DEPARTMENT OF INTELLIGENT SYSTEMS

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 and multi-agent systems, and language and speech technologies. The department collaborates closely with the Faculty of Computer and Information Science at the University of Ljubljana on the joint research program “Artificial Intelligence and Intelligent Systems”, led by Prof. Dr. Ivan Bratko. The department also collaborates closely with industry and contributes significantly to the introduction of intelligent systems into products and services.

Intelligent systems simulate intelligence so that a typical user perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to imitate human behaviour, while they also exploit raw, exponentially growing computer power. This field is rapidly developing worldwide.

Ambient intelligence is a research area aiming to introduce technology into our everyday environment in a friendly way that is undemanding for the user. The main topic of ambient intelligence tackled by the department in 2015 was e-health. As a result of our extensive earlier work on e-health, we are now attempting to translate some solutions for the elderly into practice through the H2020 project InLife. We prepared a smart-watch application that detects falls and similar events. To reduce the number of false alarms, the application takes into account the context of each potential fall, for example, it ignores events after which the user continues to move normally. We also studied user requirements and the best ways for the elderly to interact with technology, as well as developing an application to support their carers. Project solutions will be piloted in cooperation with the Slovenian company Doktor 24 and international partners. In the AAL project Fit4Work, whose goal is to help older workers do their job more easily, we worked on a method to recognize stress from the measurements of physiological sensors in a wristband. To this end, we performed extensive real-life measurements and an induced-stress experiment. In both cases intelligent stress detection was successful, but the problem proved very difficult. In the same project we also developed a method that uses ontology and sensors at the workplace to recommend actions such as changing the temperature or ventilation. In the FP7 project COMMODITY12, which telemonitors diabetic patients, we continued analysing the patients’ lifestyle with a smartphone and a wearable ECG monitor. We improved a method that first automatically recognizes which of these devices a patient carries, then it normalizes the orientation of the phone and detects in which pocket it is carried, and finally invokes the appropriate models to recognize the patient’s activity and estimates his/her energy expenditure. The method was presented at the Slovenian Innovation Forum. In addition, we analysed data from real-life patient trials. We used the trial data to develop a method that can detect too low or too high levels of blood sugar using the ECG monitor. The method for a human energy expenditure estimation from the COMMODITY12 project was adapted for the e-Gibalec mobile application, which monitors the physical activity of children and reports it to their parents and physical-education teachers. It also uses gamification and elements of social networks to encourage the users to be more active. Finally, we started analysing tennis using sensors in a postdoctoral research project.

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 multi-objective optimization and their speedup, and apply these algorithms in the FP7 project COMMODITY12 we developed a method to analyse human movement with a smartphone, which was accepted by the Slovenian Innovation Forum and included in a mobile application that encourages children to be physically active.

In the FP7 project COMMODITY12 we developed a method to analyse human movement with a smartphone, which was accepted by the Slovenian Innovation Forum and included in a mobile application that encourages children to be physically active.

The COPCAMS project results in an embedded computer system for manufacturing quality control based on computer vision, machine learning and optimization.

In the European project ACCUS we developed a platform for monitoring and controlling several key city subsystems. This figure shows energy-consumption smoothing by applying negotiations and finding the Nash equilibrium.

Figure 1: In the European project ACCUS we developed a platform for monitoring and controlling several key city subsystems. This figure shows energy-consumption smoothing by applying negotiations and finding the Nash equilibrium.
in engineering design and optimization problems. In a doctoral research project we studied the use of surrogate models in multi-objective optimization. The objective functions were approximated with Gaussian process models that, in addition to predicting the function values, estimate the confidence intervals of the predictions, while the Pareto dominance relations were generalized to take into account the confidence intervals. These extensions were incorporated into an optimization algorithm called GP-DEMO. Numerical experiments on benchmark functions and real optimization problems from metallurgical production and medical signal analysis confirmed that the new approach results in fewer incorrect comparisons of solutions and requires less-exact solution evaluations in the optimization process. The key area of testing and transferring our methods to practice is production-process optimization. We continued our work within the COPCAMS project, approved for funding under the Artemis call. Together with the Slovenian industrial partner Kolektor Group and international partners we are developing production quality-control procedures that are based on computer vision, machine learning and optimization. In the past year, our activities were concentrated on the optimization of computer-vision procedures to achieve the highest possible accuracy in predicting the product quality, and their implementation on the target embedded architecture to be deployed on the production line. For the Restoration Center in Ljubljana, which is part of the Institute for the Protection of Cultural Heritage of Slovenia, we previously developed the Pedius program for the computer-aided reassembly of wall-painting fragments, and a mobile and web application e-Pedius to support crowdsourcing in fragment reassembly. Equipped with these tools, the users managed to reconstruct the Roman frescoes based on thousands of fragments from an archaeological site in the region of Celje, Slovenia, last year.

In the field of agent and multi-agent systems the key research areas are focused on the development of smart autonomous systems for the control of smart cities and smart homes, and intelligent systems for improving existing educational processes and the preservation of cultural heritage. The European project ACCUS is aimed at developing an integration and coordination platform for urban systems to build applications across various domains, providing adaptive and cooperative control for urban subsystems, and optimizing the combined performance of the city. The platform currently balances the overall electricity consumption in the city by curbing the electricity spikes that occur during the day. In addition, the system optimizes the electricity consumption in smart houses and the production in thermal power plants, and manages the traffic flow and thus affects the external parameters, such as air quality. The smart city control continuously monitors the conditions in the city and, for example, when a warning about high air pollution is triggered, it decides to reduce the traffic flow, the energy consumption in residential areas and production in the local thermal power plant. The monitoring system, in several time steps, verifies the effects of the control actions and, if required, sends additional corrections until an adequate level of air quality is achieved. A similar system is studied within the OPUS project, where the focus is on the development of smart-home automation services. The aim is to apply advanced machine-learning and optimization methods in order to generate real-time control strategies that increase the users’ comfort and, at the same time, decrease the operational costs of the smart home. We experimentally demonstrated that it is possible to achieve energy savings without lowering the comfort. Additional improvements were achieved when applying learning algorithms to heat pumps. The controller learns the user’s behaviour and formulates a strategy for water heating during periods of cheaper electricity and, at the same time, lowers the temperature of the stored water during days of lower consumption. In the Metis project we developed an intelligent system that improves the existing educational processes and enables the early detection of pupils with learning difficulties in primary and secondary schools. This year we also started the Horizon 2020 Twinning project eHeritage.

The Twinning partners will provide support to increase the capacity and quality of the research and innovation excellence of the Romanian partner in the area of cultural heritage preservation using intelligent methods and 3D modelling, and employing augmented and virtual reality. Another important challenge addressed in the project is to expand the recognition of the project partners through an increase in the dissemination activities by targeting publications in high-profile journals and conferences.

In the field of speech and language technologies we work on speech synthesis, semantic analyses of text and question answering. Special attention is paid to the requirements of the elderly, handicapped and visually impaired for 212 Slovenian municipalities, providing answers to questions in natural language about municipalities and Slovenian regions.
impaired people, and to apply our solutions to smart devices and homes. Together with the Amebis company, we developed a new speech synthesizer for Slovene. Both the comprehensibility and naturality of the synthesized speech have been greatly improved. We also developed a free service for speech synthesis on mobile devices. For the purposes of the institute we adapted the virtual assistant, Robi, which enables employees and visitors to quickly and easily find information about the institute, and also provides a rich set of additional applications offering various functionalities (employee phone book, infrastructure malfunction reporting, etc.). We also developed virtual assistants for all 212 Slovene municipalities with a basic knowledge base that was constructed using artificial intelligence methods.

The focus points of the research and developmental potential of the department are also being expressed in successfully developed, integrated and deployed solutions, available on major digital platforms and available to a wide population of users. The methods used in typical applied projects combine the procedures of intelligent agents, statistical methods and machine learning, and serve as a basis for user interfaces on smartphones, tablets or desktop computers. The projects’ services are developed for all key mobile platforms (Android, iOS and Windows) and through classic web clients.

A system for recognizing animal species from their sounds has been implemented as an open mobile and web application (http://animal-sounds.ijs.si/). It recognises Slovenian frogs, birds, bumblebees and Chinese cuckoos.

From 28 September to 14 October 2015, the 18th International Multiconference Information Society – IS 2015 (is.ijs.si) took place at the Jožef Stefan Institute and the Faculty of Computer and Information Science. It consisted of twelve independent conferences with around 600 participants that presented approximately 300 papers. Four conference awards were presented: for lifetime achievements (“Donald Michie and Alan Turing” award) to Prof. Jurij Tasić, for current achievements in the field of information society to Asst. Prof. Domen Mongus, and the information strawberry and lemon for the best and worst public information-society services.

Some outstanding publications in the past year


Organization of Conferences, Congresses and Meetings

2. 26th Slovene Workshop on Nature-Inspired Algorithms, AVN, Katarina nad Ljubljano, 19. 5. 2015
3. Student Workshop at the Genetic and Evolutionary Computation Conference, GECCO 2015, Madrid, Spain, 11. 7. 2015
4. 1st International KEYSTONE Conference, IKC 2015, Coimbra, Portugal, 8.–9. 9. 2015
6. 18th International Multiconference Information Society, IS 2015, Ljubljana, 28. 9. – 14. 10. 2015; independent conferences:
Jožef Stefan Institute
Annual Report 2015

• Intelligent Systems
• Facing Demographic Challenges
• Collaboration, Software and Services in Information Society
• Cognitive Sciences
• Data Mining and Data Warehouses
• Education in Information Society
• 2nd Student Conference for Ph.D. Students
• 2nd Student Conference for Undergraduate Students
• Cognitonics
• 8th International Conference on Informatics in Schools: Situation, Evolution, and Perspective
• SPS EM-Health Workshop
• Workshop Smart Cities and Communities as a Development Opportunity for Slovenia
• 27th Slovene Workshop on Nature-Inspired Algorithms, AVN, Maribor, 4. 12. 2015

Awards and Appointments

2. Hristijan Gjoreski, Rok Piltaver, Matjaž Gams: Best Paper Award for “Person identification by analyzing door accelerations in time and frequency domain”, 12th European Conference on Ambient Intelligence, AMI 2015, Athens, Greece, 11.–13. 11. 2015
3. Anton Gradišek, Fulbright scholarship for work in USA, 27. 10. 2014–24. 6. 2015

Patent granted


INTERNATIONAL PROJECTS

1. 7FP - Xperience; Robots Bootstrapped through Learning from Experience
   Prof. Matjaž Gams
   European Commission
2. 7FP - Commodity12; Continuous Multi-parametric and Multi-layered Analysis of Diabetes Type 1&2
   Dr. Mitja Luštrek
   European Commission
3. Adaptive Cooperative Control in Urban (sub) Systems
   Prof. Matjaž Gams
   Ministry of Economic of the Republic of Slovenia
4. Cognitive & Perceptive CAMeras: COPCAMs
   Prof. Bogdan Filipič
   Ministry of Economic of the Republic of Slovenia
5. CIP Programme; EcoDots
   Dr. Mitja Luštrek
   European Commission
6. H2020 - IN LIFE; Independent Living support Functions for the Elderly
   Prof. Matjaž Gams
   European Commission
7. H2020 - eHERITAGE; Expanding the Research and Innovation Capacity in Cultural Heritage Virtual Reality Applications
   Prof. Matjaž Gams
   European Commission

R & D GRANTS AND CONTRACTS

1. Research on adaptive predictive domain models
   Dr. Boštjan Kaluža
2. DysLex; Universal voice e-reader for the Slovenian language as a personal learning tool for people with dyslexia and different types of visual disturbances
   Dr. Tomaz Šef
3. Metis; E-service for the early detection of learning issues
   Dr. Erik Doogan
4. e-Xercise; Mobile application to monitor and promote exercise in schoolchildren for more effective physical education
   Dr. Mitja Luštrek
5. ASP0
   Prof. Matjaž Gams
   Slovene Human Resources and Scholarship Fund, Ljubljana
6. Adaptive Cooperative Control in Urban (sub) Systems
   Prof. Matjaž Gams
   Ministry of Economic of the Republic of Slovenia
7. Cognitive & Perceptive CAMeras: COPCAMs
   Prof. Bogdan Filipič
   Ministry of Economic of the Republic of Slovenia
8. Optimizing the Management of Energy Efficient Smart Buildings
   Dr. Tomaz Šef
   Ministry of Education, Science and Sport of the Republic of Slovenia
9. Self-management of physical and mental fitness of older workers
   Dr. Mitja Luštrek
   Ministry of Education, Science and Sport of the Republic of Slovenia

RESEARCH PROGRAM

1. Artificial Intelligence and Intelligent Systems
   Prof. Matjaž Gams

NEW CONTRACTS

1. The development of text-to-speech system for Slovenian language
   Dr. Tomaz Šef
   Alpinon d. o. o.
VISITORS FROM ABROAD

1. Julien Thepot, University of Paris Sud XI, Paris, France, 15. 4 – 18. 7 2015
2. Chauraud Quentin, University of Paris Sud XI, Paris, France, 18. 4 – 18. 7 2015
3. Defendini David, University of Paris Sud XI, Paris, France, 18. 4 – 18. 7 2015
4. Liemandt Leclerc, University of Paris Sud XII, Paris, France, 18. 4 – 18. 7 2015
6. He Hui, College of Communication and Information Engineering, Shanghai University, Shanghai, China, 5. 6 – 14. 8 2015

STAFF

Researchers
1. Prof. Ivan Bratko*
2. Prof. Alois Duhnikar*
3. Prof. Bogdan Filipič
4. Prof. Matjaž Gams, Head
5. Dr. Mitja Luštrek*
6. Dr. Domen Maržič*
7. Dr. Tomaz Sef

Postdoctoral associates
8. Dr. Erik Divogar
9. Dr. Hristijan Gjoreski
10. Dr. Anton Gradišek
11. Dr. Matej Gudž*
12. Dr. Mila Mažar
13. Dr. Aleksander Pivk*
14. Dr. Tea Tašar
15. Dr. Vedrana Vidulin, on postdoctoral leave since 11. 03. 14

Technical officers
17. Liljana Lasič
18. Liljana Lasič, B. Sc.
19. Ilja Žemljak

Note:
* part-time JŠI member

BIBLIOGRAPHY

ORIGINAL ARTICLE


SHORT ARTICLE


PUBLISHED CONFERENCE CONTRIBUTION


INDEPENDENT COMPONENT PART OR A CHAPTER IN A MONOGRAPH

SCIENTIFIC MONOGRAPH

PATENT APPLICATION

PATENT

MENTORING