenia
Ministry of Finance
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2. Implementation PAT for LEK pharmaceutical company
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3. Prof. Veljko Milutinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 15. 06. 2007
4. Bojana Milasinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 15. 06. 2007

5. Madalin Stefan Vlad, University Politehnica of Bucharest, Faculty of Automatic Control and Computer, Bucharest, Romania, 19.-23. 06. 2007
6. Costantinescu Vlad, University Politehnica of Bucharest, Faculty of Automatic Control and Computer, Bucharest, Romania, 19.-23. 06. 2007
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