CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE

Annual Report 2017

CZECH INSTITUTE
OF INFORMATICS
ROBOTICS AND
CYBERNETICS
CTU IN PRAGUE

Annual Report

2017

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CYPHY	Cyber-Physical Systems, Head Prof. Ing. Michael Šebek, DrSc.
INTSYS	Intelligent Systems, Head Prof. Ing. Vladimír Mařík, DrSc., dr. h. c.
IID	Industrial Informatics, Prof. Dr. Ing. Zdeněk Hanzálek
RMP	Robotics and Machine Perception, Head Prof. Ing. Václav Hlaváč, CSc.
IPA	Industrial Production and Automation, Head Prof. Ing. Michael Valášek, DrSc.
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ČVUT

ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

Č.j. 27/2013/31937

V Praze dne 20.6.2013

ZŘIZOVACÍ LISTINA

Na základě rozhodnutí Akademického senátu ČVUT ze dne 22.5.2013 vydávám dle § 9 odst. 1 písm. a) z.č. 111/1998 Sb. v platném znění

zřizuji dnem 1.7.2013

Český institut informatiky, robotiky a kybernetiky

ve smyslu ust. § 22 odst. 1 písm. f) z.č. 111/1998 Sb. v platném znění jako vysokoškolský ústav dle čl. 25 Statutu ČVUT.

Prof. Ing. Václav Havlíček, CSc.
rektor ČVUT

MISSION

"By creating fusions of research disciplines, CIIRC 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 the CIIRC CTU is to integrate information and cybernetic research and education at the CTU, building on partnerships with out-of-city centers as well as close collaboration with international research centers. CIIRC CTU creates research opportunities as well as provides educational workplaces with a scientific atmosphere, 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 is a modern research and educational institute 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 PhD students. All of them will work in the new CIIRC building built at the CTU premises in Prague, Dejvice (in operation since April 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 transferwithin 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 has been 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 menza canteen and to provide adequate physical facilities for the work of CIIRC. The other major task is to gradually build CIIRC up into a national scientific and teaching workplace on a European and international level.

NATIONAL CENTER FOR INDUSTRY 4.0

The National Center for Industry 4.0 (NCP4.0 – www.ncp40.cz) was established on 4 September, 2017 through collaboration with academic and industrial partners and professional organizations. The founding partners are CIIRC CTU, Brno University of Technology, VŠB – the Technical University of Ostrava, Siemens, ŠKODA Auto, the Czech Chamber of Commerce, JIC - South Moravian Innovation Center, SIC - Central Bohemia Innovation Centre, the Confederation of Industry of the Czech Republic, ABRA Software, DEL, Festo, KUKA Roboter CEE, SAP ČR, and SIDAT. Subsequently, other partners have also joined.
Our vision is to "Inspire & Make the Czech Industry 4.0". The NCP4.0 is charged with assisting in the implementation of the National Initiative Industry 4.0 at the national level by providing the research potential and knowledge transfer to Czech industry supporting mainly SMEs in implementing Industry 4.0 compatible solutions in the field of manufacturing. The main goals are implementing Industry 4.0 principles, increasing awareness of Industry 4.0 and Society 4.0 solutions, and forging cooperation between academic organisations and industrial partners by sharing best practices and technologies. Our international activities are also very important as this initiative is part of the EU RICAIP project (Research and Innovation Centre on Advanced Industrial Production) and has become one of the 30 new EU Digital Innovation Hubs.

FACILITIES

The new CIIRC Testbed for Industry 4.0, comprised of research, experimentation, and the demonstration facility, is based on state-of-the-art technology with a future outlook toward further development. It is well suited for prototyping, process improvement, product development and testing in a drive to investigate new concepts and methods that would improve the manufacturing processes and optimize manufacturing.
Lab Automotive R&D 4.0 is a specialized laboratory that was established as a result of cooperation with Škoda-Auto development in response to specific requirements of modern research and development in the automotive industry.
The laboratory is focused on HMI, UI, user requirements, acceptance tests, quality in product development (QFD), requirements on and functional testing of vehicle systems, with key emphasis on user interaction.
The other CIIRC CTU labs fall in two categories: –joint labs with different external partners (AVRAR - Association of Virtual and Augmented Reality, Eaton, Factorio Solutions, MAGIK Eye, Pocket Virtuality, and SmartPlan) and our internal labs (ČVUT Media Lab, Intelligent and mobile robotics, Robotic perception, and Robotics Development labs). The 3D printers (plastic and metal) are also available.

MAJOR EVENTS

The grand opening of the CIIRC CTU building
The grand opening of the CIIRC CTU building was held on Tuesday, May 2, 2017. The President of the Czech Republic Mr. Miloš Zeman and the Prime Minister of the Czech Republic Mr. Bohuslav Sobotka opened the new building, designed by Petr Franta.

The First Lady of the Sultanate of Oman visit
On 16 May, CTU and CIIRC CTU welcomed the Sultan Qaboos University delegation led by Her Majesty Dr. Mona al Said, a prominent member of the sultanate of Oman and the executive rector Professor Ali al Bemani. The aim of the meeting was to lay the foundation of a cooperative atmosphere in the areas of research and pedagogical activities, to present the future development priorities, and to discuss possibilities of joint projects personally with ČVUT representatives in order to initiate professor and student exchange in selected fields.

Visit by the Minister of Economy, Technology and Industry of Japan
On 21 August, 2017, CIIRC CTU was visited by Japan's Minister of Economy, Technology and Industry, Mr. Hiroshige Seko who has expressed key interest in Industry 4.0 and related research activities. The central theme was scientific-Czech-Japanese cooperation and the possibilities of its expansion especially in robotics, computer vision, and industrial automation. The Minister also spoke with Mr. Yutaka Nagashima, an employee of CIIRC CTU.

Engineering forum
Digitalization and corelating topics of Industry 4.0 (also called the 4th industrial revolution) are trends which, in the last couple of years, have significantly changed the world of mature industry having advanced production automation which corresponds to changes in the labour market. Presentations were given by Dr. Petr Kolář (CIIRC) as well as by representatives of other industrial partners.

AWARDS

2017 Longuet-Higgins Prize for fundamental contributions to computer vision. The award recognizes papers from the Conference on Computer Vision and Pattern Recognition, held ten years ago, which have had a significant impact on computer vision research. Awarded for (Philbin, Chum, Isard, Šivic, Zisserman, CVPR 2007).

2x 2017 Helmholtz Prize for fundamental contributions to computer vision. The award recognizes papers from the International Conference on Computer Vision held ten or more years ago which have had a significant impact on computer vision research. Awarded for (Šivic, Zisserman, ICCV 2003) and (Šivic, Russell, Efros, Freeman, Zisserman, ICCV 2005).
Photos here: https://www.ciirc.cvut.cz/two-prizes-awarded-to-josef-sivic-in-2017/

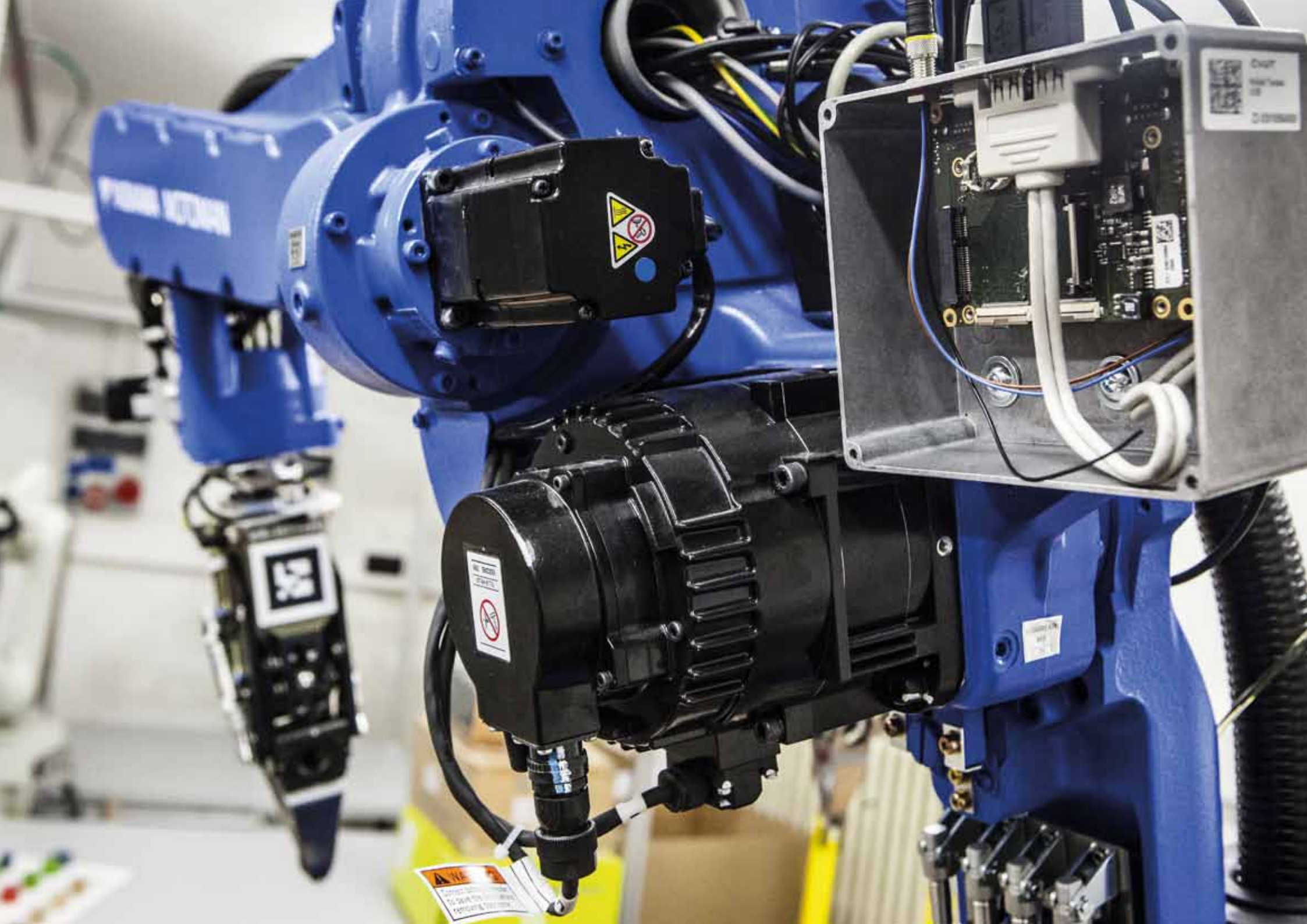
Google Cloud & YouTube-8M Video Understanding Challenge 2017 awarded, among 650 participating teams, to A. Miech, I. Laptev, J. Sivic, Learnable pooling with Context Gating for video classification, arXiv:1706.06905 (2017). https://www.kaggle.com/c/youtube8m

Annual Competition of Automated Theorem Proving Systems, the higher-order (THF) category, won by Ch. Brown for his system Satallax (CASC26 – http://tptp.org/CASC)

Google Faculty Research Award for J. Urban for collaboration with Google Research on topics combining Machine Learning and Automated Reasoning.
https://research.googleblog.com/2017/02/google-research-awards-2016.html

The Amazon Alexa Prize 2017 award for the second best social bot in competition with over one-hundred university teams. The CTU team made up of five students led by Jan Šedivý developed a conversational social bot named Alquist for Alexa intelligent speakers. The way humans interact with machines is at an inflection point, and Alquist is an advanced example of the latest Conversational Artificial Intelligence (AI). It is designed to converse coherently and engagingly with humans about popular topics such as sports, politics, news, movies, etc. The Conversational AI is leveraging several research areas including knowledge acquisition, natural language understanding, natural language generation, context modeling, commonsense reasoning and dialog planning. Alquist uses original algorithms researched in the CIIRC department of Intelligent Systems.

Medal of Merit was awarded by the President of the Czech Republic Miloš Zeman to Vladimír Mařík in October 2017.



SELECTED RESULTS

...excellence and applicability

A formal proof of the Kepler conjecture

A paper in the leading open access mathematical journal Forum of Mathematics - Pi, summarizes the formal verification of the oldest problem in discrete geometry - the Kepler conjecture. The conjecture states that no packing of congruent balls in a Euclidean three-space has density greater than that of the face-centered cubic packing (see picture).

The paper details the official published account of the pioneering formalization project referred to as Flyspeck led by Tom Hales. This large collaborative project took over ten years combining formalizations in the HOL Light and Isabelle proof assistants.

Thomas Hales, Mark Adams, Gertrud Bauer, TAT DAT DANG, John Harrison, Hoang Le Truong, Cezary Kaliszyk, Victor Magron, Sean McLaughlin, TAT THANG NGUYEN, QUANG TRUONG NGUYEN, Tobias Nipkow, Steven Obua, Joseph Pleso, Jason Rute, Alexey Solovyev, THI HOAI AN TA, NAM TRUNG TRAN, THI DIEP TRIEU, Josef Urban, KY VU, Roland Zumkeller, A formal proof of the Kepler conjecture. Forum of Mathematics, Pi, Vol. 5, 2017.

Decoupling, an open 80-year old problem

A long-standing, open problem of linear control theory, the decoupling by static-state feedback, has been resolved.

The earliest known investigation of system decoupling dates back to 1934. A rigorous formulation of the problem appeared in 1964, and a solution for square and invertible systems followed in 1967. A solution for the general case, however, has until now been unachievable.

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 single-input, single-output subsystems so that each system output can be independently controlled by a corresponding system input. The transfer matrix of the decoupled system is diagonal. That is why decoupling is also referred to as noninteractive control.

Such a structure is desirable in a number of applications since considerable conceptual simplicity can be accrued for subsequent system design. Decoupling can always be achieved using dynamic compensation, which increases the order of the system. The static-state feedback, however, does not increase the order and therefore may involve only internal dynamics.

A solution of this very complex problem is shown to depend on the existence of three lists of nonnegative integers conditioned by and only by system invariants with respect to the permissible transformations.

V. Kučera, Diagonal decoupling of linear systems by static-state feedback. IEEE Transactions on Automatic Control, 62 (2017), 12, 6250-6265.

Distortion varieties and clever elimination

The distortion varieties of a given projective variety are parametrized by duplicating coordinates and multiplying them with monomials. This study has explored their degrees and defining equations. Exact formulas have been obtained for the case of one-parameter distortions. These are based on Chow polytopes and Gröbner bases. Multi-parameter distortions are studied using tropical geometry.

The presented theory furnishes a new framework for formulating and solving minimal problems for camera models with image distortion. The theory of distortion varieties is useful to solve such systems by first eliminating all the unknowns that do not appear in the linear equations, and then extending solutions to the rest of unknowns.

This can be generalized to fully non-linear systems by linearization via lifting. We demonstrate that this approach leads to more efficient solvers in three problems of partially calibrated relative camera pose computation with unknown focal length and/or radial distortion. This approach also generates new and interesting constraints on the fundamental matrices of partially calibrated cameras, which were not previously known.

J. Kileel, Z. Kúkelová, T. Pajdla and B. Sturmfels. Distortion Varieties. Foundations of Computational Mathematics. Springer. 2017. (doi.org/10.1007/s10208-017-9361-0).
Z. Kúkelová, J. Kileel, B. Sturmfels, T. Pajdla. A clever elimination strategy for efficient minimal solvers. CVPR 2017.

Energy optimization of robotic cells

Energy optimization of industrial robotic cells is undoubtedly essential for long-term, sustainable development.. As a result the institute decided to extend the robot programming tools through a new optimization algorithm. The algorithm is used by the designers of robotic cells to reduce energy consumption without deterioration in the throughput. The crucial requirement states that optimization should take only a short time (e.g., less than 30 seconds) for robotic cells with up to 12 robots. Therefore, it is of utmost importance to design very efficient optimization algorithms.

The institute's solution optimizes many aspects such as robot speeds, path selection, the order of operations, and power saving modes of robots. Researchers have proposed a parallel hybrid heuristic which uses the processor cores and a particular simplex method to reduce runtime significantly.

Finally, practitioners verified optimization potential of this algorithm on a robotic welding cell at Skoda Auto. The outcomes indicated that consumption could be reduced by roughly 20% merely by optimizing the speed of the robots and applying power-saving modes.

L. Bukata, P. Šůcha, Z. Hanzálek, P. Burget, Energy Optimization of Robotic Cells, IEEE Transactions on Industrial Informatics, 13 (2017), 1, 92-102.

Towards driverless cars: a hybrid nonlinear predictive controller with an adaptive horizon

An original algorithm for car motion predictive control has been developed that is optimal for both hybrid car dynamics and hybrid minimization criterion. The method appears to surpass all existing approaches as it handles more realistic conditions, allows more efficient computations and results in much better performance.

Driverless cars attract enormous attention. To replace the human-driven cars on a large scale, their performance, safety, reliability must still improve, while the price itself must drop. This challenge calls for better control-theoretic methods leading to improved practical algorithms. Even though the modern model predictive control - MPC - approach is already in practice, it remains limited to simply pure linear cases that sacrifice performance quality to reduce computational complexity. There have been only few attempts to use the nonlinear MPC limit as applied to steering control.

The new nonlinear MPC method provides steering, acceleration, as well as braking control. It handles strongly nonlinear phenomena such as side-slipping effects, satisfies safety constraints, and even maximizes performance indicators. Thanks to an original hybrid nonlinear predictive control algorithm, the information about hybridity is directly incorporated into the optimization routine. To significantly reduce computational burden while still preserving maneuverability-related properties of the car, the institutes research has successfully incorporated adaptive prediction horizon strategies.

The solutions have been verified and compared with the published approximation-based nonlinear predictive control and commercial products on an industrial benchmark of racing car motion control. The robustness of the solution has been evaluated by a detailed scenario-based sensitivity analysis concerning various system and environmental parameter perturbations and scenarios, such as the no-gas-no-braking case, driving across rougher terrain and a range of road surfaces and profiles, and accounting for aerodynamic imperfections.

This research has been conducted through close cooperation between the Department of Control Engineering, Faculty of Electrical Engineering, CTU and with the Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic.

Pčolka, M; Žáčeková, E; Čelikovský, S; Šebek, M: Towards a Smart Car: Hybrid Nonlinear Predictive Controller with Adaptive Horizon. IEEE Transactions on Control Systems Technology, accepted for publication, 2017. ISSN 1063-6536.

Eye movement monitoring

Eye tracking is the measurement of eye activity that can be used in many different applications: marketing design (websites, store shelves, promotional materials); transport safety (sleep, pavement, distraction); help for the disabled (control of a PC or other devices); and in medical applications (diagnostics and therapy - nystagmus, schizophrenia, dyslexia, etc.).
Two hardware settings are used: head mounted and distant tracker. The developed software consists of several subsystems for recording, visualization and evaluation. Testing competences is one of the most recent application areas. A test environment has been developed for the effective assessment of selected skills and competencies, with an emphasis on flexibility, decision making, problem solving and stress resistance.

M. Dobiáš, J. Doležal, V. Chytrý, A. Klesalová, P. Kozelka, and J. Černohous, Determining a strategy for problem solving based on eye movements, Ad Alta: Journal of Interdisciplinary Research, 7 (2017), 1, 26-27.
M. Dobiáš, J. Doležal, A. Klesalová, V. Chytrý, J. Erlebach, V. Fabián, and M. Urban, Eye tracking methodology for human resources competence testing (In Czech: Metodika sledování očních pohybů pro testování kompetencí v personalistice) Applied Certified Methodology, 2017.

Semiological features of epileptic seizures

Across the spectrum of advancements in the treatment of epilepsy, there still remains the unresolved matter of some patients whose problems cannot be treated by antiepileptic drugs whereby the only recourse is surgery to treat their epilepsy. The precise location of the seizure's focal point is crucial for achieving positive effects through this means. The effectiveness of this approach relies not only on imaging methods, but also on important information gathered through the observation of the patient's behavior during a seizure (ictal signs). There is a number of frequent ictal signs that have already been used in diagnostics for several decades but this list is certainly not exhaustive. Recently, some new ictal signs have been introduced that are less frequently observed. asTheir description is based on data provided by 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 lengthy manual review of video records documenting the patience seizures.
A novel approach has been suggested toward identification/ verification of new ictal signs based on a computer supported systematic review of a unique, extensive dataset compiled at the Na Homolce Hospital containing approximately 1,000 seizures (representing data of 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, performing statistical analysis, as well as for analyzing sequence patterns. Toward this end, the SW tool ASTEP has been developed that significantly simplifies this transformation.

M. Nová, L. Vysloužilová, Z. Vojtěch, and O. Štěpánková, Towards computer supported search for semiological features in epilepsy seizure classification, Proceedings of the IUPESM 2018 (World Congress on Medical Physics and Biomedical Engineering), Prague 2018, to be published by Springer.

NetVLAD:
CNN architecture for weakly supervised place recognition

The institute has tackled the problem of large-scale visual place recognition where the task is to quickly and accurately recognize the location of a given query photograph. This is an important problem with applications in autonomous driving, augmented reality or geo-localizing archival imagery.
To date, the following four principal contributions have been presented. First, a convolutional neural network (CNN) architecture has been developed that is trainable in an end-to-end manner to address the task of place recognition.. The main component of this architecture, NetVLAD, is a new generalized VLAD layer, inspired by the "Vector of Locally Aggregated Descriptors" image representation commonly used in image retrieval. The layer is readily pluggable into any CNN architecture with the capacity for training via back propagation. Second, researchers have created a new weakly supervised ranking loss, which enables end-to-end learning of the architecture's parameters from images depicting the same locations over time downloaded from Google Street View Time Machine. Third, researchers have developed an efficient training procedure which can be applied on very large-scale, weekly-labelled tasks. Finally, researchers have shown that the proposed architecture and training procedure significantly outperform non-learnt image representations and off-the-shelf CNN descriptors on challenging place recognition and image retrieval benchmarks.
The example result shows that our trained image descriptor (NetVLAD) correctly recognizes the location of the query photograph despite the large amount of clutter (people, cars), detects changes in viewpoint as well as from completely different levels of illumination (ie.e. night vs daytime).

Arandjelovic, R., Gronat, P., Torii, A., Pajdla, T. and Sivic, J., NetVLAD: CNN architecture for weakly supervised place recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence, 10.1109/TPAMI.2017.2711011, (2017)

Verified laser technologies

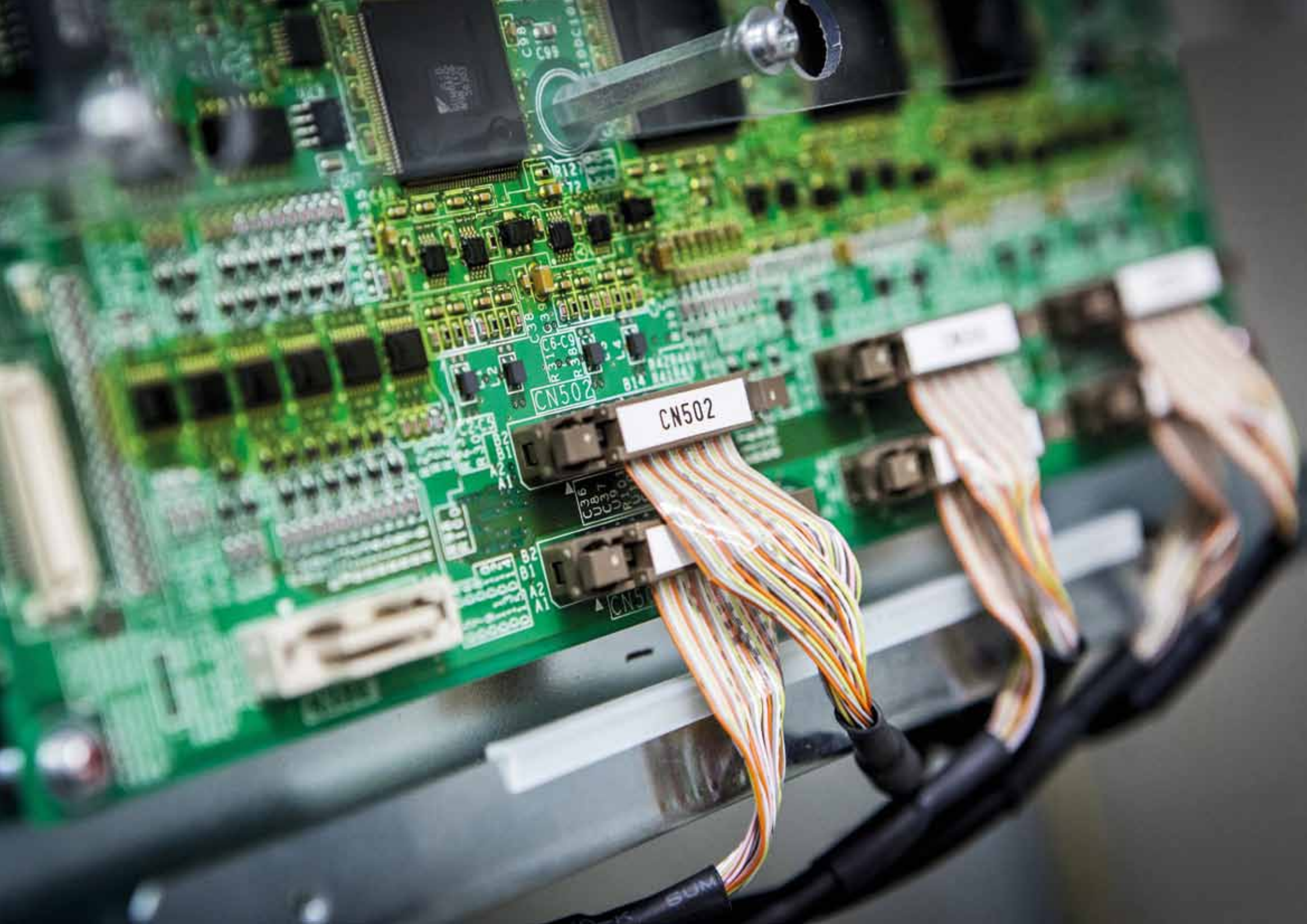
Verified technology of making cut-outs in a special material using lasers corresponds with real-life production practices, and the sets of parameters used in manufacturing the control grid of a tetrode by using laser technology. The tetrode is a thin-walled cylindrical part made of pyrolytic carbon. The developed technology replaces the original, inefficient manufacturing technology by means of punching. Another verified technology of making structured surfaces in a special material using a laser corresponding to production practices and the set of modification parameters applying to the cutting tool using laser technology. The first step of the modification is the production of a special complex shaped macrogeometry (a chip-breaker) on the rake face. Subsequently, the functional microstructure is created on the surface of the chip-breaker. This solution gives improved cutting ability with respect to friction properties, tool life and the chip formation process.

Developed by P. Zeman, P. Kožmín, and P. Žižka

Semantic Big Data Historian

A functional prototype of Semantic Big Data Historian was developed within the framework of Rockwell Automation – Distributed Intelligence Control Laboratory (RA-DIC). The tool aims to reduce semantic heterogeneity of data gathered from industrial processes as well as integrate with external data resources.
The solution is built upon the semantic web (OWL ontologies) and Big Data technologies (Apache Spark, Apache Cassandra). In the first case, the solution provides high expressivity and flexibility, while in the latter case, it provides scalability. The system architecture is organized in four layers starting with the data acquisition layer that is responsible for platform integration (sensors, additional internal and external data sources). The next layer transforms data into the semantically unified formed using COCI ontology. The third layer is responsible for data storage implemented as a Big Data Triple-Store (Apache Spark and Apache Cassandra cluster). The last layer provides analytical features and currently offers functionality based on KNIME and Apache Spark.

Developed by V. Jirkovský, M. Possolt, and P. Kadera


CN502
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A1

RESEARCH PROJECTS

...on track to achieving excellence

ESIF – European Structural and Investment Funds
OP RDE – Operational Programme Research, Development and Education

Despite strong proposals from competing applicants, the CIIRC CTU succeeded in three exceptional projects in the "Support to Excellent Research Teams" Call of the OP RDE. The projects with total eligible costs of over 400 mil. CZK (€15M) will provide leading experts with facilities at CIIRC CTU, similar to those found at their prestigious home research institutions abroad.

AI&Reasoning – Artificial Intelligence and Reasoning
CZ.02.1.01/0.0/0.0/15_003/0000466, 2017 – 2022
Principal investigator: Mgr. Josef Urban, Ph.D., beneficiary of an ERC Consolidator Grant
Eligible expenses: CZK 127.3 million

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

Main focus:
- Development of autonomous artificial intelligence systems in large-scale theory automated reasoning
- 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

IMPACT – Intelligent Machine Perception
CZ.02.1.01/0.0/0.0/15_003/0000468, 2017 – 2022
Principal investigator: Dr. Ing. Josef Šivic, beneficiary of an ERC Starting Grant
Eligible expenses: CZK 122.6 million

"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:
- Research of computer vision and machine learning
- Development of tools for synthesizing complex future predictions from aligned past visual experiences.
- Analysing dynamic patterns in shared visual experience

Strategic international partners: INRIA (France)

R4I – Robotics for Industry 4.0
CZ.02.1.01/0.0/0.0/15_003/0000470, 2017 – 2022
Principal investigator: Prof. Dr. Ing. Robert Babuška, founder of the TU Delft Robotics Institute
Eligible expenses: CZK 153.5 million

"We will contribute to the development of future intelligent robots with a high degree of autonomy that will be capable of perceiving and handling objects. The machines must be able to safely cooperate with people and to work reliably, even under unfavourable conditions."

Main focus:
- Mobile and autonomous robotics
- Machine perception
- Networked control systems and mechatronic structures

Strategic international partners: TU Delft (the Netherlands)
National partners: The Brno University of Technology, CEITEC; The NTIS Centre at the University of West Bohemia, Plzeň

European Union's Horizon 2020

AI4REASON: Artificial intelligence for extensive computer assisted reasoning
Project No. 649043, ERC Consolidator Grant, 09/2015 – 08/2020
Principal investigator: Dr. Josef Urban
The purpose of the AI4Reason project is to develop automated methods for performing computer reasoning and proving theorems, using extensive formal theories and knowledge bases. These methods are necessary to perform computational verification of large mathematical theories, software and hardware, and other advanced knowledge-based systems and technologies.

RICAIP: Research and Innovation Centre on Advanced Industrial Production
Project No. 763559, WIDESPREAD-04-2017-Teaming Phase1, 09/2017 – 08/2018
Coordinator: CIIRC CTU, Principal investigator:
Prof. Vladimír Mařík
Czech-German research project of four academic partners: two institutes of leading Czech technical universities, CIIRC CTU and BUT-CEITEC as well as two leading German research organizations DFKI and ZeMA. The RICAIP project was successful in the first phase of the Teaming H2020 call. Now the consortium strives to succeed in Phase 2.
RICAIP main principles:

- Designed as a core research facility – a distributed testbed for advanced, industrial production
- Geographically spread out, however, providing fully virtually integrated research infrastructure
- Allowing remote control as well as multi-site and multi-task operations
- Driving force for innovative industrial production process, technologies, standardization
- Operated on open access principles

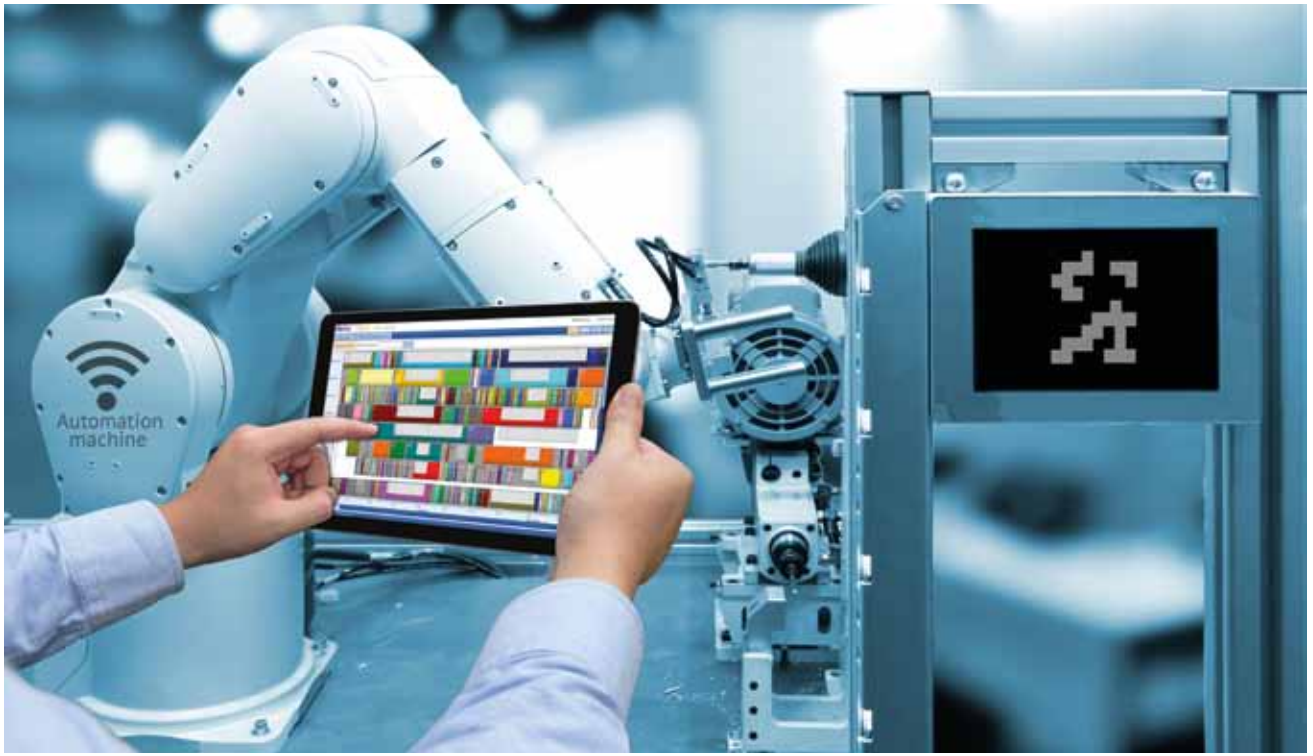
Other selected EU H2020 / EU FP7 Projects:

Project Title	Agency / Call	Ref. No.	Implementation Period
LADIO: Project: Live Action Data Input/Output	EU H2020	731970	12/2017 – 05/2018
DIGICOR: Decentralised Agile Coordination Across Supply Chains	EU Horizon 2020-IND-CE	723336	10/2016 – 09/2019
RadioRoSo: Radioactive Waste Robotic Sorter	EU FP7 ECHORD++	601116	09/2016 – 02/2018
SafeLog: Safe human-robot interaction in logistic applications for highly flexible warehouses	EU Horizon 2020-ICT	688117	01/2016 – 12/2019
UP-Drive: Automated Urban Parking and Driving	EU Horizon 2020	688652	01/2016 – 12/2019
TRADR: Long-Term Human-Robot Teaming for Robot Assisted Disaster Response	EU FP7 – ICT	609763	11/2013 – 12/2017

Competence Centres Programme

CAK: Centre for applied cybernetics
Project No. TE01020197, Technology Agency of the Czech Republic, 01/2012 – 12/2019
Principal investigator: Prof. Ing. Vladimír Kučera, DrSc., dr. h. c.
The program is focused on the development of long-term collaboration between the public and the private sectors. The project operates nationwide, involving 16 partners, of which are 4 public universities, 3 large-size enterprises, 2 medium-size and 7 small-size companies. The research and development activities include:

- Modeling and control of production, distribution and conversion of electric power
- Intelligent man-machine interaction
- Machine perception and image analysis
- Optimization tools for industrial informatics.



List of Other Research Projects

Project Title	Agency / Call	Ref. No.	Implementation Period
GenomKit	MPO TRIO II.	FV30421	01/2018 – 12/2021
Predictive modelling of student performance using learning resources	GAČR	GJ18-04150Y	01/2018 – 12/2020
Development of a modern modular system for teaching mechatronics in line with the Industry 4.0	TAČR Epsilon	TH03010448	01/2018 – 12/2020
TAČR 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	TAČR Epsilon	TH03010369	01/2018 – 12/2020
DAMiAS - Data-driven Asset Management in Automobile Industry Based on Semantic Modelling	TAČR Delta IV.	TF04000054	01/2018 – 12/2019
MWPharmASIA: database extension of drug substances and their MWPharm models for East Asian population and development of NGS diagnostic panel and algorithm for predicting statin pharmacokinetics/dynamics	TAČR Delta V.	TF05000020	11/2017 – 11/2019
ImitRob: Imitation learning supported by language for industrial robotics	TAČR Zéta I	TJ01000470	10/2017 – 09/2019
QUADSHAPE: Time-delay control laws for upcoming transportation UAV systems	MŠMT: INTER-EXCELLENCE	LTAUSA17103	09/2017 – 12/2019
OZAS - Personal Health Assistance Systems	MPO TRIO II.	FV20696	07/2017 – 06/2021
COPA - Control Platform for High-Accuracy Microelectronics Assembly	MPO TRIO II.	FV20403	07/2017 – 06/2021
Research and project concept of a multifunctional robotic effector of an underground multirobot for storage of disposal casks in a deep geological repository, and the realization of a prototype of dual robotic effector module and its master control system	MPO TRIO II.	FV20197	06/2017 – 12/2019
Institutional support of the Czech Technical University in Prague	MŠMT	CZ.02.2.69/0.0/0.0/16_015/0002382	05/2017 – 12/2022

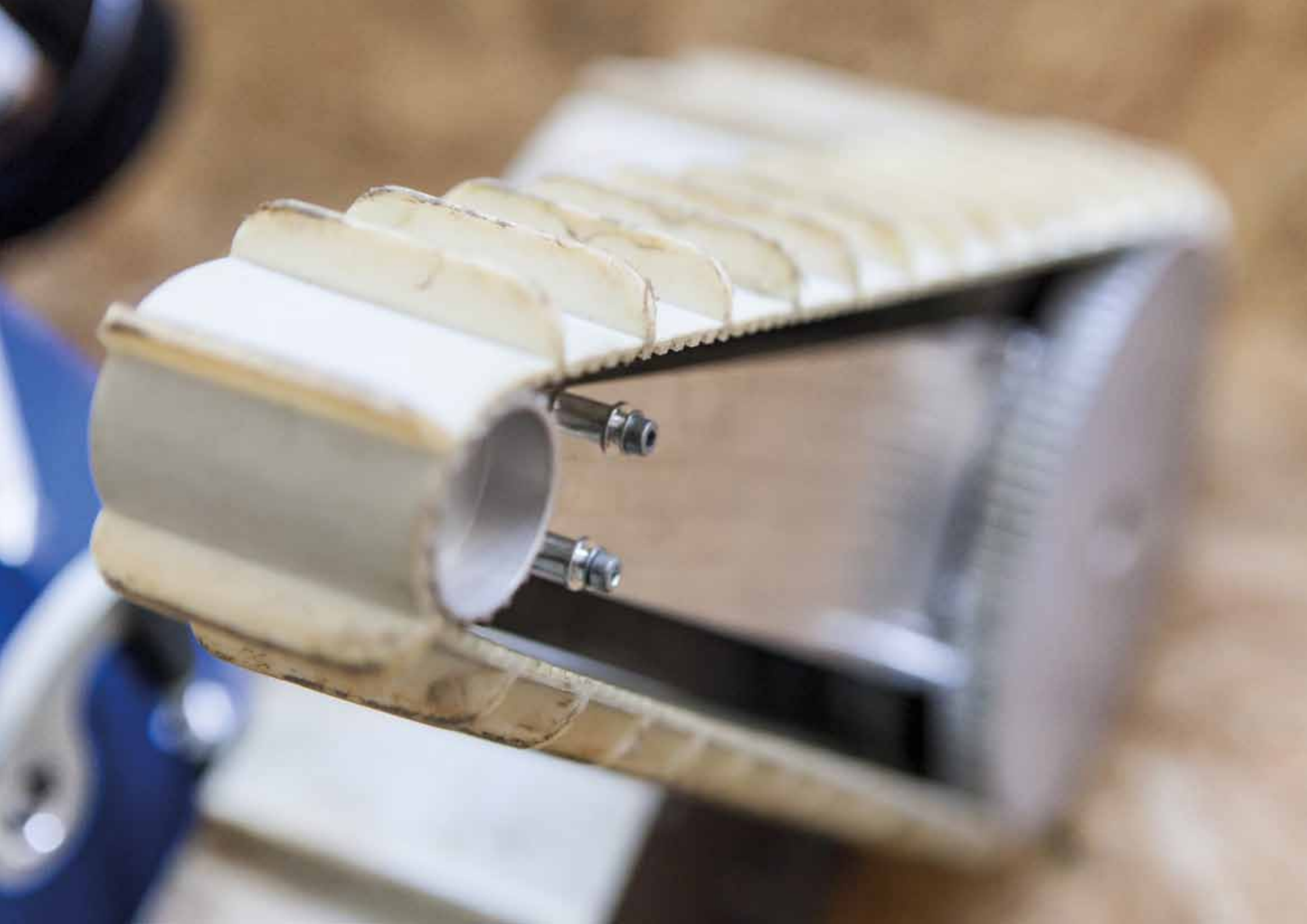
Project Title	Agency / Call	Ref. No.	Implementation Period
KnowDrift: Knowledge-Driven Industrial Robotics for Flexible Production	Die Öster. Forschungsförde rungsgesellschaft mbH (FFG), Produktion der Zukunft 2016	858707	03/2017 – 08/2019
NaoSkin: Robot self-calibration and safe physical human-robot interaction inspired by body representations in the primate brain.	GAČR	GA17-15697Y	02/2017 – 12/2019
Kassandra - multi-camera vehicles' undercarriage security scanner	Ministry of the Interior	VI20172020080	01/2017 – 04/2020
Smart Camera - New Generation Monitoring Center	Ministry of the Interior	VI20172019082	01/2017 – 12/2019
Temporal context in analysis of long-term non.stationary multidimensional signal	GAČR	GA17-20480S	01/2017 – 01/2019
KONPOLA: A robotic cell for inspection of painted parts in industrial manufacturing.	OP EIC - Operational Programme Enterprise and Innovation for Competitiveness	CZ.01.1.02/0.0/0.0/ 15_019/0004939	10/2016 – 09/2019
Technology for industrial robots integration into production systems based on Industry 4.0	MPO	FV10299	09/2016 – 08/2019
Sounds: Processing of complex sounds in the central auditory system under normal and pathological conditions	GAČR	GC16-09086J	02/2016 – 12/2018
EERA_CZ: The involvement of Czech research organizations in the EERA Energy Research Alliance	MŠMT EUPRO	LE 15024	01/2016 – 12/2017
FLOPP: The factory of the future – FLexible, Optimized and Controllable Production Platforms.	OP EIC - Operational Programme Enterprise and Innovation for Competitiveness	CZ.01.1.02/0.0/0.0/ 15_019/0004688	01/2016 – 09/2019
FOREST: Flexible Scheduling and Optimization Algorithms for Distributed Real-time Embedded Systems	GAČR	GA16-23509S	01/2016 – 12/2018

Project Title	Agency / Call	Ref. No.	Implementation Period
TDS: Time delay compensators for flexible systems	GAČR	GA16-17398S	01/2016 – 12/2018
AZV-DIABETES: Individual dynamics of glycaemia excursions identification in diabetic patients to improve self-managing procedures influencing insulin dosage	MZD ČR	NV15-25710A	05/2015 – 12/2018
CRT: Features of Electromechanical Dyssynchrony that Predict Effect of Cardiac Resynchronization Therapy	MZD ČR	NV15-31398A	05/2015 – 12/2019
SeLeCt: Structures, Learning, Cognition	GAČR	GA15-04960S	01/2015 – 12/2017
Symbolic Regression for Reinforcement Learning in Continuous Spaces	GAČR	GA15-22731S	01/2015 – 12/2017
LASER: Advanced Laser Technology	TAČR Alfa	TA04011000	07/2014 – 12/2017

Note:
TAČR - Technology Agency of the Czech Republic
GAČR - Grant Agency of the Czech Republic
MPO – Ministry of Industry and Trade of the Czech Republic
MŠMT – Ministry of Education, Youth and Sports of the Czech Republic

Ph.D. Education

There were 54 Ph.D. students enrolled in different Ph.D. study programs at CTU who were supervised by the CIIRC staff members and participated in the CIIRC research projects in 2017.



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...publish and flourish

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