

DEPARTMENT OF INTELLIGENT SYSTEMS

E-9

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, language and speech technologies, electronic and mobile health, and smart cities. The department closely collaborates 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. Dr. Ivan Bratko. The department also continuously collaborates with industry and contributes significantly to the inclusion of intelligent systems in 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 platforms to imitate human behaviour by exploiting raw, exponentially growing computer power. This field is somewhat broader than artificial intelligence, both are rapidly growing worldwide and enabling the development of the information society.

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 2017 was health. We coordinate the H2020 project **HeartMan**, which is developing an application to help congestive-heart-failure patients manage their condition: it monitors them with a sensing wristband, and provides advice on exercise, nutrition, etc. Most of the technical work is complete: we developed methods for activity monitoring and estimating blood pressure from a PPG sensor in the wristband, as well as a decision-support system that utilises expert knowledge and predictive models. In the H2020 project **IN LIFE**, we are translating solutions intended to prolong the independence of the elderly into real life. We developed a smart-watch application that detects falls and similar events, which is connected to a web application for carers. This solution was piloted with 150 users in cooperation with the Slovenian company Doktor 24, and we are now attempting to commercialise it. The AAL project **Fit4Work** is aiming to help older workers do their job more easily by providing advice on relaxation, exercise and work environment (temperature, CO₂ in the air, etc.). In 2017 we focused on methods for improving the work environment: we developed predictive models and a simulator to evaluate the actions that can improve the environment and recommend the best one. The project was successfully concluded with a pilot. We started the H2020 project **CrowdHealth**, whose objective is to mine health data to help craft better public-health policies. We started developing methods that can forecast time-series data and assess health risk based on such forecasts. One of the use cases is the SloFit data describing the fitness of Slovenian primary- and high-school students, on which we cooperate with the Faculty of Sports of the University of Ljubljana. We also recently started the H2020 project **WellCo**, where we will develop a virtual coach advising older users on wellbeing and health. Our ambient-intelligence projects use wearable sensing devices, whose use is limited by their typically small batteries. As a **doctoral research project** we thus developed a general method that can intelligently turn sensors on and off in such a way that the energy consumption is as small as possible without sacrificing a lot of quality of the results obtained with these sensors. We also work on merging different sensor datasets for the purpose of machine learning.

Computational intelligence is the study of stochastic search, optimization and learning methods, inspired by biological and physical systems. Research in this area at the Department of Intelligent Systems focuses on the evolutionary computation methods. We study evolutionary algorithms for multi-objective optimization, their acceleration through parallel com-



Head:
Prof. Matjaž Gams

In the H2020 project HeartMan, which we coordinate, we are finalizing an application that provides comprehensive personalized support for the self-management of congestive heart failure.



Figure 1: The Department Head, Prof. Matjaž Gams, was elected national councillor for research activities in December 2017.

We started two new H2020 projects on ambient intelligence and health, which have joined three on-going European projects on these topics. Our department is thus becoming a leading research group in this area.



Figure 2: We are developing a computer system for the multi-objective optimization of process parameters in the continuous casting of steel. The system evaluates parameter settings with a numerical simulation of the casting process and supports the visualization of results.

puting and surrogate models, visualization of their results, and applications in engineering design and optimization problems. In the H2020 Twinning project SYNERGY we are strengthening our research and innovation potential in parallelization, surrogate modelling and combining the two techniques in multi-objective optimization. The project is carried out by three partners with complementary expertise: the Jožef Stefan Institute, the University of Lille, and Cologne University of Applied Sciences. The expertise and solutions gained in this cooperation are targeted at both academic and industrial organizations, particularly those participating in the Slovenian Smart Specialisation Strategy. Together with the Chamber of Commerce and Industry of Slovenia we are preparing educational activities for these companies. The goal of the **bilateral Slovenian-Japanese research project** is to enhance the methodology of evolutionary multi-objective optimization for real-world applications. We cooperate with Shinshu University, Nagano, on developing optimization algorithms and visualizing their results. The methodology is evaluated on the design of the JAXA (Japan Aerospace Exploration Agency) Destiny mission. The postdoctoral basic research

project **Incorporating real-world problems into the benchmarking of multi-objective optimizers** builds on the state-of-the-art open-source COCO (Comparing Continuous Optimizers) platform for optimization-algorithm benchmarking and extends it by incorporating real-world problems and their properties in order to bridge the gap between research and application in multi-objective optimization. The transfer of our knowledge and methods to industrial practice takes place in the project **Upgrade of the optimization system for steel continuous casting (KN3)** for the Štore Steel company. We are developing a computer system to search for the optimal setting of process parameters with respect to criteria for process output variables. The system is based on the numerical simulation of steel casting and supports the visualization of results.

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, smart homes and the preservation of cultural heritage. In the Slovenian Smart Specialisation program EkoSMART we continue with research activities in the field of smart cities and communities. The purpose of the program is to develop a smart-city ecosystem with all the support mechanisms that are necessary for the efficient, optimized and gradual integration of different smart-city areas into a unified and well-connected system. Within the program we are involved in activities linked to the research and development projects “Zasnova ekosistema pametnega mesta” and “Elektronsko in mobilno zdravstvo” (EMZ), where we are the leading partner. The main goal is to develop new and innovative devices and solutions to support the elderly and chronic patients at home. We are also involved in the Smart Specialisation program IQDOM in the field of smart buildings and homes, coordinated by Gorenje. Our focus is on the development of smart-home automation services. The aim is to apply advanced machine-learning and optimization methods to build user models and consumption profiles for housing units in order to generate control strategies that increase user comfort and, at the same time, decrease the operational costs of a smart home. Similar approaches are also applied to heat pumps. The controller learns the behaviour of the user 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 Interreg AS-IT-IC project we will develop an integrated tourist platform for cross-border tourist exchange, tour planning and effective communications between tourists and tourist offices. The platform will support natural language communication between the users and the system and the automatic creation of personalized itineraries based on the search concepts and preferences of users. In the Horizon 2020 Twinning project eHeritage we continue to 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. To this end we are developing innovative applications that enable efficient search and richer visualisations of digital content related to cultural heritage from various internet sources and dedicated databases. As part of the project activities, the “Advanced Study Institute” event was organized in Padova, Italy, where we delivered lectures and a hands-on workshop regarding the use of systems for natural language processing and communication, information extraction from textual data, and data fusion from various sources. The goal of the **bilateral Slovenian-Macedonian research project** is to study

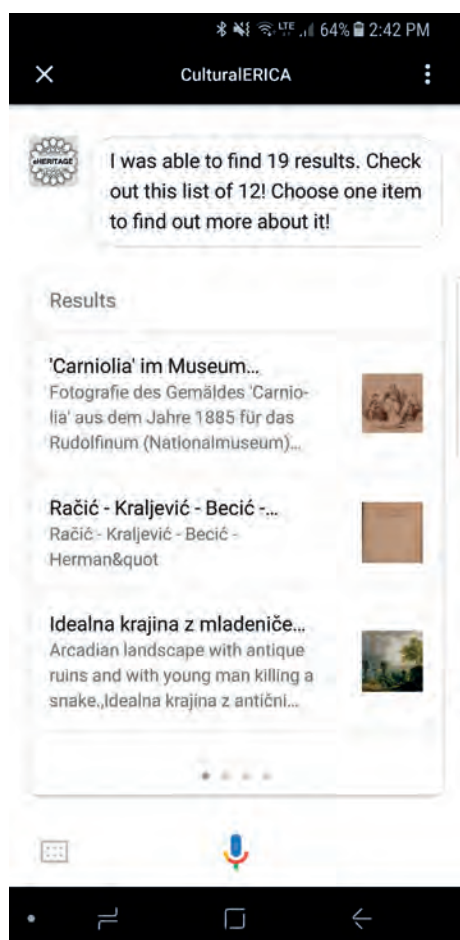


Figure 3: A mobile application, where the user can interact in natural language and visualize content related to cultural heritage from Europeana.

and advance wearable and non-wearable sensors for detecting the user's physical and mental state.

In the field of **speech and language technologies** we work on speech synthesis, the semantic analysis of text and question answering. Together with the companies Alpineon and Amebis we developed a new, high-quality speech synthesizer eBralec (<http://ebralec.si/>). The synthesizer is improved in terms of both comprehensibility and natural perception of the speech. The software package has more than a thousand subscribers and is an indispensable tool for blind and visually-impaired users (it is the "official" speech synthesizer of the Slovenian Association for the Blind and Visually Impaired) and people with reading impairments (the Bravo association). For these users, eBralec is free of charge and can be ordered at the Library for the Blind and Visually Impaired (<http://www.kss-ess.si/ebralec-sintetizator-govora-slovenskega-jezika/>). eBralec is also an integral part of the DarsTraffic+ application, which provides traffic information, while its server version has been used by the National and University Library since 2017. We have also developed a service of speech synthesis for mobile devices (<http://dis.ijs.si/dyslex/>), which is free for anyone to use.

We have developed two plugins for Orange, an open-source machine-learning, data-mining and data-visualization toolkit. **Audio-IJS** makes it easy to build and test models for the classification of different kinds of audio recordings. The plugin is intended primarily for users without extensive prior knowledge of machine learning. By means of a graphical interface, the user determines the filtering and segmentation parameters of the sound recordings and then tests various classification models. **Hybrid Trees** provides users with three widgets that have a user-friendly interface for learning, validating, evaluating and using classifiers built with the MOLHC algorithm for the multi-objective learning of comprehensible and accurate hybrid trees.

The **20th International Multiconference Information Society – IS 2017** (<https://is.ijs.si>) took place at the Jožef Stefan Institute from 9 to 13 October 2017. It consisted of 11 independent conferences with 200 presentations. Four conference awards were presented: for lifetime achievements ("Donald Michie and Alan Turing" award) to Prof. Marjan Krisper, for current achievements in the field of information society to Prof. Andrej Brodnik, and the information strawberry and lemon for the best and worst public information-society services.

Some outstanding publications in the past year

1. Gjoreski, M., Luštrek, M., Gams, M., Gjoreski, H. Monitoring stress with a wrist device using context. *Journal of Biomedical Informatics*, 73 (2017), 159–170
2. Kužnar, D., Piltaver, R., Gradišek, A., Gams, M., Luštrek, M. An intelligent system to monitor refrigeration devices. *Expert systems*, 34 (2017), e12199-1-e12199-13
3. Tavčar, A., Kužnar, D., Gams, M. Hybrid Multi-Agent Strategy Discovering Algorithm for human behavior. *Expert Systems with Applications*, 71 (2017), 370–382
4. Tušar T., Gantar, K., Koblar, V., Ženko, B., Filipič, B. A study of overfitting in optimization of a manufacturing quality control procedure. *Applied Soft Computing*, 59 (2017), 77–87

Awards and appointments

1. Tomaž Šef: Gold recognition for product innovation, Slovenia, Chamber of Crafts Gorenjska, "Text-to-Speech Synthesizer eBralec", 14 June, 2017

Organization of conferences, congresses and meetings

1. AS-IT-IC project meeting, Ljubljana, 28 February–1 March 2017
2. IN LIFE project review meeting, Ljubljana, 2–3 March 2017



Figure 4: HeartMan mobile application, which helps patients with heart failure manage their disease, and the sensing wristband that collects the patients' physiological signals for the application.

In cooperation with Shinshu University in Nagano, Japan, we utilize methods of visualization in multi-objective optimization to analyse alternative trajectories for the JAXA (Japan Aerospace Exploration Agency) Destiny mission.

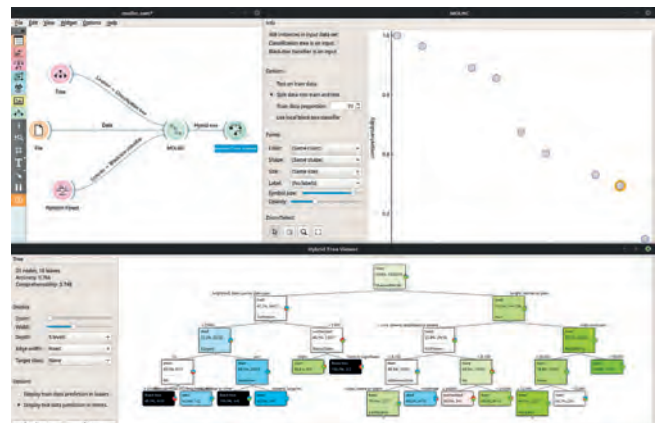


Figure 5: The Hybrid Trees plugin for the Orange toolkit supports learning, validating, evaluating and using hybrid trees, which offer different trade-offs between comprehensibility and the accuracy of the predictions.

3. 30th Slovene Workshop on Nature-Inspired Algorithms, AVN, Šmarna gora, 9 May 2017
4. Presentation of the Internet application for tourism, Nazarje, 30 June 2017
5. Genetic and Evolutionary Computation Conference, GECCO 2017, Berlin, Germany, 15–19 July 2017 and the co-located events:
 - VizGEC (Visualisation Methods in Genetic and Evolutionary Computation) workshop
 - BBOB (Bi-Objective Blackbox Optimization Benchmarking) workshop
 - Women@GECCO workshop
 - GECCO Job Market
6. 20th International Multiconference Information Society, IS 2017, Ljubljana, Slovenia, 9–13 October 2017; independent conferences:
 - Slovenian Conference on Artificial Intelligence
 - Facing demographic challenges
 - Cognitive science
 - Collaboration, software and services in information society
 - Data mining and data warehouses – SiKDD
 - Education in Information Society
 - Cognitonics
 - 10th International technology transfer conference – 10ITTC
 - AS-IT-IC Workshop
 - Robotics
 - Workshop Electronic and Mobile Health and Smart Cities
7. Site visit and AS-IT-IC project presentation, Ljubljana, 30 November 2017
8. 31st Slovene Workshop on Nature-Inspired Algorithms, AVN, Ljubljana, 8 December 2017

INTERNATIONAL PROJECTS

1. COST TD1405; ENJECT, European Network for the Joint Evaluation of Connected Health Technologies
Božidara Cvetković, B. Sc.
Cost Office
2. H2020 - IN LIFE; INdependent Living support Functions for the Elderly
Prof. Matjaž Gams
European Commission
3. H2020 - eHERITAGE; Expanding the Research and Innovation Capacity in Cultural Heritage Virtual Reality Applications
Prof. Matjaž Gams
European Commission
4. H2020 - CrowdHEALTH; Collective Wisdom Driving Public Health Policies
Dr. Mitja Luštrek
European Commission
5. H2020 - WellCo; Wellbeing and Health Virtual Coach
Dr. Mitja Luštrek
European Commission
6. H2020 - HeartMan; Personal Decision Support System for Heart Failure Management
Dr. Mitja Luštrek
European Commission
7. H2020 - SYNERGY; Synergy for Smart Multi-Objective Optimisation
Prof. Bogdan Filipič
European Commission
8. Advanced Methodology of Evolutionary Multi- and Many-Objective Optimization for Real-World Applications
Prof. Bogdan Filipič
Slovenian Research Agency
9. Patient Health Prediction and Diagnostics based on Sensor Data and Machine Learning
Prof. Matjaž Gams
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- Prof. Matjaž Gams
Ministry of Education, Science and Sport
3. Food for future - F4F
Dr. Mitja Luštrek
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4. HEP-Y: Application for raising awareness about viral hepatitis infections
Prof. Matjaž Gams
Javni štipendijski, razvojni, invalidski in preživninski sklad Republike Slovenije
5. Innovative student project to benefit society
Prof. Matjaž Gams
Javni štipendijski, razvojni, invalidski in preživninski sklad Republike Slovenije
6. Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC)
Prof. Matjaž Gams
Government Office for Development and European Cohesion Policy
7. Strategic Research & Innovation Partnership (SRIP) Smart Cities and Communities
Prof. Matjaž Gams
Ministry of Education, Science and Sport
8. Self-management of physical and mental fitness of older workers
Dr. Mitja Luštrek
Ministry of Education, Science and Sport
9. 20th International Multiconference Information Society 2017 (IS 2017), Ljubljana, Slovenia, 9.10.2017-13.10.2017
Prof. Matjaž Gams
10. Young Ph.D. - Mlakar Miha
Dr. Miha Mlakar
Andra - The French National Radioactive Waste
11. IN LIFE Smartwatch – advanced solutions for safety of elderly
Prof. Matjaž Gams
12. eBralec Project
Dr. Tomaž Šef
Amebis, d. o. o., Kamnik
13. Information Society IS 2017 – Multiconference
Prof. Matjaž Gams

RESEARCH PROGRAM

1. Artificial Intelligence and Intelligent Systems
Prof. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Intelligent home of the new generation designed on smart appliances and wood
Prof. Matjaž Gams
Ministry of Education, Science and Sport
2. Smart City Ecosystem – EkoSmart

NEW CONTRACTS

1. Upgrade of the optimization system for steel continuous casting (KN3)
Prof. Bogdan Filipič
Štore Steel d. o. o.
2. The development of text-to-speech system for Slovenian language
Dr. Tomaž Šef
Alpineon d. o. o.
3. System for analysing and managing bank customers
Dr. Miha Mlakar
Unicredit Banka Slovenija d. d.

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Alpineon d. o. o.
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Dr. Miha Mlakar
Unicredit Banka Slovenija d. d.

VISITORS FROM ABROAD

1. Prof. El-Ghazali Talbi, Prof. Nouredine Melab, University Lille 1, Lille, France, 9-10 January 2017
2. Prof. Hernán Aguirre, Shinshu University, Nagano, Japan, 8-10 March 2017
3. Vadim Ilkin, IUT de Cachan, Paris, France, 10 April-11 July 2017
4. Redione Reddad, IUT de Cachan, Paris, France, 10 April-11 July 2017
5. Antoine Voreux, IUT de Cachan, Paris, France, 10 April-11 July 2017
6. Monika Simjanoska, Ss. Cyril and Methodius University in Skopje, Skopje, Republic of Macedonia, 24 April-24 June 2017
7. Prof. Boris Naujoks, Cologne University of Applied Sciences (TH Köln), Gummiesbach, Germany, 8-11 May 2017
8. Vanessa Volz, Technical University Dortmund, Dortmund, Germany, 8-11 May 2017
9. Dr. Hristijan Gjoreski, University of Sussex, Brighton, Great Britain, 15 June 2017
10. Andreas Røyset Stensbye, Norwegian University of Science and Technology, Trondheim, Norway, 16 June-25 August 2017
11. Stephane Gu, Polytech Paris UPMC, Robotics Engineering school, Paris, France, 19 June-18 August 2017
12. Mathieu Russo Polytech Paris UPMC, Robotics Engineering school, Paris, France, 19 June-18 August 2017
13. Prof. Juan Antonio Alvarez-Garcia, University of Seville, Seville, Spain, 1 July-31 September 2017
14. Blagoj Mitrevski, Ss. Cyril and Methodius University in Skopje, Skopje, Republic of Macedonia, 3 July-3 September 2017
15. Prof. El-Ghazali Talbi, University Lille 1, Lille, France, 2-3 October 2017
16. Prof. Gerhard Widmer, Johannes Kepler University Linz and Austrian Research Institute for Artificial Intelligence Vienna, Vienna, Austria, 12-13 October 2017
17. Prof. Vladimir Trajkovikj, Ss. Cyril and Methodius University, Skopje, Republic of Macedonia, 23 November 2017
18. Prof. Sašo Koceski, Univerza Goce Delcev, Štip, Republic of Macedonia, 23 November 2017
19. Prof. Franz Wotawa, Oliver Tazl, Institute for Software Technology, Graz, Austria, 30 November 2018
20. Prof. El-Ghazali Talbi, Jan Gmys, Univeristy Lille 1, Lille, France, 11-13 December 2017
21. Prof. Boris Naujoks, Beate Breiderhoff, Cologne University of Applied Sciences (TH Köln), Gummiesbach, Germany, 11-13 December 2017

STAFF

Researchers

1. Prof. Ivan Bratko*
2. Dr. Erik Dovgan*
3. Prof. Bogdan Filipič
4. Prof. Matjaž Gams, Head
5. Dr. Anton Gradišek
6. Dr. Mitja Luštrek
7. Dr. Tomaž Šef

Postdoctoral associates

8. Dr. Hristijan Gjoreski, on leave 01.12.16
9. Dr. Matej Guid
10. Dr. Boštjan Kaluža, left 01.04.17

11. Dr. Miha Mlakar
12. Dr. Rok Piltaver*
13. Dr. Aleksander Pivk*
14. Dr. Tea Tušar

Postgraduates

15. Jani Bizjak, B. Sc., left 30.10.17
16. Robert Blatnik, M. Sc., 01.12.17, transferred to Department CTT
17. Božidara Cvetković, B. Sc.
18. Martin Gjoreski, B. Sc.
19. Vito Janko, B. Sc.
20. Tomaž Kompara*, B. Sc.
21. Dr. Jana Krivec*

22. Damjan Kužnar, B. Sc.
 23. Aleš Tavčar, B. Sc.
 24. Aljoša Vodopija, B. Sc.
 25. Jernej Zupančič, B. Sc.
- ### Technical officers
26. Luka Colarič, B. Sc.
 27. Gregor Grasselli, B. Sc.
 28. Gašper Slapničar, B. Sc.
 29. Sebastijan Stanivuk, B. Sc.
 30. Jure Šorn*, B. Sc.
 31. Jure Šorn, B. Sc., left 01.09.17
- ### Technical and administrative staff
32. Grigory Evseev, B. Sc.
 33. Vesna Koricki, B. Sc.
 34. Mitja Lasič
 35. Liljana Lasič
 36. Blaž Mahnič, B. Sc.
 37. Pavel Maslov, B. Sc.
 38. Nina Rešič, B. Sc.
 39. Luka Stepančič, B. Sc.
 40. Lana Zemljak

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLE

1. Alen Ajanović, Jaka Konda, Gašper Fele-Žorž, Anton Gradišek, Matjaž Gams, Ana Peterlin, Karolina Počivavšek, Mojca Matičič, "Application for sexually transmitted infection risk assessment", *Informatica (Ljublj., Tisk. izd.)*, **41**, 2, 253-254, 2017.
2. Jani Bizjak, Anton Gradišek, Luka Stepančič, Hristijan Gjoreski, Matjaž Gams, "Intelligent assistant carer for active aging", *EURASIP J. Adv. Signal Process.*, **2017**, 76, 2017.
3. Martin Gjoreski, Mitja Luštrek, Matjaž Gams, Hristijan Gjoreski, "Monitoring stress with a wrist device using context", *J Biomed Inform.*, **73**, 159-170, 2017.
4. Anton Gradišek, Gašper Slapničar, Jure Šorn, Mitja Luštrek, Matjaž Gams, Janez Grad, "Predicting species identity of bumblebees through analysis of flight buzzing sounds", *Bioacoustics (Berghamsted)*, **26**, 1, 63-76, 2017.
5. Vito Janko, Božidara Cvetković, Anton Gradišek, Mitja Luštrek, Boro Štrumbelj, Tanja Kajtna, "e-Gibalec: mobile application to monitor and encourage physical activity in schoolchildren", *Journal of ambient intelligence and smart environments*, **9**, 5, 595-609, 2017.
6. Andraž Kocjan, Luka Kelhar, Anton Gradišek, Blaž Likozar, Kristina Žagar, Jaafar Ghanbaja, Spomenka Kobe, Jean-Marie Dubois, "Solid solubility in $\text{Cu}_2\text{Gd}_{1-x}\text{Ca}_x$ system: structure, stability, and hydrogenation", *Adv. Mater. Sci. Eng.*, **2017**, 9203623, 2017.
7. Jana Krivec, Tea Golob, "Psychosocial approach to migrants: current state, issues and improvement possibilities", *Innovative issues and approaches in social sciences*, **10**, 2, 42-61, May 2017.
8. Damjan Kužnar, Rok Piltaver, Anton Gradišek, Matjaž Gams, Mitja Luštrek, "An intelligent system to monitor refrigeration devices", *Expert syst.*, **34**, 5, e12199, 2017.
9. Aleš Tavčar, Damjan Kužnar, Matjaž Gams, "Hybrid multi-agent strategy discovering algorithm for human behavior", *Expert syst. appl.*, **71**, 370-382, 2017.
10. Tea Tušar, Klemen Gantar, Valentin Koblar, Bernard Ženko, Bogdan Filipič, "A study of overfitting in optimization of a manufacturing quality control procedure", *Applied soft computing*, **59**, 77-87, 2017.
11. Hongyang Zou, Anton Gradišek, Samuel B. Emery, John J. Vajo, Mark S. Conradi, "LiBH₄ in aerogel: ionic motions by NMR", *The journal of physical chemistry. C, Nanomaterials and interfaces*, **121**, 28, 15114-15119, 2017.
12. Jernej Zupančič, Matjaž Gams, "Dynamic protocol for demand management of heterogeneous resources with convex cost functions", *Informatica (Ljublj., Tisk. izd.)*, **41**, 1, 121-128, 2017.

PUBLISHED CONFERENCE CONTRIBUTION

1. Alen Ajanović, Karolina Počivavšek, Matic Podpavec, Andrej Ulčar, Ana Marija Peterlin, Ana Prodan, Saša Rink, Anton Gradišek, Matjaž Gams, Gašper Fele-Žorž, Mojca Matičič, "Application for viral hepatitis infection risk assessment", In: *Delavnica za elektronsko in mobilno zdravje ter pametna mesta: zbornik 20. mednarodne multikonference Informacijska družba - IS 2017, 9.-13. oktober 2017, [Ljubljana, Slovenija]: zvezek I: proceedings of the 20th International Multiconference Information Society - IS 2017, 9th-13th October, 2017, Ljubljana, Slovenia: volume I*, Matjaž Gams, ed., Aleš Tavčar, ed., Ljubljana, Institut Jožef Stefan, 2017, 46-48.
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