CZECH INSTITUTE OF INFORMATICS, ROBOTICS AND CYBERNETICS CTU IN PRAGUE

ANNUAL REPORT 2018

CZECH INSTITUTE
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CTU IN PRAGUE


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ANNUAL REPORT 2018

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Head Prof. Ing. Michael Valášek, DrSc.

COGSYS Cognitive Systems and Neurosciences
Head Doc. Ing. Lenka Lhotská, CSc.

BEAT Biomedical Engineering and Assistive Technology
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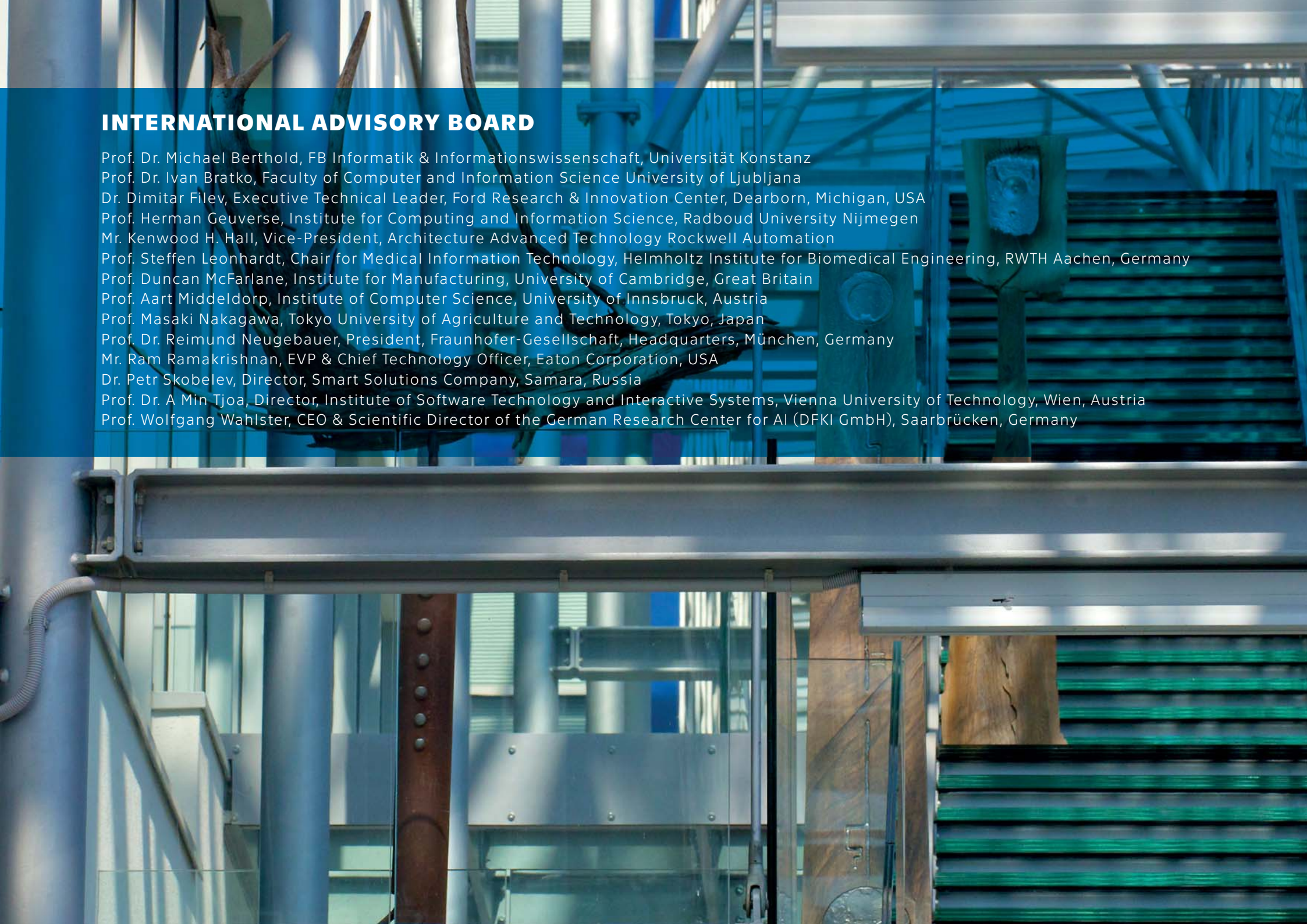
PLAT Scientific Management of Platforms
Head Prof. Ing. Vladimír Kučera, DrSc., dr.h.c.



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MISSION

„By creating fusions of research disciplines, CIIRC CTU turns ideas into breakthrough technologies for industry, health and society. It serves as a broadly open cooperation platform enabling collaboration, exchange and knowledge transfer on both national and international levels.“

One of the main objectives of CIIRC CTU is to integrate information and cybernetic research and education at CTU, building on partnerships with out-of-city centres as well as close collaboration with international research centres.
CIIRC CTU creates research opportunities as well as provides educational workplaces with scientific environment, pleasant work conditions in a number of specializations, and achieving note-worthy results at the highest international level. The institute opens its doors to experts from both the Czech Republic and abroad providing a forum for individuals to become part of the CIIRC CTU team or cooperate with it. A very significant part of the cooperation is also in the area of collaboration with other institutions within CTU as well as with the Academy of Sciences of the Czech Republic, with the industrial sector and similarly oriented foreign institutions.

VISION

“CIIRC CTU is a modern research and educational institution bringing together the best research teams, young talent and unique know-how to move the boundaries of technology, providing motivation to produce world-class results and raising a future generation of researchers of an international calibre.”

Since its inception CIIRC CTU has experienced constant growth with the goal of recruiting up to 350 employees by 2020, namely in research positions and Ph.D. students. All of them will work in the new CIIRC building built at the CTU premises in Prague, Dejvice (in operation since May 2017). One of the key tasks is to link research results not only with university teaching, and to attract students to research primarily from the master‘s and doctoral study programs, but also with a focus on the needs of the industrial sector and clinical practice.
CIIRC CTU has become a place of interdisciplinary cooperation, a natural fit for the fields of informatics, robotics and cybernetics. This cooperation opens the gates of opportunity and greatly supports knowledge transfer within industry whereby it serves to provide guidance to staff members.

HISTORY

CIIRC CTU was established by the Academic Senate of the Czech Technical University in Prague on April 22nd, 2013, whereby it came into effect on July 1st, 2013. The main task in the first phase of the establishment of CIIRC CTU was to prepare a high-quality project in the area of the Research and Development for Innovation to revitalize the existing premises in the building that housed the Technical canteen and to provide adequate physical facilities for the work of CIIRC.
The new building was opened on May 2nd, 2017 and there are nearly 250 researchers working in this facility exploring well-equipped labs and facilities. The industrial testbed, the first of its type in the Czech Republic, represents a unique infrastructure and serves as the key element of the Research and Innovation Centre on Advanced Industrial Production (RICAIP). CIIRC CTU became the seat of the National Centre for Industry 4.0 (2017), National Centre of Competence for Cybernetics and Artificial Intelligence (2018), Centre of City of the Future (2018), RICAIP (2018), and European Digital Innovation Hub for AI (2019). CIIRC CTU turnover has risen permanently, from nearly zero in 2013 to 10 mil EUR in 2018. CIIRC CTU represents a self-sustainable research institution: one third of its budget comes from industry, nearly two thirds from competitive European and national project funding.
The major task is to build CIIRC CTU up gradually into a national scientific and teaching workplace visible both on European and international levels.

JOINT LABS WITH INDUSTRY

Automotive Lab R&D 4.0: Joint laboratory among CTU CIIRC, CTU FTS and Škoda Auto a. s.

In 2018, the laboratory performed contracted research projects with industrial partners - Škoda Auto and Volkswagen. There was an intensive development of hardware and software tools for interactive simulation and data analysis support and the creation of a Hardware-In-the-Loop (HIL) specialized workplace. Currently, the laboratory is capable of performing complex experimental activities based on research assignments from the automotive industry.

Ten permanent researchers and developers work in the laboratory, five of whom are Ph.D. students; selected students from master's and bachelor's degree programs at CTU FTS are also participating in projects. There are specialized workplaces with advanced vehicle simulators, a workplace focused on using virtual reality and HMD (Head Mounted Display), as well as HIL (Hardware-In-the Loop) simulation. These 2018 projects dealt with user interface topics and user interface ergonomics, ADAS (Advanced Vehicle Driving Assistants) and biosensor applications in cars. The Automotive Lab R&D 4.0 leads several multidisciplinary teams, which were formed in close partnership with other laboratories and institutions such as CIIRC BEAT, CTU FBMI, VSB TUO and UWB.

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Rockwell Automation

The long-time joint research conducted within the RA-DIC laboratory is focused on the facilitation of flexible manufacturing. Semantic Big Data Historian (SBDH), an enabler of flexible production, was proposed and implemented. This prototype has many innovative features, e.g., the Plug&Play concept of cyber-physical systems and the exploitation of Apache Spark for the rapid and robust processing of data streams produced from shop floor sensors. The actual research being conducted at RA-DIC deals with the utilization of the OPC UA discovery concept for enabling the Plug&Play concept, which is a possible deployment of SBDH as a cloud-cyber physical system and means for dashboarding.

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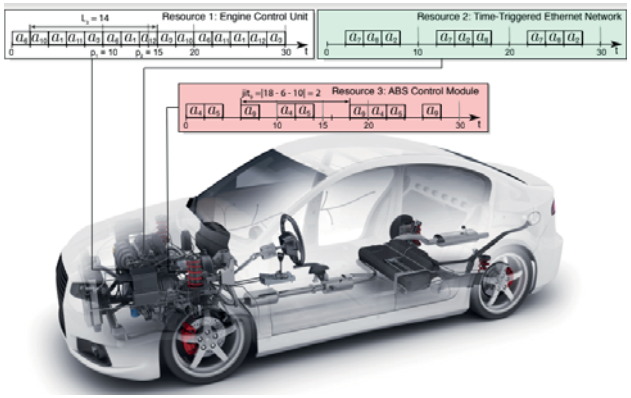
Eaton

One of the topics that Eaton lab is working with is safety-critical embedded control systems, where the utility of computations is sensitive to the timing behaviour of applications comprising the system. To reduce the cost, manufacturers minimize the number of platform components on which the applications are running.
As a result, applications share platform resources, which causes conflicts and worsens their timing behaviour. Applications can be scheduled on platform resources during the design time to guarantee that their time requirements are satisfied. In the Eaton lab, we are dealing with this time-triggered scheduling problem, both from the theoretical and practical points of view. We have developed algorithms that automatically construct schedules with guaranteed certain time-related behaviour have and implemented the protocol on suitable hardware to run such schedules.



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CENTRES

RICAIP Centre

RICAIP

Mission

- To make a significant contribution to fundamental and applied research in artificial intelligence, machine learning, computer science and robotics for advanced industry;
- to create a collaborative ecosystem where academia, strategic industries, SMEs and national and regional authorities produce high-impact results addressing the key challenges in the economy and society;
- to promote interdisciplinary research and collaboration with non-technical scientific disciplines to address current needs and the demands of society;
- to contribute to the education & training of highly qualified professionals for research, industry, and the public;
- to develop EU R&D Infrastructure for advanced industrial production (RICAIP Industrial Testbed Core) and also to support other related European research infrastructures.

Vision

- To be an outstanding international team of scholars with international visibility and an impact in scientific research;
- to have an excellent scientific, experimental infrastructure and professional administrative and business development services;
- to provide an attractive and stable working environment for both young and established talents in artificial intelligence, robotics, machine learning, computer science and advanced industry;
- to act as a key partner in major European research infrastructures for artificial intelligence, robotics, machine learning, computer science and advanced industry;
- to be the key centre for innovation and technology transfer for industry, business and the public.

RICAIP is a newly established international Centre of Excellence (CoE) in the area of artificial intelligence and industrial robotics. Within the frame of this Centre, a distributed testbed for intelligent manufacturing will be built. The parts and components of this geographically distributed testbed will be integrated by using virtual and augmented reality technologies and will serve as the core of the Pan/European testbed infrastructure. The goal is to help reduce the ramp-up time and costs in the processes connected with introducing Industry 4.0 principles.
RICAIP, from the long-term perspective, will become a world-class, EUR 30 mil/year, 350-researcher, distributed research centre that significantly transcends the initial consortium members. With infrastructure in Prague and the core partnering institutions VUT CEITEC Brno, DFKI Saarbrücken, ZEMA Saarbrücken, as well as further nodes in Europe, RICAIP will be working together with industrial partners on over 100 projects in all aspects of Industry 4.0 and distributed manufacturing systems and value chains in a profoundly changing industrial sector.
The RICAIP Centre is being funded by Project No. 857306 of the TEAMING H2020 Programme. Its Phase I was successfully completed in August 2018. Phase II, which covers 2019-2026, was approved by the EU in April 2019. The total confirmed funding for this period from EU and ESIF funding reaches almost 50 mil. EUR.

Contact

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NCI 4.0: National Centre for Industry 4.0

NATIONAL CENTRE
FOR INDUSTRY 4.0

Inspire & Create Czech Industry 4.0

NCI 4.0 is an open platform joining innovation leaders from universities, corporations and different industry organizations, including start-ups and SMEs.
NCI 4.0 aims to be the main author as well as a carrier of technological visions and industry digitization principles in the Czech Republic. It wishes to encourage cooperation among universities and shared use of their research capacities with an emphasis on industry implementation.

Main objectives

- Increase awareness of Industry 4.0 and Society 4.0 concepts in the CR
- Help implement Industry 4.0 principles into Czech industrial companies, especially to SMEs and Midcaps
- Encourage close cooperation between universities and industry, stimulate the exchange of experience and good practice
- Encourage and enable the participation of Czech researchers and industry experts in the establishment of advanced European industrial infrastructure
- Help design, develop, connect and operate a network of Industry 4.0 Testbeds in the Czech Republic
- Support I4.0 education

Partners

NCI4.0 would not be able to reach its ambitious goals without the support of its academic, industrial and public sector partners. In the first year of operation of NCI 4.0, it has gathered more than 45 partners from large industrial producers, I4.0 technology suppliers and integrators, universities and associations.

Contact

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CENTRES

Testbed for Industry 4.0

Testbed is a research and experimental laboratory aimed at transferring the research results of CIIRC to an industry-like environment with the aim of developing and promoting the principles of Industry 4.0. Testbed is based on a flexible production line and additional production machines, which resemble the scenarios existing in industrial production lines and processes. It is possible to test and verify the compatibility, functionality and effectiveness of new solutions for smart factories. Various technologies are utilized here, such as additive manufacturing, machine tooling, robotic manipulation, vision systems, collaborative and mobile robots, intelligent conveyor systems and others. Testbed has been inspired by the modern laboratories in our partners' facilities, especially at leading research institutes including DFKI and ZeMA in Saarbrücken, Germany. The partnership has helped us to build Testbed as a future-proof concept for advanced and distributed manufacturing and has also contributed significantly to the fact that Testbed has become part of the core of the European research project RICAIP.

Currently, Testbed is focused on building infrastructure for flexible manufacturing together with the concept of digital twins, which allows utilizing the same production resources to execute various operations, which are planned and scheduled as needed, and test the production scenarios before they are actually implemented in production.
Since its establishment in 2017, Testbed has proved to be very well accepted by industrial companies, which get inspired by the integration of individual tools and resources of the value chain to form digitalized and interconnected production. This has resulted in starting several research projects such as Cluster 4.0: Methodology of System Integration and RICAIP: Research and Innovation Centre on Advanced Industrial Production, as well as starting industrial cooperation with companies such as Siemens, Skoda Auto, LEGO, Ceska Zbrojovka and others. Several other research projects have utilized the Testbed infrastructure to build demonstrators of their research results such as DAMiAS: Data-driven Asset Management in the Automobile Industry and DIGICOR: Decentralized Agile Coordination Across Supply Chains.

Contact
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Industry 4.0 trainings take place
in the Testbed as many of the relevant
technologies are right there

Testbed for Industry 4.0 and the
Digital Twin technology in a tablet

Digital Innovation Hub

NCI 4.0 is a part of the European infrastructure of Digital Innovation Hubs (DIH) supported by the European Commission and further by the national states. DIHs act as one-stop-shops where companies – especially SMEs, start-ups and mid-caps – can get access to technology testing, financing advice, market intelligence and networking opportunities.
In 2018 NCI 4.0 participated in program Smart Factories in New EU Countries managed by the European Committee for the European Parliament with the aim to contribute to the efforts to build a Digital Innovation Hubs network in Europe.

AI Digital Innovation Hub

In 2019 representatives of the European Commission and the Steering Committee of the Digital Innovation Hubs focusing on Artificial Intelligence (AI DIH) project have confirmed the selection of CIIRC CTU application among 150 other applications. CIIRC CTU was enrolled into AI DIH initiative.
The DIH project will provide assistance in the modelling of a cross-border cooperation blueprint for DIHs and will support the creation of a network of DIHs allowing for the transfer of technical knowledge and the development of an integration and cooperation plan between hub/networks with DIHs and stakeholders at the EU level.

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CENTRES

Centre of City of the Future CIIRC

It was inaugurated on May 23, 2018.

The main partners who joined CCF since the very beginning were Cisco Systems, Operator ICT, and Siemens.

Along with them, another 19 SME companies offering products, services, applications and other solutions for cities of all sizes and regions of the future have joined the CCF.
CCF is a professional and independent platform connecting the academic sphere, the commercial sector and municipal representatives. Its objective is to seek the optimal development of urban structures of all types and sizes. It is a partner of cities, municipalities, regions and other entities in making strategic decisions about the further development of their location.
Along with CCF partners and external experts from all areas of technical and human interest, it provides expert information on products, services, business models and other innovations with innovative potential that will enable stakeholders to increase their competitiveness as well as to enhance the urban resilience of the structures concerned. The result should be a more attractive space for its users to share it effectively with other users. At the same time, it can assess the optimal implementation of new technologies in existing and planned infrastructures and development.

CCF is conceived as an experimental and virtual testbed of the city, the region, the landscape and the technical infrastructure deployed in it, creating a complex and interconnected system. The goal of the CCF platform is to explore all phenomena and processes in these systems and subsystems.
In addition to the regular meetings of all CCF partners, partners will collaborate on several projects to simulate the potential development of „smart" streets and squares, a small community or city district and the region to implement their products. These simulations will be mainly performed using augmented and virtual reality. CCF wants to become a recognizable entity not only in the Czech Republic, but also beyond its borders, and link up with similar platforms around the world.

Contact
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Centre of City of the Future CIIRC

CCF Grand Opening May 23rd, 2018

CAK: Centre for Applied Cybernetics

The project focuses on the development of long-term collaboration between the public and the private sectors and operates nationwide, involving 16 partners.

The results achieved include:

- A fully parametrized software model of the pan European electricity market
- An automatic multi-camera surveillance system for the detection of crime in a city
- Automatic gripping of assembly components by a collaborative robot
- Optimal production scheduling and resource allocation

The Centre was established by the support of project No. TE01020197 of the Technology Agency of the Czech Republic (01/2012 – 12/2019)

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CSP: Computing Intelligence and Signal Processing Centre

Research interests of the CSP centre are devoted to methodology, applications and general methods of digital signal and image processing in biomedical and engineering applications. It brings together researchers with an interdisciplinary approach towards multichannel and multidimensional data processing oriented towards the use of similar mathematical methods in different areas. Theoretical topics studied within this multidisciplinary platform include functional transforms for data analysis, wavelet transforms and coherence methods, digital filters for the rejection of undesirable signal components, segmentation and classification methods, image registration, computational intelligence and geometrical methods for three-dimensional modelling. Applications include (i) analysis of brain activities and EEG signal processing, (ii) polysomnography and breathing analysis, (iii) EMG signal processing and classification of muscle disorders, (iv) spatial modelling in gait and movement analysis, (v) segmentation and digital modelling in orthodontia, (vi) GPS data processing in sport activities, and (vii) general computational intelligence methods. Close collaboration with further research institutes, scientific societies and prestigious universities around the world allows for detailed coordination of research activities, Ph.D. projects and joint courses. The interdisciplinary approach taken towards these topics also assumes very close collaboration with specialized research centres including the Department of Neurology of the Faculty of Medicine in Hradec Kralove. Results include the statistical evaluation and verification of proposed methods for selected data sets in most cases. The general platform of digital signal processing methods will include further extensive interdisciplinary collaboration and applications of selected methods in biomedicine, neurology, robotics, diagnostics, human-man interaction and assistive technologies in the future as well.

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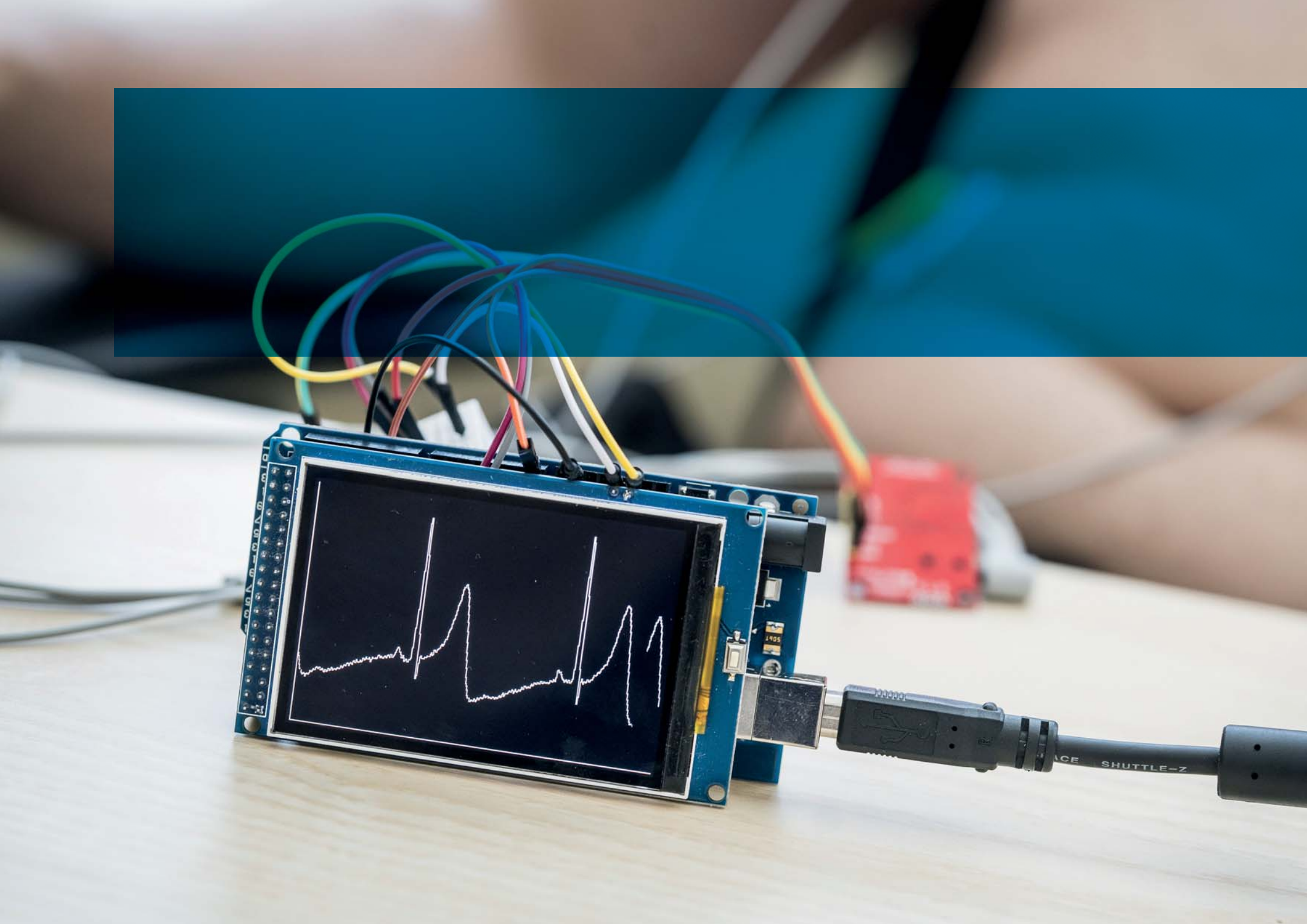

SHUTTLE-Z

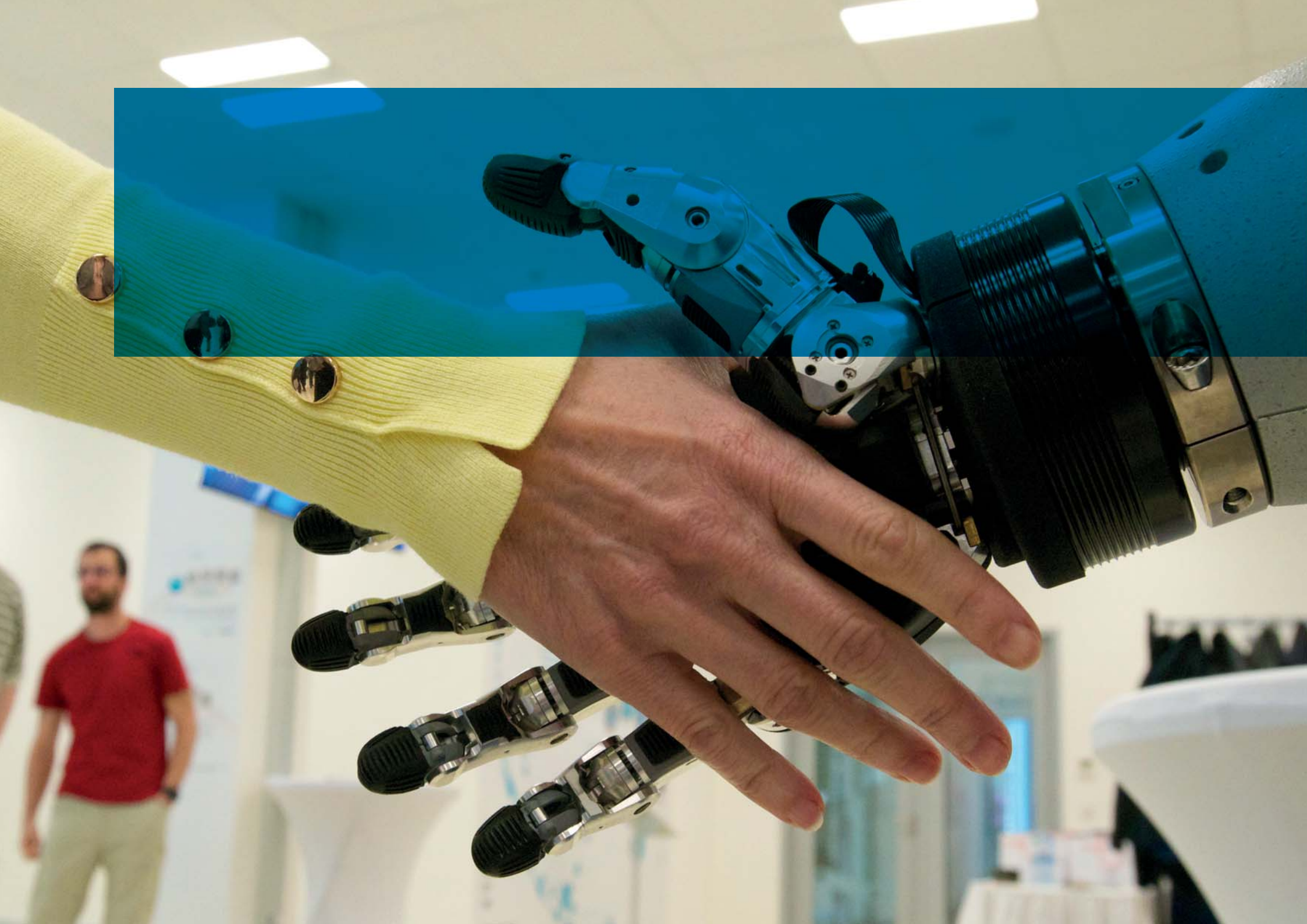
Major events

25th IUPESM World Congress on Medical Physics and Biomedical Engineering

The 25th IUPESM World Congress on Medical Physics and Biomedical Engineering took place in Prague, Czech Republic on June 3 – 8, 2018. The IUPESM World Congress on Biomedical Engineering and Medical Physics, a triennially organized joint meeting of medical physicists, biomedical engineers and adjoining health care professionals was for the first time organized in a country of the Central and Eastern Europe region.

As in previous congresses, this congress was jointly organized by the three international organizations, namely IUPESM, IFMBE and IOMP, and two national societies – The Czech Society of Biomedical Engineering and Medical Informatics and The Czech Society of Medical Physicists. It was held under the auspices of the Czech Technical University in Prague, The Czech Medical Association Jan Evangelista Purkyne, The International Atomic Energy Agency (IAEA), The State Office for Nuclear Safety (SUJB), International Union of Pure and Applied Physics (IUPAP) and supported by the City of Prague.
CTU CIIRC was a collaborating institution.

Doc. Ing. Lenka Lhotská, CSc., Head of Department of Cognitive Systems and Neurosciences, CIIRC CTU, acted as co-chair of the scientific committee.



Selected Results

Assignment of Zeros in Linear Systems

Poles and zeros are important descriptors of linear systems. Whereas the poles can be shifted by state feedback or output injection, the zeros cannot. So, it is the zeros that pose hard limitations in the design of control systems.
The zeros depend on the way the input affects the state of the system, or how the state is reflected in the output. Technically speaking, the zeros are determined by the selection of sensors or actuators while designing the control system.
This is a problem that is not always technically feasible. Furthermore, there are inherent theoretical limitations in the system. It is therefore of interest to determine the limits of input and output selection in assigning the zeros of a linear system.
Generalizing the seminal result of Rosenbrock on the subject, it was possible to determine these limits for any multivariate linear system that gives rise to a proper rational transfer matrix. For sensor placement, these limits can be expressed in terms of the controllability indices of the system whereas for the actuator placement, the limits are given by the observability indices of the system. The limits concern the multiplicities of the zeros to be assigned; the zero values can be chosen at will.

Publication

Kučera, V. (2018). Assignment of invariant and transmission zeros in linear systems. 26th Mediterranean Conference on Control and Automation (MED), Zadar 2018, pp. 116-120. DOI: 10.1109/MED.2018.8442915

Contact

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SELECTED RESULTS

Block decoupling of linear systems using static-state feedback

Decoupling is a specific decomposition of systems with many inputs and outputs that can be achieved by an appropriate compensation. When a system is decoupled, it is broken down into smaller subsystems so that each subsystem outputs can be controlled by the corresponding subsystem inputs and are not influenced by any other inputs. That is why decoupling is also referred to as non-interactive control. Such a structure is desirable in a number of applications since considerable conceptual simplicity can be accrued for subsequent system designs.

The problem of diagonal decoupling, where the subsystems are to be single-input single-output ones, was a long-standing open problem whose solution was made available just last year.
If diagonal decoupling cannot be achieved, it is of interest to investigate the possibility of block decoupling into smaller but still multi-input multi-output subsystems. Such a solution is often adequate in practice.
The existence of block decoupling feedback is shown to depend on the existence of three lists of nonnegative integers conditioned by, and only by, system invariants with respect to the group of permissible transformations of the system, which includes state feedback, input and state coordinate transformations, and output coordinate permutations. A block-decoupling algorithm is described, which permits researchers to determine the sizes of the smallest diagonal blocks attainable.

Publication

Kučera, V. (2018). Block decoupling of linear systems by static-state feedback. IEEE Transactions on Automatic Control (Early Access), pp. 1-1. DOI: 10.1109/TAC.2018.2879595.

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Improving the Thermal Behaviour of DOOSAN Machine Tools

Challenges for machining include greater and greater material removal rates coupled with an increase in the use of difficult-to-machine materials, as well as environmentally-friendly dry or MQL machining. These trends lead to a large and variable heat input into the machine structure causing thermo-elastic displacements of the given machine tool, the tool, the workpiece and clamping devices. Up to 75% of all geometrical errors of machined workpieces can be induced by thermal effects. Therefore, this topic has been the focus of a significant number of recent research activities.

A project for developing a thermal error compensation model and its testing on a five-axis milling machine tool was carried out in cooperation with the DOOSAN Machine Tool company. A joint team of CTU in Prague involved the IPA/CIIRC and RCMT/FME departments. A software compensation method based on transfer functions for predicting thermal errors at the tool centre point (TCP) has been developed and incorporated into the machine tool.

Firstly, calibration tests on the DOOSAN machining centre took place at the Doosan European operation centre in Dormagen, Germany. The measured data were analysed at CTU and a compensation algorithm was proposed.

Consequently, the developed compensation algorithm was implemented into the CNC controller FANUC FS31i-B5 using the Focas library, which had been imported into LabVIEW software. Furthermore, verification tests using the included compensation model were carried out, as were machining tests with the actual workpiece. The machining test results showed that up to an 80 % reduction in thermal errors was achieved after compensation compared to the uncompensated state of the machining centre. This enormous increase in precision opened avenues for future cooperation.

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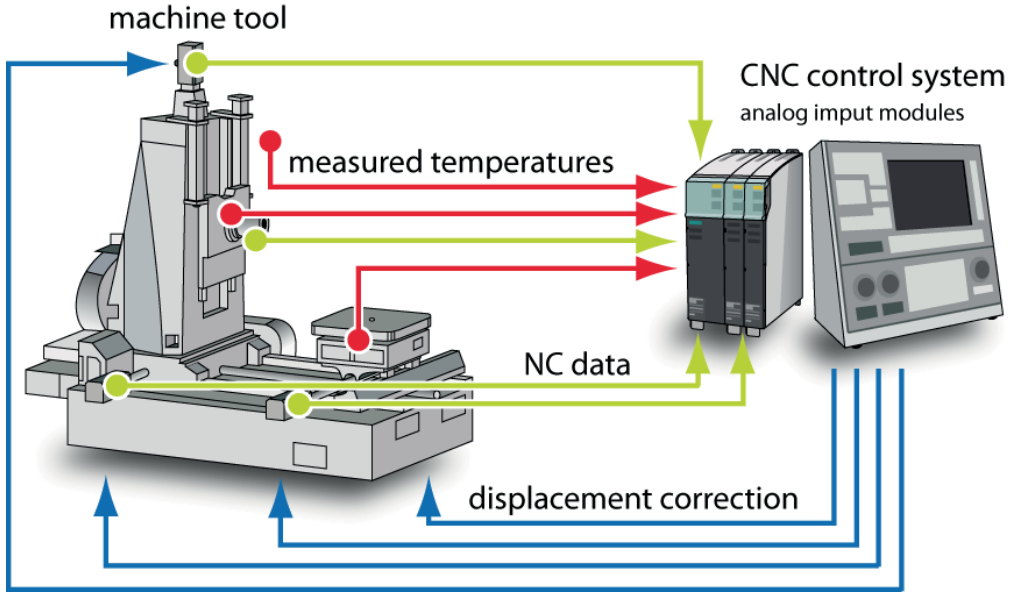

SELECTED RESULTS

Control Design for the Smooth Manipulation of Flexible Multi-body Systems

A complex methodology for controlling flexible multi-body systems has been proposed with the objective of achieving a favourable distribution of system motion so that the oscillatory mode of the flexible part is not excited. As the key element, an inverse shaper with a distributed delay deployed in the feedback loop is applied. Unlike in existing works, the mutual coupling between the primary (controlled) structure and the secondary (flexible) structure of oscillatory nature in this methodology is explicitly taken into account in the controller design.

First, a method to isolate the flexible mode to be targeted in the shaper design is proposed. Secondly, the closed loop composed of the multi-body system, the inverse shaper and the dynamic controller is formulated as an interconnected time delay system. Finally, the controller design is performed by the spectral optimization technique to achieve fast and smooth dynamics. In particular, the control design has proven to be a challenging task due to the infinite dimensionality of time delay system dynamics. The theoretical results were thoroughly validated by both simulations and experiments.

The presented research was conducted within a recently finished project entitled "Time delay compensators for flexible systems" supported by the Czech Science Foundation, which was coordinated by Prof. Vladimír Kučera. The project team composed of researches from CIIRC, Faculty of Mechanical Engineering and Faculty of Electrical Engineering, CTU in Prague, proposed a number of original high-performance compensator concepts and design methods applicable in effective crane manipulation, robotics and light flexible machine control.

Publication

Pilbauer, Dan, Wim Michiels, Jaroslav Bušek, David Osta, and Tomáš Vyhlídal. „Control design and experimental validation for flexible multi-body systems pre-compensated by inverse shapers." Systems & Control Letters 113 (2018): 93-100.

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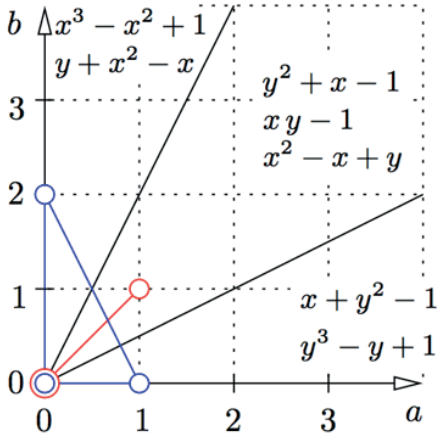
Beyond Groebner Bases: Basis Selection for Minimal Solvers

Many computer vision applications require robust estimation of the underlying geometry, in terms of camera motion and 3D structure of the scene. These robust methods often rely on running minimal solvers in a RANSAC framework. In this work, we show how we can make polynomial solvers based on the action matrix method faster, by carefully selecting the monomial bases. These monomial bases have traditionally been based on a Groebner basis for the polynomial ideal. Here, we describe how we can enumerate all such bases in an efficient way. We also show that going beyond Groebner bases leads to more efficient solvers in many cases. We present a novel basis sampling scheme with which we evaluate a number of problems.



Publication

V. Larsson, M. Oskarsson, K. Åström, A. Wallis, Z. Kukelova, T. Pajdla. Beyond Gröbner Bases: Basis Selection for Minimal Solvers. CVPR 2018. https://arxiv.org/pdf/1803.04360.pdf

Contact

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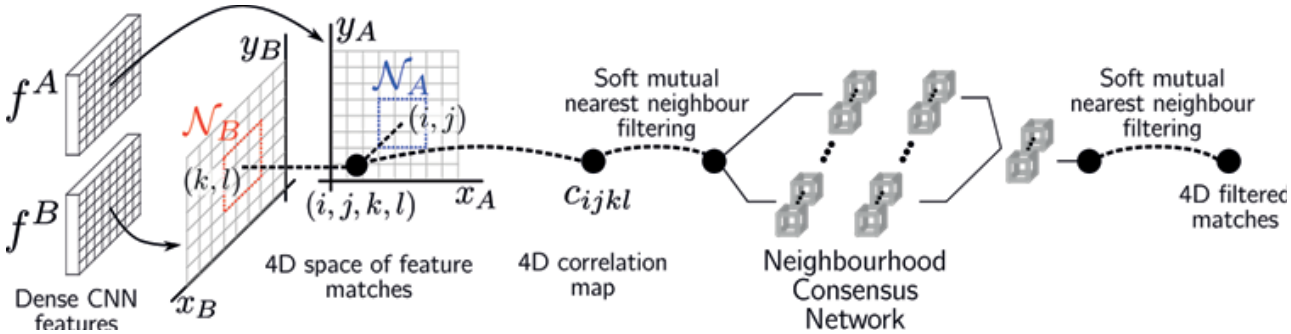
SELECTED RESULTS

Neighbourhood Consensus Networks

We address the problem of finding reliable dense correspondences between a pair of images. This is a challenging task due to strong appearance differences between the corresponding scene elements and ambiguities generated by repetitive patterns. The contributions of this work are threefold. First, inspired by the classic idea of disambiguating feature matches using semi-local constraints, we develop an end-to-end trainable convolutional neural network architecture that identifies sets of spatially consistent matches by analysing neighbourhood consensus patterns in the 4D space of all possible correspondences between a pair of images without the need for a global geometric model. Second, we demonstrate that the model can be trained effectively from weak supervision in the form of matching and non-matching image pairs without the need for costly manual annotations of point-to-point correspondences. Third, we show the proposed neighbourhood consensus network can be applied to a range of matching tasks, including both category-level and instance-level matching, obtaining state-of-the-art results on the PF Pascal dataset and the InLoc indoor visual localization benchmark. The work was presented at the NeurIPS 2018 conference as a spotlight (approximately the top 4% of submitted papers).

Publication

I. Rocco, M. Cimpoi, R. Arandjelović, A. Torii, T. Pajdla and J. Sivic, Neighbourhood Consensus Networks, In Proceedings of the 32nd Conference on Neural Information Processing Systems (NeurIPS), 2018



Contact

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Human-robot interaction in logistics and transportation systems

→ → →

Project

Safe human-robot interaction in logistics applications for highly flexible warehouses (SafeLog, H2020)

Performed in collaboration with

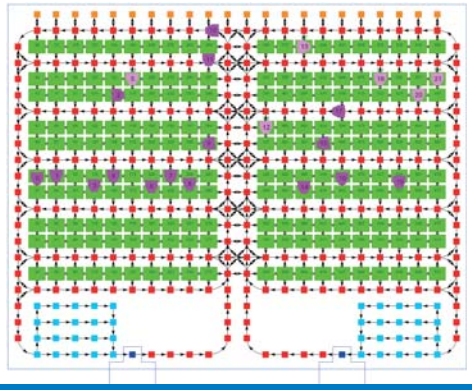
The Karlsruhe Institute of Technology (D), Fraunhofer Institute IML (D), SwissLog A.G. (D), The University of Zagreb (HR), The Institute of Electrical Engineering KONCAR Inc. (HR)

Example of an automated warehouse space.

The overall objective of the SafeLog project lies in the concept design and prototype implementation of large-scale flexible warehouse system control, which enables the safe and efficient collaboration between humans and robots in a shared area and at the same time. The activity addresses the investigation of a robotic warehousing system design leading to safe and autonomous operation in physical collaboration with humans, allowing in-place operators to perform pick and/or carry items in a warehouse and assisting with packing and unpacking operations. The system requires increased human-robot interaction capabilities on one hand, whilst exhibiting adaptability to environment and work-load changes. The SafeLog major design strives to avoid substantial re-engineering of a warehouse through easy re-configurability of the warehouse setup as well as maintain in-place user safety.

The given task comprises advanced warehouse optimization and operations planning in the context of NP-completeness of the (M)TSP problems addressed herein. This necessitates the elaboration of novel methods of any-time planning approaches, capable of delivering approximate plans for logistics robots in the given warehousing case and in real time. The target scaling of the problems is 1,000+ robots and 10,000+ warehouse positions (storage racks). Yet another novelty of the studied and developed methods is the incorporation of uncertainty in the planning process, which is typically imposed by in-place human co-workers. To reduce the level of human-imposed uncertainty, intention recognition process analyses and predicts human co-worker behaviour, which supports refinement of particular planner goals

Safety zones and onboard sensor-based navigation of in-place personnel. Nested safety zones cause re-routing, slowing down or a complete stop of the warehouse robots.



Connectivity structure for optimal routing of the warehouse robots from the storage positions (green) to pick stations (blue) and vice-versa.

in dynamic manner. In addition, the capability of the developed planners to maintain uncertainty substantially improves the runtime robustness of the warehousing system by being able to adapt to unexpected events (other system failures) in the workplace.

As mobile logistics systems share space and collaborate in place with human operators, it is of paramount importance that future autonomous robotic systems should take into account human safety and comfort. These both need to be addressed at a basic level (e.g. guaranteed reliable sensors and algorithms for human detection), and at the systems level (e.g., new algorithms for people tracking, new human-robot interfaces) and through systems for performing validation and certification operations. The approach elaborated herein relies on a multi-modal and multi-zone safety system, delivering the position of in-place humans relative to logistics robots and estimating possible collisions between both entities. A multi-modal approach combining diverse visual navigation principles and ultra-wide band ranging provides the greatest amount of possible safety to avoid collisions with robots in-place, all on a level necessary for TUV/CE safety certification of the target solution. Addressing uncertainty boosts performance of the SafeLog system in terms of providing improved adaptability and flexibility to existing solutions; all in order to improve overall efficiency in logistics and transportation systems, which requires being able to adapt to changes in the environment, as well as to learning from experience and reusing that knowledge to optimize its future performance. In addition to the processes of pure optimization in local parameter adaptation, re-planning of operations under changing conditions are also performed, e.g. steady re-scheduling of operations over robots and humans are the key technologies addressed herein.

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SELECTED RESULTS

Dynamic 3D reconstruction of moving surfaces

Project

A safety scanner for vehicle undercarriage reconstruction under motion (Kassandra, The Czech Ministry of the Interior)

Performed in cooperation with

VOP CZ (CZ)

Recovery of RGBD images of moving objects, in particular their visible surfaces, represents a major contribution towards security scanning of vehicle undercarriages. In this connection, off-the-shelf sensing and surface reconstruction solutions either deliver 2D (RGB/Y) images lacking enough in-depth information, or allow for laser-based range images registering with very low resolution and insufficient data due to sensing constraints. Neither approach provides sufficient resolution for the detection and recognition of objects of interest (mainly via a comparison of to-date and preceding images/scans).

The Kassandra project addresses the research and development of methods and tools, in particular advanced image processing algorithms that enable to construction of safety vehicle undercarriage scanners. The suggested system combines intense, colour images from several regular line/stripe cameras for the recovery of 2D RGB/Y images and simultaneously reconstructs scene depth from multiple sensors. The respective methods are being designed so that they can also handle vehicle motion over the cameras' frames. The solution faces problems of being able to reliably reconstruct 2D intensity images from a sliding-window frame using a space-to-frequency domain transform, a selection of dominant descriptors and performing the respective correlation process. To recover scene depth, the gathered images are further processed to determine correspondence points/features and help to recover dense scene depth via calculating perspective.

The created method was designed to be robust with respect to the processed scene look, which appears very uniform in intensity and evenly coloured images and is very typical like those currently used for vehicle undercarriages. Generally said, scene uniformity spoils the efficiency of standard perspective transforms for recovery of the scene depth and which therein developed method effectively bridges.

The major properties of the targeted approach include its ability to handle surfaces moving at a speed of up to 20km/hr and being able to attain a spatial and depth resolution of the reconstructed 3D surface models under 1mm.

Contact

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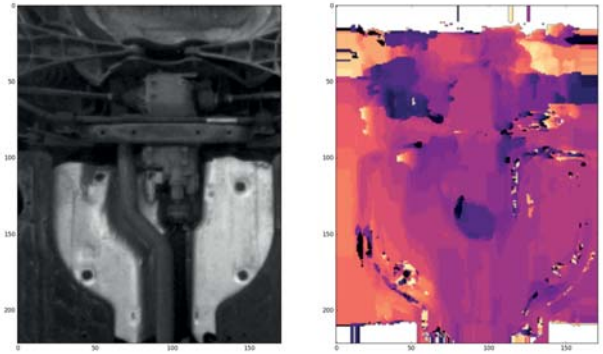
Kassandra system prototype. Imaging cameras, lighting and mirror holder frame (courtesy of VOP CZ).



Kassandra moving vehicle undercarriage RGBD reconstruction. Intense colour image (left) and the corresponding depth.

Loosely oriented object picking

Projects

Smart bin picking of assembly parts in the automotive industry, Prepack pick and place

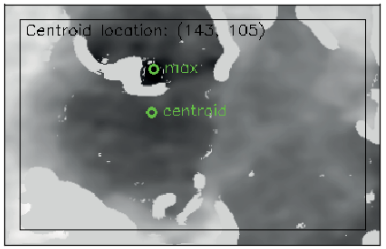
Performed in cooperation with

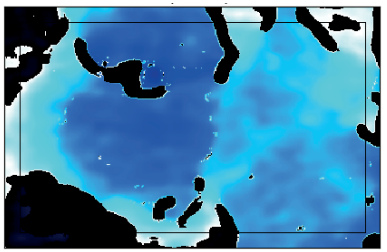
Škoda Auto, Mladá Boleslav (CZ) and others

Even the high levels of automation that exist in many industrial processes face problems associated with the automated manipulation of loosely oriented parts. Up to now, these cases have been overcome by (besides the involvement of human manpower) applying sorting systems that assured bringing parts to a defined position and provided orientation and picking using standard manipulators. This solution appears expensive and production-space costly (the sorting technology) as well as insufficiently flexible in cases of part type changes or production reconfiguration.
One straightforward way to automate the picking of randomly oriented parts is through the use of 3D cameras with a subsequent recognition process, for which the costs are high.

The approaches and solutions investigated herein eliminate the need for expensive 3D camera sensors and suggest a substitute solution relying on a combination of regular monocular cameras (typically low-end) followed by a deep neural network (DNN) that is responsible for part identification, position and orientation recognition, as well as controlling the manipulator approach to the respective part to be picked. Yet another strength of DNN application for this problem is the flexibility of the approach – the readiness to perform a learning process to either improve picking performance on the fly, or even to learn how to handle completely new parts and/or situations. Furthermore, the use of DNN allows handling specific cases with a high complexity of parts, their orientation, occlusion, etc., which are all major obstacles to efficiently using currently available off-the-shelf part picking solutions.

The aforementioned approaches and their combinations are being applied to feasibility demonstrators and early prototypes and tested under both laboratory and actual production environments. The tested picking success rate of approximately 95% with processing times on an order of seconds with standard PC HW, the flexibility to learn other cases together with its replication costs proves the high value and applicability of these created solutions.

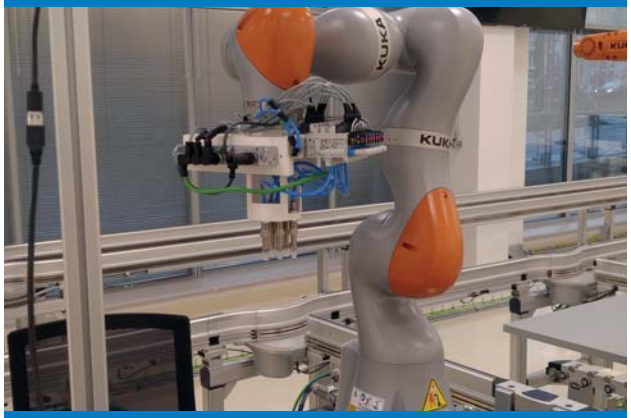




HIGHEST POINT DEPTH MAP INFRARED IMAGE

Object image processing phases in the picking task. The parts being moved have complex shapes, a diverse look and exhibit transparency, all which hinder visual identity.

Use of DNN-based bin picking of loosely oriented glossy parts.



Randomly oriented prepacks being picked and placed (for final boxing).

Contact

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SELECTED RESULTS

Tracking of Eye Movements and Pupil Dilation

Pupil responses are known to indicate brain processes involved in perception, attention and decision-making. They can be used as biomarkers of human memory performance and cognitive states in general. Changes in the pupil size during encoding and the recall of word lists have been investigated. Consistent patterns in pupil response were found across and within distinct phases of the free recall task. The pupils were most constricted during the initial fixation phase and became gradually more dilated through the subsequent encoding, distractor and recall phases of the task, as the word items were maintained in memory. Within the final recall phase, retrieving memory for individual words was associated with pupil dilation in the absence of visual stimulation. Words that were successfully recalled showed significant differences in pupil response during their encoding compared to those that were forgotten – the pupils were more constricted before and more dilated after the onset of word presentation. Our results suggest pupil size as a potential biomarker for probing and modulating memory processing.
Recording gaze position and pupil size was performed using the 'i4tracking' system (Medicton Group Inc.) designed for clinical applications in patients.

Publication

Kucewicz, Michal T.; Dolezal, Jaromir; Kremen, Vaclav; Berry, Brent M.; Miller, Laura R.; Magee, Abigail L.; Fabian, Vratislav; Worrell, Gregory Alan. Pupil size reflects successful encoding and recall of memory in humans. In: Scientific Reports. 2018 ; Vol. 8, No. 1.

Contact

Doc. Ing. Lenka Lhotská, CSc. (lenka.lhotska@cvut.cz)

Sparse Learning for Intrapartum Fetal Heart Rate Analysis

Fetal Heart Rate (FHR) monitoring is used during delivery for assessing fetal well-being. Classically based on the visual evaluation of FIGO criteria, FHR characterization remains a challenging task that continuously receives intensive research attention. Intrapartum FHR analysis is further complicated by the two different stages of labour (dilation and active pushing). Research works aimed at devising automated acidosis prediction procedures are either based on designing new advanced signal processing analyses or on efficiently combining a large number of features proposed in literature. Such multi-feature procedures either rely on a prior feature selection step or end up with decision rules involving long lists of features. This many-feature outcome rule does not permit the user to easily interpret the decision and is hence not well suited for clinical practice. Machine-learning-based decision-rule assessment is often impaired by the use of different, proprietary and small databases, preventing meaningful comparisons of results reported in literature. Here, sparse learning is promoted as a way to perform joint feature selection and acidosis prediction, hence producing an optimal decision rule based on as few features as possible. Making use of a set of 20 features (gathering ‘FIGO-like’ features, classical spectral features and recently proposed scale-free features), applied to two large-size (respectively sime1800 and sime 500 subjects), well-documented databases, collected independently in French and Czech hospitals, the benefits of sparse learning are quantified in terms of: (i) accounting for class imbalance (few acidotic subjects), (ii) producing simple and interpretable decision rules, (iii) evidence of differences between the temporal dynamics of the active pushing and dilation stages, and (iv) of the validity/ generalizability of decision rules learned on one database and applied to the other one.

Publication

Abry, P.; Spilka, J.; Leonarduzzi, R.; Chudáček, V.; Pustelnik, N.; Doret, M.: Sparse learning for Intrapartum fetal heart rate analysis, Biomedical Physics & Engineering Express. 2018, 4(3), 11 pages, ISSN 2057-1976

Contact

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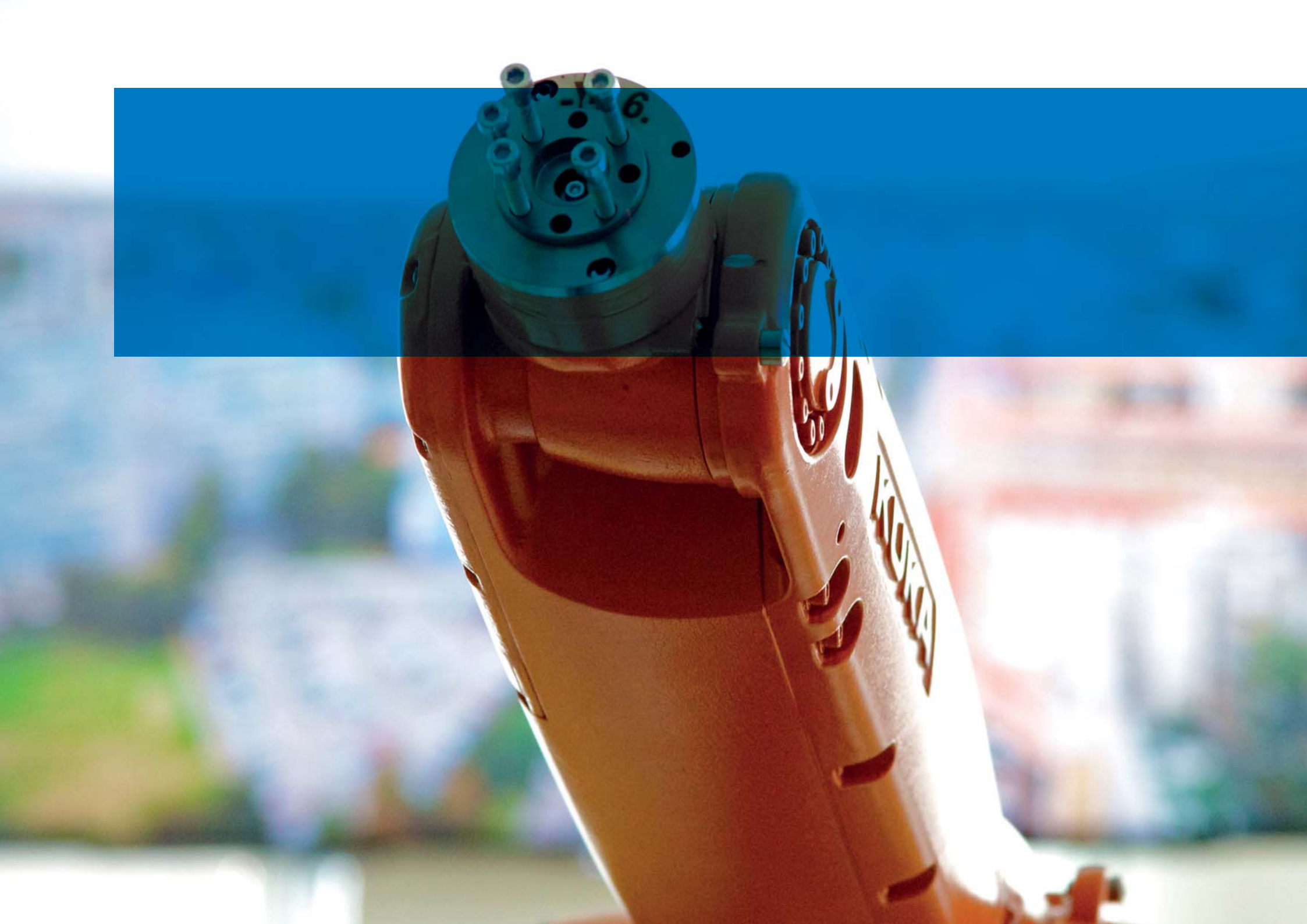

Selected Projects

ERC PROJECT **AI4REASON - Artificial Intelligence for Large-Scale Computer-Assisted Reasoning (ai4reason.org)**

This is an ERC Consolidator project (no. 649043) running from 2015 to 2020, whose principal investigator is Josef Urban. The project is funded by the European Research Council under the European Union's Horizon 2020 research and innovation program.
The project's goal is to develop new combinations of AI, Machine Learning and Theorem Proving methods that learn reasoning guidance from large proof corpora and use such guidance to steer automated reasoning processes at various levels of granularity.

The work includes close collaboration with several international partners: The University of Innsbruck, Google Research, The University of Miami, DHBW Stuttgart, The University of New Mexico, and others.

The research and development activities include:

- machine learning procedures over large proof libraries
- methods that propose useful intermediate lemmas for long proofs
- methods that efficiently apply learned knowledge in proof searches
- feedback loops between learning and automated reasoning
- statistical and deductive methods for the automated formalization of informal mathematics

Contact

Mgr. Josef Urban, Ph.D., Principal Investigator (josef.urban@cvut.cz)

SELECTED PROJECTS

ESIF - EUROPEAN STRUCTURAL AND INVESTMENT FUNDS OP RDE - OPERATIONAL PROGRAMME RESEARCH, DEVELOPMENT AND EDUCATION

IMPACT - Intelligent Machine Perception

CZ.02.1.01/0.0/0.0/15_003/0000468, 2017 – 2022

"Our goal is to develop methods that will make it possible for robots to learn from videos how to replace a defective tyre, resuscitate a person or provide safe autonomous automotive navigation under difficult and continuously changing conditions."

Main focus:

- The research of computer vision and machine learning
- The development of tools for synthesizing complex future predictions from aligned past visual experiences.
- Analysing dynamic patterns in shared visual experiences

Strategic international partners:
INRIA (France)

Contact
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Robotics for Industry 4.0

CZ.02.1.01/0.0/0.0/15_003/0000470, 2017 - 2022

Robot learning, autonomy and mobility. Machine learning will ease robot adaptation to new tasks and environments, including robot-human cooperation. Effective and safe machine learning algorithms are an important prerequisite for autonomy in robotics, which has been recognized as a strategic bottleneck for smart industrial applications. High-level reasoning in robotics needs a suitable representation of the environment, which continues to be a challenging task. We deal with robot learning, mobility, and with the mechanical aspects essential for effective human-robot collaboration.

Perception, grasping and manipulation in industrial environments. Reliable sensing and perception methods for mobile industrial robots are essential for the use of robots in modern industrial applications. However, the ability of robots to perceive and understand their environment is still very limited. Additional challenges are present when it comes to combining perception and dexterity. We therefore address the integration of perceptual systems with dexterous manipulation in the context of cooperative robots. Advanced perception, calibration and hybrid sensor-fusion are studied in conjunction with the mechatronic side of the problem.

Networked control systems. Strongly interconnected systems, which are the backbone of the Industry 4.0 concept, give rise to additional complexity due to the interaction of the subsystems. Having a profound understanding of the phenomena arising in networked systems is a prerequisite for the successful implementation of the Industry 4.0 paradigm. We are developing methods for control-theoretic understanding of 'systems of systems' and also research mechanisms constituting mechanical networks in two areas – controlled mechanical impedance to increase the mechanism's stiffness and mechatronic solutions for grasping and manipulation.

This project, supported by the European Regional Development Fund, focuses on advanced robotics for future industrial applications. The scope includes perception, machine learning, human-robot collaboration, distributed control and advanced mechatronics solutions.

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AI&Reasoning – Artificial Intelligence and Reasoning

CZ.02.1.01/0.0/0.0/15_003/0000466, 2017 – 2022

"We will focus on the automated translation of mathematical, scientific and technical texts written in a natural language into a form that will be comprehensible for computers."

Main focus:

- The development of autonomous artificial intelligence systems in large-scale theory automated reasoning
- The verification of advanced systems and technologies
- Computer verification of advanced mathematics based on complex formal theories

Strategic international partners: Radboud University Nijmegen (Netherlands), Universität Innsbruck (Austria). National partners: The IT4Innovations National Supercomputer Centre, VŠB – Technical University of Ostrava, The NTIS Centre at the University of West Bohemia, Plzeň

Contact
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TACR PROJECT

National Centre of Competence for Cybernetics and Artificial Intelligence

The NCK KUI project aims to create a national platform for cybernetics and artificial intelligence which interlinks research and application oriented centres of robotics and cybernetics for Industry 4.0, Smart Cities, intelligent transport systems and cybersecurity. The connection of innovation leaders will raise effectivity of applied research in key areas, as advanced technology for globally competitive industry, ICT and transportation for the 21st century. NCK KUI is closely related to application sector and enables cross-domain collaboration, innovation development and technology transfer.

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EU PROJECTS

UP-Drive - Automated Urban Parking and Driving (up-drive.eu)

UP-Drive aims at developing a technology needed for a self-driving car to be able to drive in general city traffic at low speeds of up to 30 km per hour. The experimental car is a VW Golf (electric) with several sensors including lidars, radars, sonars, and cameras. The CTU team is contributing to the perception capabilities of the car, camera calibration and to driving situation scenario understanding, including the short-time prediction of traffic situations, e.g. the prediction of a pedestrian crossing the road with a maximum time horizon of three seconds.

EU project no. 688652, Automated Urban Parking and Driving

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SELECTED PROJECTS

EU PROJECTS

Open Source Photogrammetric Computer Vision Framework

AliceVision

Photogrammetry is the science of taking measurements from photographs. It infers the geometry of a scene from a set of unordered photographs or videos. Photography is the projection of a 3D scene onto a 2D plane, which therefore loses depth information. The goal of photogrammetry is to reverse this process. The dense modelling of the scene is the result yielded by chaining two computer vision-based pipelines: "Structure-from-Motion" (SfM) and "Multi View Stereo" (MVS). AliceVision (alicevision.github.io) is an open source photogrammetric pipeline integrating technologies from many partners into a unique 3D reconstruction technology available to the research and industrial communities. The Applied Algebra and Geometry group of CIIRC contributed to AliceVision within the EU LADIO project (ladioproject.eu) via state-of-the-art MVS components and camera modelling and camera parameter estimation.

EU project no. 731970, Live Action Data Input / Output

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DIGICOR Project

In 2018, the DIGICOR project which is coordinated by Airbus entered its second half. The chievements reached in the field of distributed production planning and control were presented to representatives of the European Commission during the mid-term review at CIIRC on April 19. The very good results of the evaluation were verified through the use of the Industry 4.0 Testbed, which demonstrates the capabilities of the DIGICOR platform in practice.

The CTU's team is focused on the utilization of semantic technologies to increase interoperability among companies within supply chains. The researchers at CTU designed and implemented semantic data models describing production processes in a way that enables the decomposition of large production tasks into subtasks according to the capabilities of individual companies. Semantic Web Rule Language (SWRL) technology was used as an enabler for an advanced production monitoring tool. This tool uses explicitly defined production formulas and a log of conducted manufacturing operations to derive the current state of production that is simultaneously running at multiple production resources.
The CTU's team also developed a novel manufacturing execution system that uses a formalized description of manufacturing

operations as well as capabilities of physical production resources to model a production task as a planning problem using the Planning Domain Description Language (PDDL) format. The developed system uses a freely available planner called Fast Downward to compute a production plan. Consequently, the plan is executed by a Plan Executor component that starts manufacturing operations on physical machines in the specified order. The developed method was demonstrated on a LEGO case study. In this study, three KUKA robots and a Montrac conveyor system were used to automatically build a LEGO model according to a customized order.

EU project no. 723336, Decentralised Agile Coordination Across Supply Chains

Contact
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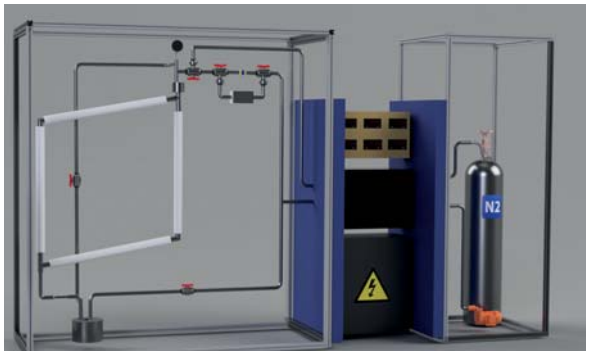
Advanced high temperature reactor

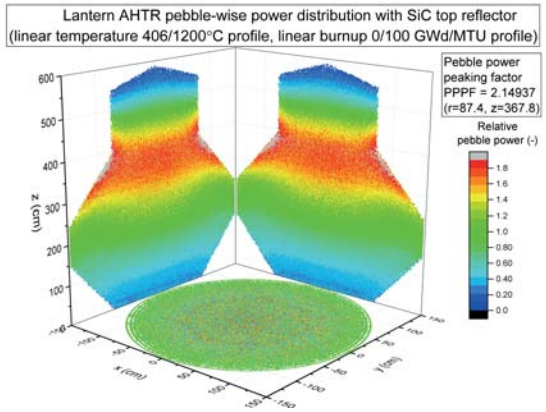
New Small Modular Reactors (SMR) are in the forefront of nuclear energy research and development. The AHTR project, in conjunction with the South African utility ESKOM in cooperation with the University of Witwatersrand, deals with a new type of SMR with heat storage and high temperature gas cooling. The compact high efficiency nuclear reactor builds on variety of new, but feasible features.

The Power System 4.0 team is focused on:

1/ optimization and design of the AHTR reactor core, where new reactor core shapes are being studied. Contrary to standard cylindrical reactor shapes, AHTR counts on Radially and Axially Derived Core geometry in which both radial and axial profiles of the core change. Also, as the core is composed of spherical fuel elements (a.k.a. pebbles), the continuous flow of pebbles through the core is simulated and optimized with respect to heat and energy generation.

2/ The heat storage system design for AHTR. As nuclear reactors are best operated under base load electricity patterns, there is a need to accommodate for real life changing electricity demand. For such situations, a new heat storage system (HSS) coupled between the reactor and the steam turbine is being studied, simulated, and built in a mock-up scale. HSS utilizes molten nitride salts at high temperatures under atmospheric pressure and it is proposed to store up to 8 hours of produced energy of AHTR.





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SELECTED PROJECTS

NATIONAL PROJECTS

DAMiAS Project

The DAMiAS project is being developed in cooperation with Factorio Solutions, s.r.o. The CIIRC team focuses on modelling industrial systems using the AutomationML data format and the ISA-95 industry standard. Significant parts of the project include innovative ways of collecting data with the main emphasis on OPC UA technology and the processing of event logs by process mining methods.

For the Pilot Verification of New Algorithms and Design of User Scenarios, the Industry 4.0 Testbed is being used and co-operation with the following industrial partners is ongoing:

- LEGO Production s.r.o., Kladno
- Continental Automotive Czech Republic s.r.o., Brandýs nad Labem
- ŠKODA Auto a.s., Mladá Boleslav

The DAMiAS project fits into the international asset management initiative entitled ‚Asset Administration Shell' (AAS). It originally was a trilateral (Germany, France, Italy) attempt to standardize AAS. Industry 4.0 associations from these member states as well as the European Commission are interested in expanding cooperation across the EU. As part of the DAMiAS project, a member of the research team participated at the AAS meeting of the European Commission in Brussels, and the latest findings and developments in AAS were taken into account in the proposed DAMiAS project solution.

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Predictive Modelling of Student Performance Using Learning Resources

The project is aimed at developing predictive modelling methods reflecting different views (levels) of student academic paths and dependencies between the "resources" the student interacts with during the learning process. In addition, by investigating dependencies between "educational resources", we will develop methods for making an analysis of student learning behaviour. All developed methods will be tested on real data provided by partner institutions - Open University and Faculty of Mechanical Engineering, CTU in Prague. To reflect the educational aspects of the research, we will investigate the educational impact of predictive modelling outputs on study results.

Publications

VÁCLAVEK, J. et al. Learning Analytics Dashboard Analysing First-Year Engineering Students. In: Lifelong Technology-Enhanced Learning. EC-TEL 2018. THIRTEENTH EUROPEAN CONFERENCE ON TECHNOLOGY ENHANCED LEARNING, Leeds, 2018-09-03/2018-09-06. Springer, Cham, 2018. s. 575-578. Lecture Notes in Computer Science. sv. 11082. ISBN 978-3-319-98571-8. DOI 10.1007/978-3-319-98572-5__48.

KUŽÍLEK, J. et al. Student Drop-out Modelling Using Virtual Learning Environment Behaviour Data. In: Lifelong Technology-Enhanced Learning. EC-TEL 2018. THIRTEENTH EUROPEAN CONFERENCE ON TECHNOLOGY ENHANCED LEARNING, Leeds, 2018-09-03/2018-09-06. Springer, Cham, 2018. s. 166-171. Lecture Notes in Computer Science. sv. 11082. ISBN 978-3-319-98571-8. DOI 10.1007/978-3-319-98572-5__13.

Contact
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Personal Assistive and Health Systems

The Project is focused on the development and customization of a mobile system for acquiring physiological and technical parameters in real time from several subjects at once and monitoring individual physiological responses to various stimuli. A universal wireless system with a variety of applications in security training, psychophysiological training and classification, as well as diagnostics should be developed.

Contact
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Project investigator
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NATIONAL PROJECTS

Semiological Features of Epileptic Seizures

All off the major advancements that have been reached in the treatment of epilepsy, there still remain some patients whose problems cannot be resolved by antiepileptic drugs and their hope lies in epilepsy surgery. The precise location of seizure focus is crucial for this approach to have a positive effect – it relies not only on imaging methods, but important information is provided from observing the patient's behaviour during a seizure (ictal signs). There is a number of frequent ictal signs that have been used in diagnostics for several decades, but this list is certainly not comprehensive. Recently, some new ictal signs that are observed less frequently have been introduced – their description is based on data provided from just a few dozen patients and consequently lacks the necessary statistical evidence. This is no surprise since checking for the presence of a specific ictal sign in a patient requires a lengthy manual review of video records documenting his/her seizures. We have suggested a novel approach towards the identification/verification of new ictal signs based on a computer supported systematic review of the unique extensive dataset from Na Homolce Hospital containing approximately 1,000 seizures (representing data from 400 patients with up to 5 video-documented seizures). This requires transforming the original set of patient records into a database consisting of annotated ictal video-EEG recordings in a structured form suitable for answering complex queries, for performing a statistical analysis as well as for making an analysis of sequence patterns. We have developed a SW tool, ASTEP that significantly simplifies this transformation. Neurologists have used ASTEP to enter the data of approximately 50 patients into a searchable database and its content is now being analysed with the intention of finding new complex symptoms (sequences of elementary symptoms) that can distinguish various types of epilepsy.

Journal article:

Abry, P.; Spilka, J.; Leonarduzzi, R.; Chudáček, V.; Pustelnik, N.; Doret, M.: Sparse learning for Intrapartum fetal heart rate analysis, Biomedical Physics & Engineering Express. 2018, 4(3), 11 pages, ISSN 2057-1976

Contact

Prof. RNDr. Olga Štěpánková, CSc., Project Investigator (olga.stepankova@cvut.cz)

Analysis of the Approach towards DataFlow Solutions for DataHub (study)

The aim of the project is to analyse trends and outlooks in power network development with regard to the decentralization of the production capacity portfolio, to the onset of intermittent renewable resources, to accumulation and other technical or business phenomena. This is being done to assess the impacts and risks (threats and opportunities) related to increasing data processing requirements, as well as the impacts of new roles and operators. The project provides a conceptual design of the methods and tools used to mitigate the negative impact of identified information uncertainties and for changing access to data sources for operating processes and preparation, for system development planning in the short to the medium term, and for identifying the necessary data types and process changes. We are also formulating the possible uses of the acquired data (use cases) from the point of view of individual market participants (TSO, DSO, market operators, state authorities, traders, aggregators), evaluating the benefits for other participants, evaluating the necessary level of cooperation and participating in collecting, processing and storing identified sets of data to achieve synergistic effects.

Contact

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Other selected ESIF OPRDE projects:

Project title	Agency/Call	Ref. No.	Start	End	Acronym
Cluster 4.0 - Methodology of System Integration	EC / MEYS CR	CZ.02.1.01/0.0/0.0/16_026/0008432	01.07.2018	30.09.2022	Cluster 4.0
Engineering applications of microworld physics	EC / MEYS CR	CZ.02.1.01/0.0/0.0/16_019/0000766	01.11.2017	31.10.2022	INAFYM

EU H2020 / EU FP7 Projects:

Project title	Agency/Call	Ref. No.	Start	End	Acronym
Artificial Intelligence for Large-Scale Computer-Assisted Reasoning	Horizon 2020	649043	01.09.2015	31.08.2020	AI4REASON
Safe human-robot interaction in logistic applications for highly flexible warehouses	Horizon 2020	688117	01.01.2016	31.12.2019	SafeLog
High-Performance Real-time Architectures for Low-Power Embedded Systems	Horizon 2020	688860	01.01.2016	31.12.2018	HERCULES
Automated Urban Parking and Driving	Horizon 2020	688652	01.01.2016	31.12.2019	UP-Drive
Decentralised Agile Coordination Across Supply Chains	Horizon 2020	723336	01.10.2016	30.09.2019	DIGICOR
ECHORD Plus Plus / RadioRoSo: Radioactive Waste Robotic Sorter	EU FP7 ECHORD++	FP7-ICT-601116	01.09.2016	28.02.2018	RadioRoSo
Live Action Data Input and Output	Horizon 2020	731970	01.12.2017	31.05.2018	LADIO
RICAIP: Research and Innovation Centre on Advanced Industrial Production	Horizon 2020	763559	01.09.2017	31.08.2018	RICAIP
TRADR: Long-Term Human-Robot Teaming for Robot Assisted Disaster Response	EU FP7 ICT	609763	01.11.2013	30.06.2018	TRADR
EIT Manufacturing (Made by Europe)	EIT: Added Value Manufacturing		01.01.2018	31.12.2027	EIT Manufacturing

List of Other Research Projects

Project title	Agency/Call	Ref. No.	Implementation Period
KnowDrift: Knowledge-Driven Industrial Robotics for Flexible Production	Die Öster. Forschungsförderungsgesellschaft (FFG), Produktion der Zukunft 2016	858707	03/2017 - 08/2019
TDS: Time delay compensators for flexible systems	GA CR	GA16-17398S	01/2016 - 12/2018
FOREST: Flexible Scheduling and Optimization Algorithms for Distributed Real-time Embedded Systems	GA CR	GA16-23509S	01/2016 - 12/2018
Sounds> Processing of complex sounds in the central auditory system under normal and pathological conditions	GA CR	GC16-09086J	02/2016 - 12/2018
NaoSkin: Robotic self-calibration and safe physical human-robot interaction inspired by body representations in primate brains	GA CR	GJ17-15697Y	09/2017 - 12/2019
Temporal context in analysis of long-term non. stationary multidimensional signal	GA CR	GA17-20480S	01/2017 - 01/2019
Predictive modeling of student performance using learning resources	GA CR	GJ18-04150Y	01/2018 - 12/2020
QUADSHAPE: Time-delay control laws for upcoming transportation UAV systems	MEYS CR: INTER-EXCELLENCE	LTAUSA17103	02/2017 - 12/2019
AZV-DIABETES: Individual dynamics of glycaemia excursions identification in diabetic patients to improve self managing procedures influencing insulin dosage	Ministry of Health CR	NV15-25710A	05/2015 - 12/2018
CRT: Features of Electromechanical Dyssynchrony that Predict Effect of Cardiac Resynchronization Therapy	Ministry of Health CR	NV15-31398A	05/2015 - 12/2019
Kassandra: Multi-camera vehicles' undercarriage security scanner	Ministry of interior CR	VI20172020080	01/2017 - 04/2020
Smart Camera: New Generation Monitoring Center	Ministry of interior CR	VI20172019082	01/2017 - 02/2019
Technology for industrial robots integration into production systems based on Industry 4.0	MIT CR - TRIO	FV10299	09/2016 - 08/2019
Research and project concept of a multifunctional robotic effector of an underground multirobot for storage of disposal casks in deep geological repository, and realization of a prototype of dual robotic effector module and its master control system	MIT CR - TRIO II.	FV20197	06/2017 - 12/2019
COPA: Control Platform for High-Accuracy Microelectronics Assembly	MIT CR - TRIO II.	FV20403	07/2017 - 06/2021
OZAS: Personal Health Assistance Systems	MIT CR - TRIO II.	FV20696	07/2017 - 06/2021

Project title	Agency/Call	Ref. No.	Implementation Period
GenomKit	MIT CR - TRIO II.	FV30421	01/2018 - 12/2021
FLOPP: The factory of the future - Flexible, Optimized and Controllable Production Platforms	OP EIC - Entrepreneurship and Innovations for Competitiveness Operational Programme	EG15__019/0004688	01/2016 - 09/2019
KONPOLA: A robotic cell for inspection of painted parts in industrial manufacturing	OP EIC - Entrepreneurship and Innovations for Competitiveness Operational Programme	EG15__019/0004939	10/2016 - 09/2019
Centre for Applied Cybernetics 3	TA CR	TE01020197	01/2012 - 12/2019
DAMiAS: Data-driven Asset Management in Automobile Industry Based on Semantic Modelling	TA CR Delta IV.	TF04000054	01/2018 - 12/2019
MWPharmASIA - database extension of drug substances and their MWPharm modelsfor East Asian population and development of NGS diagnostic panel and algorithm for predicting statin pharmacokinetics/dynamics	TA CR Delta V.	TF05000020	11/2017 - 11/2019
CREOBOT: Research and realization of prototype of a breakthrough solution of multifunctional autonomous modular Creobot Modular for transport and manipulation in sophisticated manufacturing and assembly operations	TA CR Epsilon	TH03010369	01/2018 - 12/2020
MERKUR: Development of a modern modular system for teaching mechatronics in line with the Industry 4.0 challenge	TA CR Epsilon	TH03010448	01/2018 - 12/2020
ImitRob: Imitation learning supported by language for industrial robotics	TA CR Zeta I.	TJ01000470	10/2017 - 09/2019
MAFRI: Transposition of MAF-type reliability indicators into the national reliability standards applicable in the corrective measures planning and evaluation in case of indication of generation inadequacy within the CZ grid	TA CR - Theta	TK01010037	07/2018 - 05/2020
SecureFlex: Secure power flexibility for grid control and market purposes (SecureFlex)	TA CR - Theta	TK01030078	06/2018 - 05/2024
Robotic machine head	TA CR	TH02010942	01/2017 - 06/2020
NCK KUI: National Centre of Competence – Cybernetics and Artificial Intelligence	TA CR	TN01000024	11/2018 - 12/2020


ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE
10

Awards and Honours

Saburo Tsuji Paper Award

James Pritts, Zuzana Kukelova and Ondrej Chum won the Saburo Tsuji Paper Award at the 14th Asian Conference on Computer Vision (ACCV) for their paper entitled “Rectification from Radially Distorted Scales”.

AWARDS AND HONOURS

2018 World Championship for Automated Theorem Proving

On July 13th and 14th 2018, the 2018 World Championship for Automated Theorem Proving (CASC-J9) took place in Oxford at the 2018 Federated Logic Conference (FLoC18). This was the 23rd edition of the competition, running annually since 1996. More than twenty systems by teams from the USA, Asia and Europe competed in six divisions.

Two divisions of the competition were won by systems developed by the CIIRC/CTU team from the AI4REASON ERC project of Dr. Josef Urban and their collaborators. The LTB (large theory) division was won by the "Machine Learner for Automated Reasoning" (MaLARea 0.6) system developed by J. Urban and his colleagues, solving 16% more of the 5,000 competition problems than the runner up. The THF (higher-order) division was won by the Satallax 3.3 system developed by Dr. Chad Brown and his colleagues, solving 14% more of the 500 competition problems than the runner up.

The LTB division contains problems arising in large projects concerning the verification of mathematics and software. This year, the problems came from the CakeML project, which produces a verified implementation of the ML programming language. The THF division contains a selection of problems formulated in higher-order logic. This is one of the most common formalisms used for verifying large mathematical proofs and complicated software designs.

The Amazon Alexa Prize 2018 Award

For the second time, the CTU student team lead by Jan Šedivý beat more than one hundred other university teams and placed second in the Amazon Alexa Prize Award. This international competition focuses on developing the best social bot using the latest achievements of conversational Artificial Intelligence (AI). Conversational AI utilizes several research areas including knowledge acquisition, natural language understanding, natural language generation, context modelling, common-sense reasoning and dialog planning.

The system called Alquist, whose name proudly points to the historical significance that Czechs have in the field of AI and robotics, is based on unique algorithms that were developed and subsequently researched in the Department of Intelligent Systems and represents one of the main flagships of the CIIRC.

F1/10 Race Competition of Autonomous Car Models

A CTU team won the F1/10 race competition of autonomous car models. The completion is organized by the University of Pennsylvania. Seven teams from the USA, Europe, and South Korea participated.

Control and optimization algorithms created by the team lead by Professor Hanzalek at CIIRC CTU and students from FEE CTU made the fastest lap at 9.1s while the team from the US, holding second place, made their fastest lap at 11.5s.
The F1/10 competition focuses on creating a meaningful and challenging design experience for students. The competition involves designing, building, and testing an autonomous 1/10th scale F1 race car (capable of speeds up to 40 km per hour) all the while learning about perception, planning, and control for autonomous navigation. The racing competition was held at Cyber Physical Systems Week 2018 in Porto.

Video link
https://www.youtube.com/watch?v=L5iJm3AojGU

Selected Publications

JOURNAL ARTICLES

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