2019

Annual Report of Department of Robotics

Faculty of Mechanical Engineering

VŠB – Technical University of Ostrava

Czech Republic

27th January 2020

VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF MECHANICAL ENGINEERING | DEPARTMENT OF ROBOTICS

Annual Report 2019

Department of Robotics

Faculty of Mechanical Engineering,
VŠB – Technical University of Ostrava,
Czech Republic

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1. CONTENT

2. DEPARTMENT PROFILE

Since its foundation (1989), the Department of Robotics has been focused on the issue of robotics at all levels of education, in science and research and in professional practice. In accordance with the current trends, the department staffs and PhD students develop the topics of service robotics and robotics and the application of robots outside of engineering. This is reflected in research, teaching and publishing. In this respect, grants, contract research and topics of diploma and doctoral theses are based on research. The department provides several fields of study - Robotics, as part of the bachelor's study program in Mechanical Engineering and subsequently also in the follow-up master's program in the study program Mechanical Engineering at the Faculty of Mechanical Engineering. The department also guarantees the doctoral program of the same name Robotics and the bachelor study program Mechatronics.

The Department also intensively focuses on new topics related to the Industry 4.0 concept, in particular the areas of collaborative robotics, IoT, digital twins, etc. In this area, it works closely with a number of automotive companies in our region.

The areas of interest of the Department of Robotics can be divided into: design, operation, construction, testing and diagnostics, simulation, measurement, control and sensors, dynamics, use of computer support to solve problems and innovations in the field. The Department also profiles students interested in the design and implementation of control systems designed for process and visualization control levels in mechatronic systems. Emphasis is mainly on industrial PCs and their properties, including methods of ensuring the required reliability of operation. The Department enables students interested in master and doctoral studies to complete selected courses at the Faculty of Electrical Engineering and Computer Science of our University in the form of an individual study plan.

Teaching and research activities of the department are also focused on mathematical modelling of mechanisms and their drives in terms of control, design of technical and software means of control systems of positioning mechanisms and sensory subsystems, including image processing technology for various applications, tools and methods - including optimization – design of mechatronic systems. The scientific and research activities of the department lead to the strengthening of the department's profile in the field of service and collaborative robotics, methods and tools for designing relevant systems, as an obvious trend of the coming years with wide application possibilities.

The Department actively offers study internships for foreign students under the Erasmus+, IAESTE, etc. programs.

The staffs of the department and students solve the theoretical and application tasks corresponding to the given specialization. Teaching takes place in the Robotics Centre, in various types of industrial and collaborative robots and their subsystems, in service robotics laboratories and in CAD systems classrooms. Robotics and mechatronics are characterized by broad and comprehensive use of computer support for all areas of activity. Classrooms of CAD systems are equipped with appropriate software tools.

3. PEOPLES

Head of Department:	Prof. Dr. Ing. Petr Novák
Vice Head:	Ing. Václav Krys, Ph.D.
Secretary:	Ing. Petr Široký
Assistant:	Ing. Tereza Fittlová
Professors:	Vladimír Mostýn, Petr Novák
Associate professors:	Zdeněk Konečný, Zdenko Bobovský
Assistant professor:	Ing. Ladislav Kárník, Ph.D.. Ing. Václav Krys, Ph.D., Ing. Milan Mihola, Ph.D. Ing. Jan Lipina, Ph.D. Ing. Petr Široký Ing. Jiří Suder Ing. Aleš Vysocký, Ph.D. Ing. Robert Pastor Ing. Michal Vocetka Ing. Stefan Grushko
Scientist researchers	
	Ing. Ján Babjak, Ph.D. Ing. Tomáš Kot, Ph.D. Ing. Dominik Heczko Ing. Jakub Mlotek Ing. Petr Oščádal Mgr. et Mgr. Richard Papřok Ing. Zdeněk Zeman Bc. Vyomkesh Jha Kumar
Technicians:	Karel Ranocha

4. EDUCATION ACTIVITIES

4.1. Guaranteed study fields

4.1.1. Bachelor Fields of Study

Title: **Robotics**
Item number: **23 01R013-T70**
Guarantor: **Associate professor, Ing. Zdenek Konecny, Ph.D.,**
Graduate Profile:

Bachelor graduates in this field will be employed as designers of robot elements, manipulators and peripheral devices of robotized workplaces / conveyors, bins, heads of industrial robots etc./, but also as designers of these devices and especially operational technicians ensuring operation, adjustment, programming, diagnostics, maintenance and repair. Application possibilities are not limited to mechanical engineering, as robots are quickly applied in a number of other sectors such as agriculture, healthcare, glass, food, textile and shoe industries, services etc. Due to this trend, one can speak of the possibility of universal promotion of this technique.

In addition to the necessary theoretical background, graduates will gain practical experience at robotized workplaces in newly built laboratories of industrial robots. The direct part of the study is the mastering of computer work for the whole spectrum of activities, starting with the use of text editors, spreadsheets and designing using CAD systems, to the use of computers in robot control systems and automated devices.

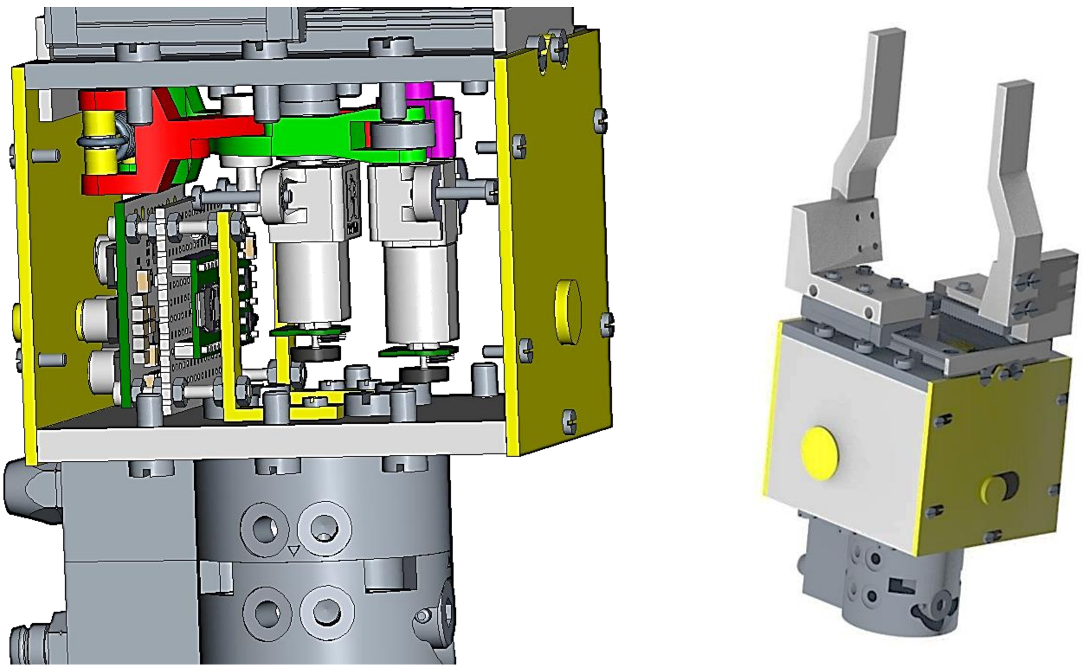


Fig. (Bc.) Adam Boleslavský ***Mechanical Design of Effector for ABB robots,*** *Bachelor Thesis, supervisor – Associate professor Zdeněk Konečný, Ph.D.*

Title: **Mechatronics**
Item number: **B0714A270002**
Guarantor: **prof. Dr. Ing. Petr Novák, Assoc. professor, Ing. Zdenko Bobovský, Ph.D.** – since November 2019
Graduate Profile:

The aim of the three-year Mechatronics study program is to educate graduates with broad practical skills and basic theoretical knowledge in the multidisciplinary field of Mechatronics. Students will acquire the necessary targeted knowledge and skills by completing a number of courses from the Faculty of Mechanical Engineering and also from the Faculty of Electrical Engineering and Computer Science, especially in the areas of automation, electrical engineering and electronics, mechanical engineering and robotics. Graduates of the bachelor study program Mechatronics have the knowledge needed to work with complex structure systems that they are interconnected mechanical, electrical and control subsystems. They have knowledge of measurement, synthesis of control systems, design knowledge of the properties and applications of actuators and sensors. Knowledge of mechanics, measurement and signal processing allows them to solve application tasks in the field of control systems with high dynamics and high demands on the resulting utility machine properties. They know basic methods of synthesis of mechatronic systems and they know the tools of computer support of their design.

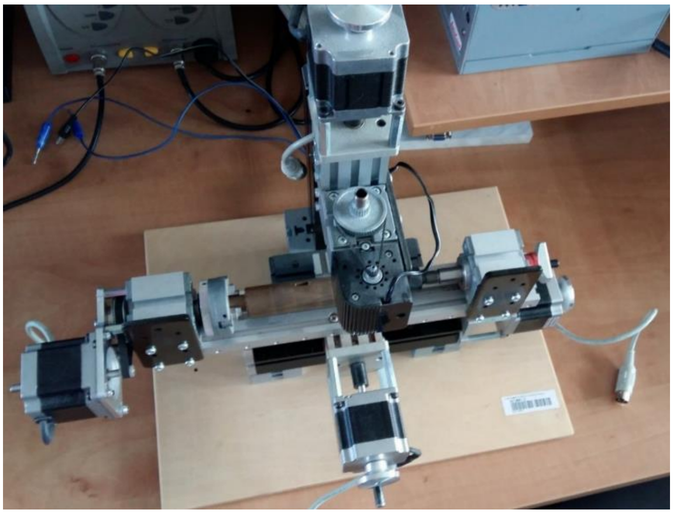


Fig. (Bc.) Aaron Robin Sitek, *Unit for Controlling Step Motors, Bachelor thesis, supervisor: Assoc. professor. Jaromír Škuta, Ph.D. – Department of Control Systems and Instrumentation.*

Graduates are prepared to carry out activities within the design, commissioning and operation of mechatronic systems with applications in various types of production with different technologies. They are able to solve the links between mechanical, electrical and control subsystems with respect to the Industry 4.0 concept.

4.1.2. Magister Fields of Study

Title:	Robotics
Item number:	23 01T013-00
Guarantor:	Prof. Ing. Dr. Ing. Petr Novák

Graduate Profile:

The specialisation "Robotics" is focused on design, construction and control of industrial robots and manipulators and their subsystems. The field is also focused on designing robotized technological workplaces, including their control, and issues of current legislation and safety regulations. In connection with current trends in robotics, the course is also focused on the issue of service robotics and for those interested in biorobotics. Part of the study of the field is a comprehensive mastery of powerful computer-aided design systems such as Creo Parametric and other computational and simulation systems, suitable for advanced modelling and simulation in the field of industrial and service robotics. Considerable attention is paid to the methodology of creating technical systems and the methodology of support of the innovation process based on TRIZ technology, including computer support of these activities. The field of Robotics is therefore very complex, the primary machine focus has a large overlap into related areas such as control, sensor technology, drive systems and computer science. In the final phase of their studies, students learn about the latest developments in the Industry 4.0 concept, such as IoT, augmented reality and the digital twin. They can apply these new skills in the development of their theses.

Graduates of the Robotics field of study have knowledge in the design of industrial robots and manipulators, design of robotized technological workplaces and creation of service robotic systems, including their deployment. The knowledge in the field of mechanical engineering is complemented by the necessary knowledge in the field of control and sensor technology, software engineering, design of control systems both in software and hardware, as well as knowledge in the field of electronics, machine vision and drives. Graduates are ready to solve engineering tasks in the field of automation and robotics of engineering production, application of service robots in production or services. In the field of designing production systems with industrial robots, graduates have the necessary knowledge of securing their operation, maintenance, reliability, safety, adjustment and programming of robotized workplaces.

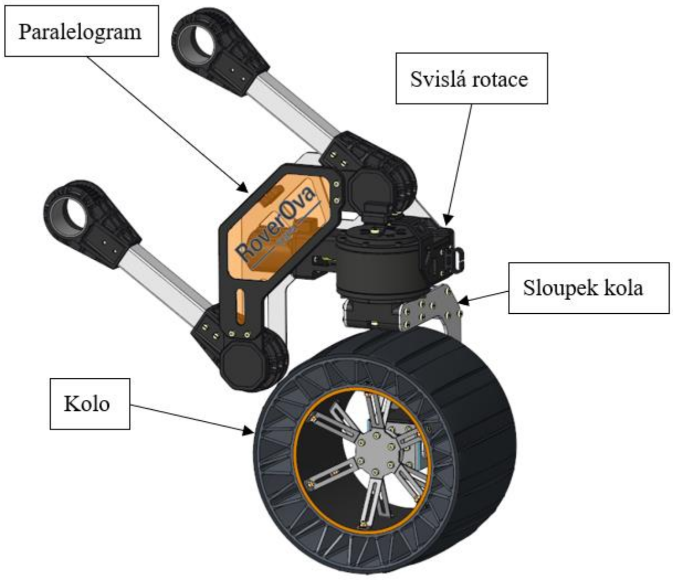


Fig. (Ing.) Bc. Zdeněk Zeman, Mechanical Design of a Wheel with Active Steering, diploma thesis, Supervisor: Ing. Robert Pastor (Execution for K3P4 mobile robot and testing at European Rover Competition (ERC) 2019 in Kielce – Poland.

Also gained is the knowledge gained in the use of high-performance computer support systems for design, design, modelling, simulation, programming, control, etc., which are fully usable outside the studied field. Graduates will be employed as designers, designers, operation engineers, specialists for various areas of computer applications - CAD, CAI, covering in addition to design activities and design and the entire field of technical preparation of production and product life cycle management (PLM systems).

4.1.3. Doctoral fields of study

Title:	Robotics
Field of Study:	2301V013
Guarantor:	prof. Dr. Ing. Vladimír Mostýn

Graduate Profile:

Graduates will learn the methodology of scientific work in the area of applied research and development of industrial and service robots and their applications with a significant application of the mechatronic approach to the development of these complex technical systems. In the area of creation and solution of innovative tasks the graduates will acquire basic methodological and scientific procedures, in the area of construction the graduates will acquire relatively extensive knowledge in the area of creation and optimization of mechanical subsystem with computer support, perception of the environment and communication with humans and in the field of propulsion subsystems are knowledge of new electric, hydraulic and pneumatic drives and their applications. The aim of the study is to deepen the theoretical knowledge of the master's degree, to understand the context and to combine this knowledge to acquire a mechatronic complex approach to the creation of robot-engineering systems in the area of production and service activities.

(*Note: the pictures used, are from projects, bachelor's, master's and doctoral´s theses of students.*

4.2. List of defended theses

4.2.1. Bachelor theses

	Student	Supervisor	Topic
1.	Jan Bém	Ing. Robert Pastor	Soil Sample Storage System
2.	Bc. Adam Boleslavský	doc. Ing. Zdeněk Konečný, Ph.D.	Design of Effectors for Laboratory Tasks on ABB Robots
3.	Tereza Kanisová	Ing. Ladislav Kárník, CSc.	Design of a Manual Telescopic Grabber
4.	Michal Konečný	Ing. Lukáš Podešva	Detailed Development of the Packing Line Module - Effector for Manipulation with Sets of Objects
5.	Tomasz Kowalczyk	Ing. Michal Vocetka	Design of End Effector for Cardboard Box Palletizing
6.	Jakub Krejčí	Ing. Lukáš Podešva	Detailed Development of the Packing Line Module - Palletisation Portal Manipulator
7.	Marek Mihálik	Ing. Tomáš Kot, Ph.D.	Docking Station of the Robot ABB IRB 14000 - YuMi
8.	Libor Pavlík	Ing. Aleš Vysocký, Ph.D.	Design of the Drive Unit for Hand Trolley
9.	Marek Ročňák	Ing. Michal Vocetka	Detailed Development of the Packing Line Module – Objects Accumulation Conveyor
10.	David Smékal	Ing. Milan Mihola, Ph.D.	Expansion of the 3D Printer REBEL II on the Possibility of PCB Milling
11.	Tomáš Spurný	doc. Ing. Zdeněk Konečný, Ph.D.	Design of a Robot Effector with Variable Grip Width and Great Force
12.	Adam Stehlík	doc. Ing. Zdenko Bobovský, PhD.	Soft Robotics and its Applications
13.	Luboš Varecha	Ing. Milan Mihola, Ph.D.	Construction Design of Belt Conveyor for the Transport of Oil Pumps
14.	Rostislav Wierbica	doc. Ing. Zdeněk Konečný, Ph.D.	Design of an Effector for Manipulating whit Fragile Objects

Fig. Graduates of Bachelor study - Robotics

4.2.2. Diploma theses

	Student (bc)	Supervisor	Topic
1.	Martina Dašková	Ing. Václav Krys, Ph.D.	Creation of a Digital Twin of a Robotic Cell in Simulation Tool Tecnomatix
2.	Jan Dziak	Ing. Ján Babjak, Ph.D.	Safety in the Design of Automated Systems
3.	Marek Fuciman	doc. Ing. Zdeněk Konečný, Ph.D.	Design and Cost Optimalization of Hand Holder Reclining Mechanism on Birthing Bed AVE2
4.	Lukáš Káňa	Ing. Václav Krys, Ph.D.	End Effectors for Collaborative Robotic Workplaces
5.	Tomáš Krejčí	Ing. Tomáš Kot, Ph.D.	Design of the Robotized Workcell Using the Simulation Software RobotExpert
6.	Jakub Mlotek	Ing. Václav Krys, Ph.D.	Functionalities Enhancement of the Mobile Robot Viper
7.	Petr Oščádal	doc. Ing. Zdenko Bobovský, PhD.	Sensor and Navigation Subsystem for Mobile Robot
8.	Jiří Skalický	Ing. Milan Mihola, Ph.D.	Construction Design of The Four-Wheeled Mobile Robot Designed for Moving in Indented Terrain
9.	Daniel Vrbka	doc. Ing. Zdenko Bobovský, PhD.	Pick-and-Place Application for Non-oriented Objects
10.	Zdeněk Zeman	Ing. Robert Pastor	Mechanical Design of a Wheel with Active Steering

Fig. Graduates of Magister study - Robotics

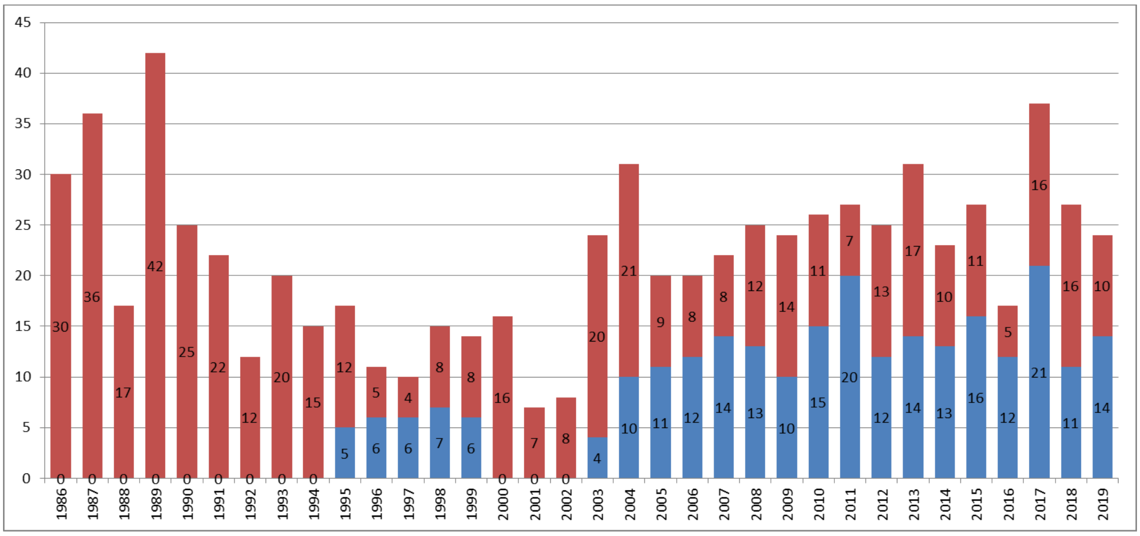


Fig. Overview of numbers of graduates (former Manufacturing Systems with Industrial Robots and Manipulators and now Robotics) Departments of Robotics: Bc.- Blue, Ing. - Red

4.3. List of PhD students

	Ph.D. student	Disertation	Supervisor	State exam	Status 2019
1.	Ing. Stefan Grushko	Motion planning for manipulator in dynamic environment using RGB-D sensor	doc. Ing. Zdenko Bobovský, PhD.		Active
2.	Ing. Dominik Heczko	Increasing the accuracy of position and orientation of the objects placed by the manipulator	doc. Ing. Zdenko Bobovský, PhD.		Active
3.	Ing. Daniel Huczala	Digitalization of the Manufacturing Process	prof. Dr. Ing. Vladimír Mostýn		Active
5.	Ing. Jakub Mlotek	Assisted assembly with Collaborative Robot	prof. Dr. Ing. Petr Novák		Active
6.	Ing. Petr Oščádal	Robot Arm Trajectory Optimization under Dynamically Changing Work Space	doc. Ing. Zdenko Bobovský, PhD.		Active
7.	Ing. Robert Pastor	Machine learning applications in robot kinematics design	prof. Dr. Ing. Petr Novák	Passed	Active
8.	Ing. Lukáš Podešva	Automatic Calibration of TCP of Confocal Sensor on an Industrial Robot	prof. Dr. Ing. Vladimír Mostýn		Active
9.	Ing. Radek Řehák	Research of functional safety principles for automated vehicle systems	prof. Dr. Ing. Vladimír Mostýn		Active
10.	Ing. Jiří Suder	The use of 3D printing in the design of robots	doc. Ing. Zdenko Bobovský, PhD.	Passed	Active
11.	Ing. Petr Široký	Development of Reconfigurable Chassis Frames of Mobile Robots.	doc. Ing. Zdeněk Konečný, Ph.D.	Passed	Interrupted
12.	Ing. Michal Vocetka	Manipulator accuracy improvement	doc. Ing. Zdenko Bobovský, PhD.		Active
13.	Ing. Zdeněk Zeman	Topological Design of Robotic´s Arms	prof. Dr. Ing. Petr Novák		Active

4.4. Defended Dissertations

Ing. Aleš Vysocký, Ph.D.

Topic: Direct cooperation of Robots with Humans

Supervisor: prof. Dr. Ing. Petr Novák

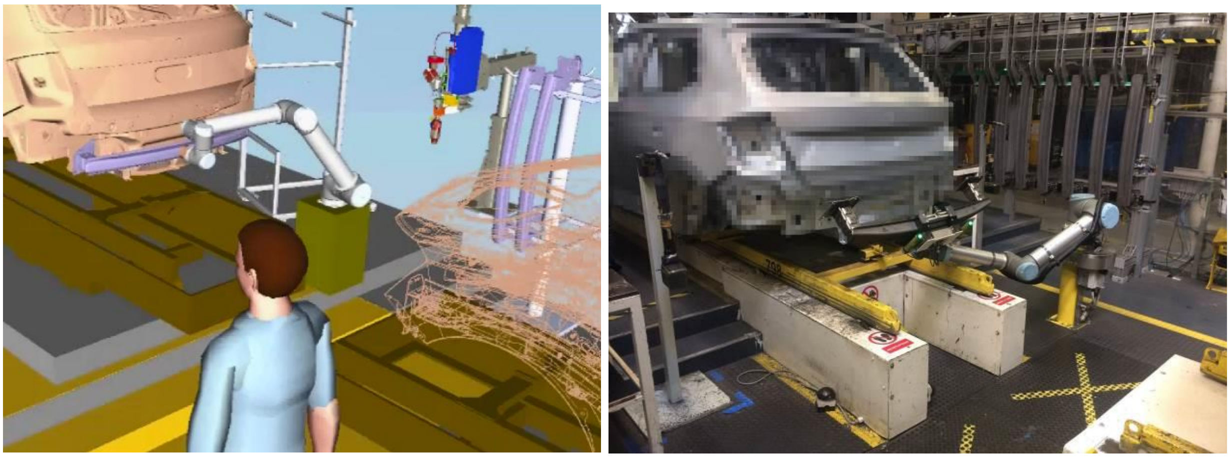


Fig. Application of COBOT on Manipulation with unstable part - Dissertation

4.5. Quality and culture of academic life

- In 2019, a group of 23 doctoral and postgraduate students was involved in the project of the student grant competition “Digital twins of robotic systems and their verification”. The following achieved significant results:

  - Ing. Tomáš Krejčí – educational material for the simulation system

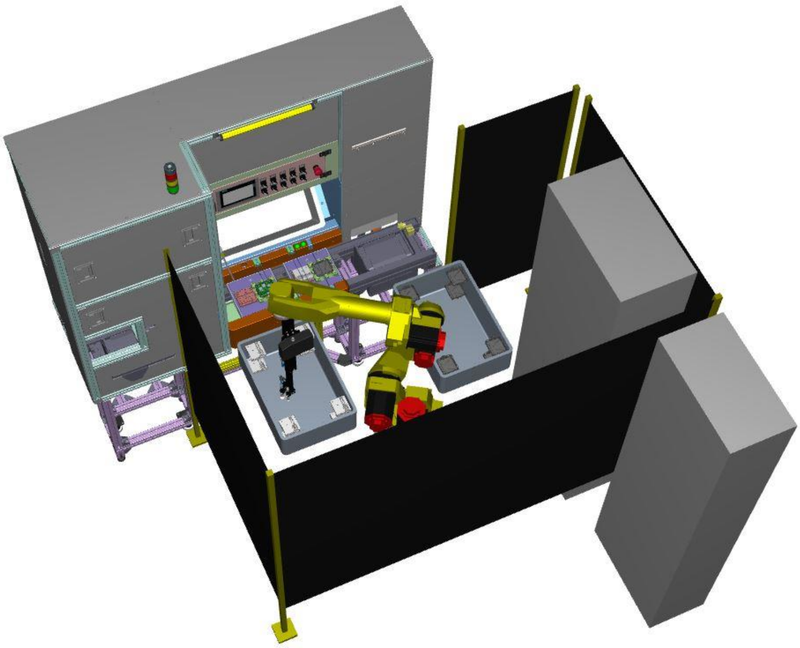


Fig. Preview of the simulation model of a workplace in RobotExpert system

- RoverOva team, which placed third in the international ERC competition.

Fig. Our RoverOva competition team

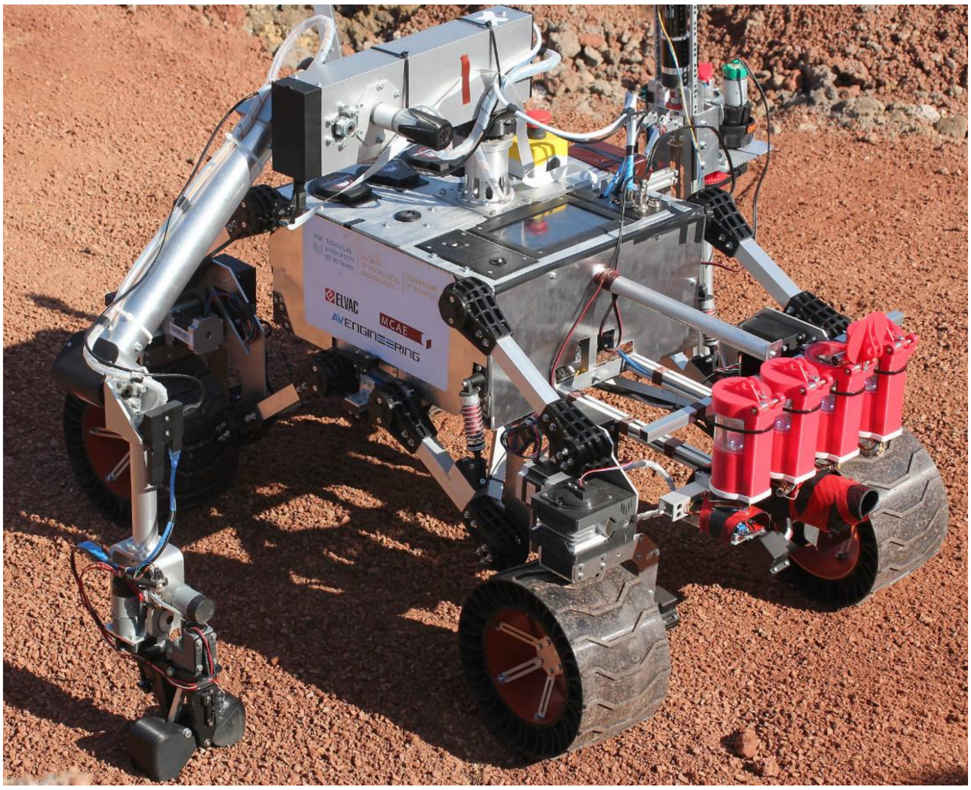


Fig. Competition robot K3P4 (model 2019) of our team during sampling

5. PEDAGOGICAL COOPERATION

5.1. Significant cooperation of the workplace with subjects in Czech republic

- HELLA Autotechnik Nova, s.r.o.,
- Brose CZ,
- VOP CZ (Military repair company),
- Moravskoslezský automobilový klastr,
- Brano,
- Varroc,
- Continental,
- Vitesco Technologies,
- ABB
- And others…

As a result of our multi-year closer cooperation with ABB, students in the 5th year of robotics are allowed to obtain the official ABB certificate "Level 3 IRC5 - Specialist". This year (2019) students of the 5th year in the pilot run of this test were 100% successful and all received a certificate valid for 2 years. From 2021 onwards, robotics students will also receive "Programmer" and "RobotStudio" levels as certification, a complete set of core training courses provided by ABB for a fee. The ceremonial handover of the pilot run was performed by the director of the robotics division and the whole Czech branch of ABB Vítězslav Lukáš in the premises of our modernized Robotics Centre. In his address to the students, the director mentioned, among other things, that the long-term efforts of the Department of Robotics have reached the state where Ostrava has the best managed and equipped robotic laboratory in the Czech Republic. At the end of his speech, he stated that the ABB Robotics Division is ready to further develop cooperation not only with the Department of Robotics but also with other workplaces of VŠB - TU Ostrava, which is its Alma Mater.

Fig. Ing. Vítězslav Lukáš, Ph.D. - ABB's Czech branch manager and robotics division hands over ABB robotics certificates to students

5.2. Significant cooperation of the workplace with foreign partners

- Ton Duc Thang University – Vietnam – contract on teaching Vietnamese students - PhD students, self-payers, in the field of Robotics (4th March 2019).
- Preparation of the bachelor's and master's study of Robotics for Vietnamese students.
- Bach Khoa Da Nang University - Vietnam

5.2. Abroad stays of teachers and students

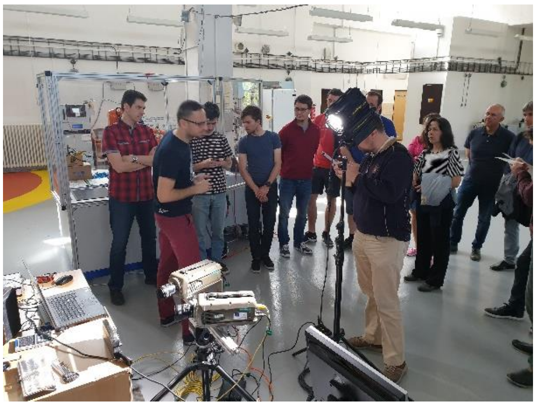
- Ing. Aleš Vysocký –Tohoku University, Sendai, Japan, – October 2018 – February 2019 – Collaborative robot laboratory

- Students – 3 x Erasmus+ , Finland

- Technical University of Košice, Slovakia

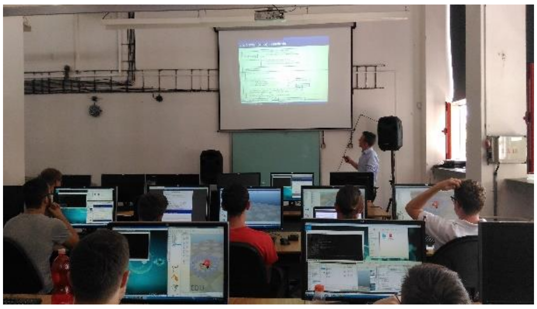
5.3. Foreign guests and students

Assoc. professor. Ing. Huňady, Ph.D., Ing. Hagara, Ph.D,
Slovakia, Technical University of Košice, Department of Applied Mechanics and Mechanical Engineering
Lecture: Digital image correlation and its application in experimental mechanics
Term: 20th May 2019

Assoc. professor. Ing. Virgala, Ph.D
Slovakia, Technical University of Košice, Department of Mechatronics
Lecture: Application of potential field method in robotics
Term: 20th June 2019


Ing. Panfil, PhD., Ing. Piotr Przystałka, Ph.D. D.Sc.
Poland, Silesian University of Technology Gliwice
Institute of Fundamentals of Machinery Design, Silesian University of Technology
Workshop: High-level Design Methods Used in Robotics
Term: 25th June 2019

Ing. Andres Faina
Denmark, IT University of Copenhagen, Robotics, Evolution, and Art Lab
Lecture: EDHMOR and EMERGE: Designing and building robots automatically
Term: 25th September 2019

Ing. Martin Pfurner, Ing. Mathias Brandstötter,
Austria, Universitat Innsbruck, Joanneum research – Robotics,
Lectures: Kinematic Analysis and Synthesis of Serial and Parallel Manipulators,


prof. Ing. Juraj Smrček, Ph.D.
Slovakia, Technical University of Košice, Department of Robotics,
Lecture: Selected problems of operating parameters of industrial robots
Term: 20th November 2019

IAESTE – 3 Internships:

Vyomkesh Kumar Jha, 14. 1. – 10. 4. 2019 (Student of Manipal Institute of Technology, Faculty of Electrical and Electronics Engineering, India)
The main objective of the research activity was to develop the software for calibration of a group of 3D cameras monitoring workspace of the collaborative robot.

Matheus Joseli Coutinho de Souza, 12. 08. 2019 – 11. 10. 2019 (Instituto Federal do Sudeste de Minas Gerais – Campus Juiz de For, Brasil)
The main objective of the activity was: Work with simulation software V-REP, Work with ROS software, Cooperation V-REP and ROS software, Sensor data acquisition by Arduino

Jong Mun Jeong 6. 9. – 28. 11. 2019 (Student of Hanyang University, Faculty of Electrical and Biomedical Engineering, South Korea)
The main objective of the research activity was to develop the hardware unit for measuring the power consumption of the six subsystems of the mobile robot RoverOva designed for European Rover Challenge competition.

6. SCIENCE - RESEARCH ACTIVITIES

6.1. Currently solved projects

Name	Period	Budget (Euro)
Research and development of a new type of multichambered insulated glazing and its production.	2017 - 2020	0,85M
Research Centre of Advanced Mechatronic Systems	2018 - 2022	2,6M (from 9,6M)
Research Platform focused on Industry 4.0 and Robotics in Ostrava Agglomeration	2018-2022	0,64M (from 3,2M)
Digital twins of robotic systems and their verification	2019	0,1M
National Competence Centre of Mechatronics and Smart Technologies for Mechanical Engineering	2019 - 2020	0,6M

6.2. Main directions of R&D

The following chapters present selected topics from the field of R&D, which were solved mainly by the employees and doctoral students of the Department of Robotics within the above-mentioned projects.

6.2.1. Methodology and theory of conceptual design of robotic manipulators with computer support

The main output is a methodology of the conceptual design of the mechanism and tools of computer support design of the optimal kinematic structure of the manipulator / robot and its gripper with respect to its size, weight, energy consumption and other preferred working cycle parameters such as accuracy, dexterity, workstation clock. The project outputs will be applicable to automated production systems using modular low-cost automation of handling tasks, as well as to all robotized site operators who can use them to optimize existing robot programs or robotized site layouts to optimize robot work cycles and save energy. Tools for the automatic synthesis of the optimal kinematic structure of robot, manipulator and gripper for a given duty cycle will be applicable especially for system integrators designing robotic workplaces. Solved in cooperation with the Department of Applied Mechanics.

6.2.2. Research and development of a new type of multichambered insulated glazing and its production

Research and development of technical means for robotized production line FIS. Problems of film handling with the thickness of 50 micrometres, frame manipulation and integration of film frames between glasses. The solution of in-process containers. Simultaneously, in cooperation with the Department of Energy - optimization of insulated glass with split chamber and very low thermal conductivity for individual applications in practice with regard to product orientation and location and synthesis of the target product in terms of thermomechanical phenomena and thermal transmissions for different numbers of chambers, and that is, the separating films in the insulating glass. Measurement of prototype properties and their optimization. (Started in 2018)

6.2.3. Detection of camera position and orientation in manipulator coordinate

The basic problem when capturing the manipulator's working environment by a camera is to determine the position and orientation of the camera relative to the coordinator system of the manipulator. From this position, the possibility of obtaining more detailed information about the environment then follows. In order to refine and speed up the process of positioning and orienting cameras, which is currently done only manually, a process has been created that solves this problem automatically.

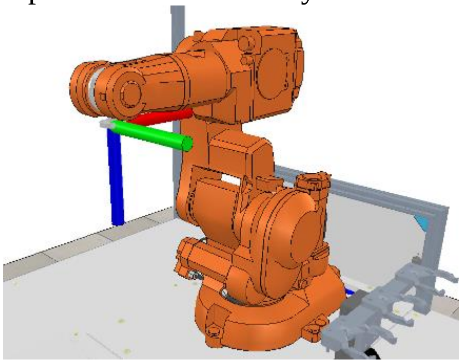
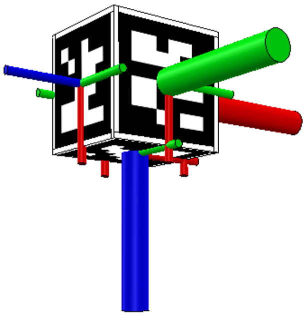
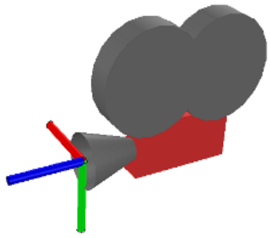




Fig. Robot IRB140 in V/REP environment, Calibration effector, Simulation camera

The process allows detection of camera position and orientation in the space where the manipulator with calibration effector is located. After starting the calibration process, the robot begins to move to predefined positions with a calibration effector (hereinafter referred to as the effector). After the position of the manipulator is set, a calibrated camera is created and processed. Position adjustment and image capture are repeated until the effector is clearly detected in the image. Based on the effector detection, a basic calibration matrix is then created that represents the approximate position and orientation of the camera in the coordinate system of the manipulator against which the effector position was set. The camera position is then refined using multiple images with different effector positions and orientations. The process was tested in V-Rep simulation environment.

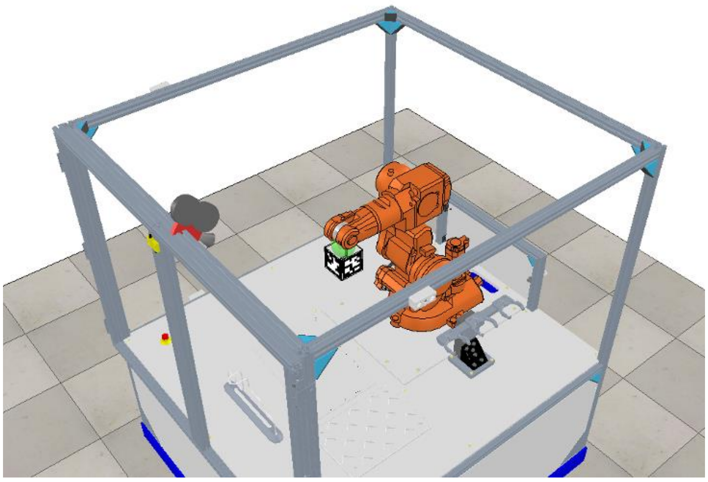


Fig. Test calibration model in V-Rep environment

The system has been reworked from simulation to a real stand with the UR3 robot. The ability to determine the position and orientation of the camera relative to the manipulator coordinate system in real conditions were subsequently tested.

Fig. Position Testing 1 *Position Testing 2*

6.2.4. Improve repeatable positioning accuracy

The aim of this research is to improve repeatable accuracy at a defined point in the working area of an industrial robot (tested here by ABB). Data obtained using the Digital Image Correlation (DIC) method using a Dantec Dynamics system is used to improve this parameter. This research is carried out in close cooperation with Associate professor Huňady and Ing. Hagarom, Ph.D. from the Technical University of Košice, Faculty of Mechanical Engineering, Department of Applied Mechanics and Mechanical Engineering.

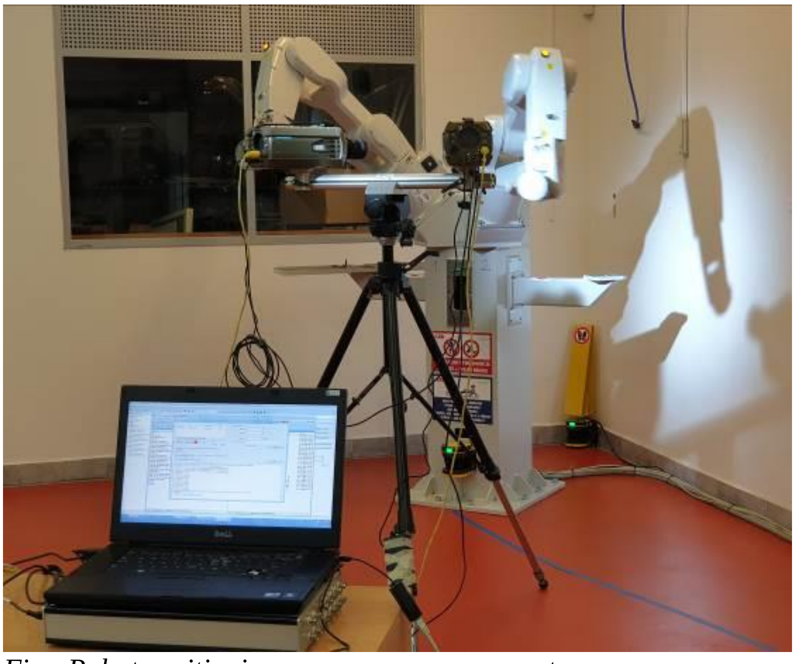


Fig. Robot positioning accuracy measurement

6.2.5. COBOTs

Within the COBOTS project, 3 workplaces with collaborative robots for the Moravian-Silesian Automotive Cluster are solved, as a subcontract for the Brano Group a.s., for Vitesco Technologies (formerly Continental Powertrain) and for Brose.

In the part of the project dealing with the integration of ABB 14000 YuMi collaborative robot in Brano Group the place of integration and the process to be automated were specified with the client. It is a replacement of the manual assembly section of the seat actuator production line for the VW concern. Thanks to the integration of the two-handed "COBOT", the company saves one worker.

A number of simulations were carried out within the project, which showed a possible way to solve a given assembly task. On this basis, the whole assembly workplace was designed, manufactured and adjusted, incl. vibrating conveyor and B&R PLC. The project is solved in cooperation with the Moravian-Silesian Automotive Cluster

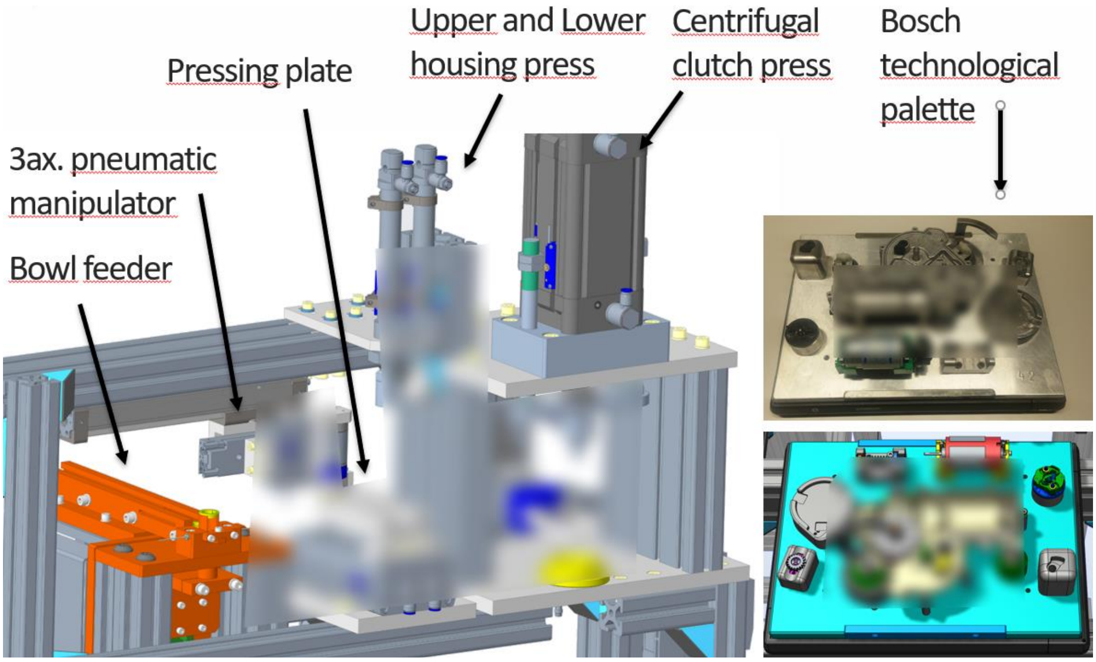


Fig. Simulation of engine assembly, pair of bushings and centrifugal clutch by COBOT

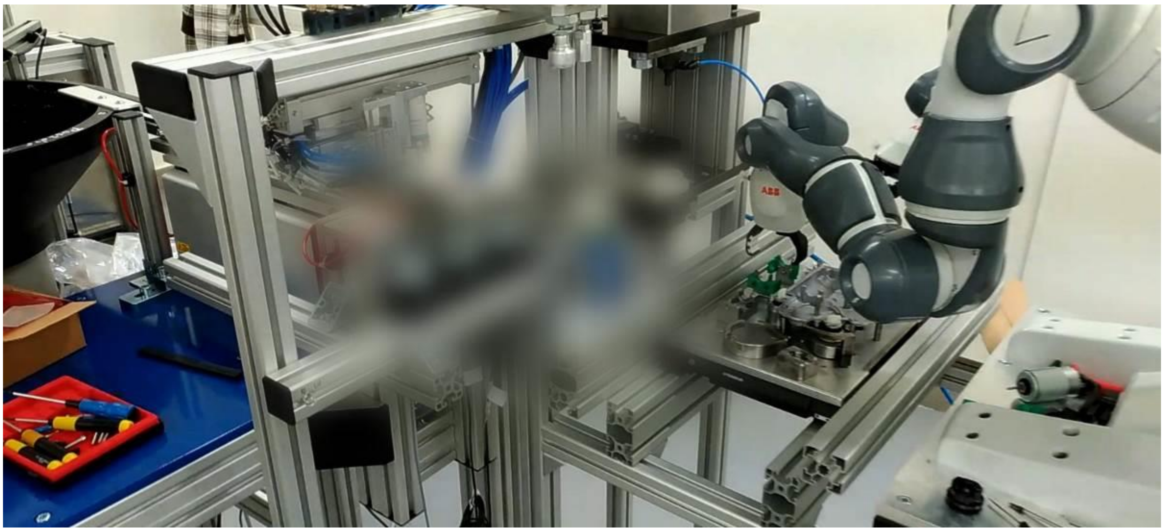


Fig. Photo Actuator motor mounting station

In the part of the project for Vitesco Technologies is solved the issue of Bin Picking, the selection of non-oriented objects from crates. These are plastic boxes, where the top and bottom of the box are loaded into the system pallet on the EOL line.

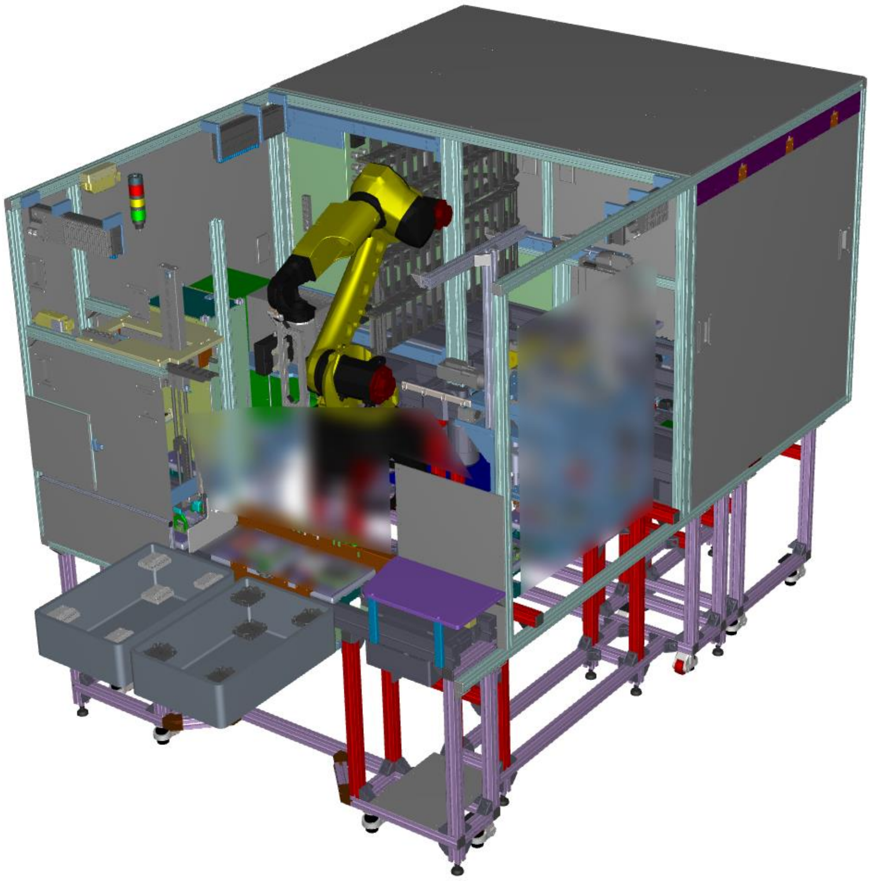


Fig. EOL line with integrated Fanuc robot, gripper and 3D visual system. (Is realized)

6.2.6. Automated assembly of pipe clamps

In cooperation with Faculty of Electrical Engineering and Computer Science (beneficiary), the project "Research of the possibilities of robotization of the technology of assembling metal products with rubber" - is carrying out an applied system research, which could fully automate the assembly of pipe clamps. The challenge is primarily to apply a rubber DGL profile to the sleeve body, a process whose automation is very complicated. Work on the project began in January 2019. So, the design phase of the device for applying the profile to the sleeve is now in the design phase.

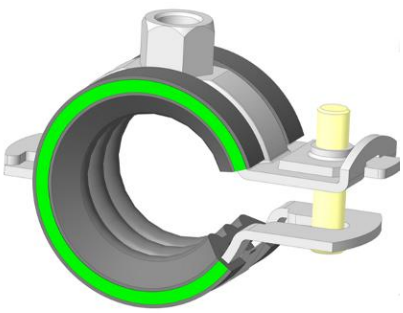


Fig. Pipe clamp

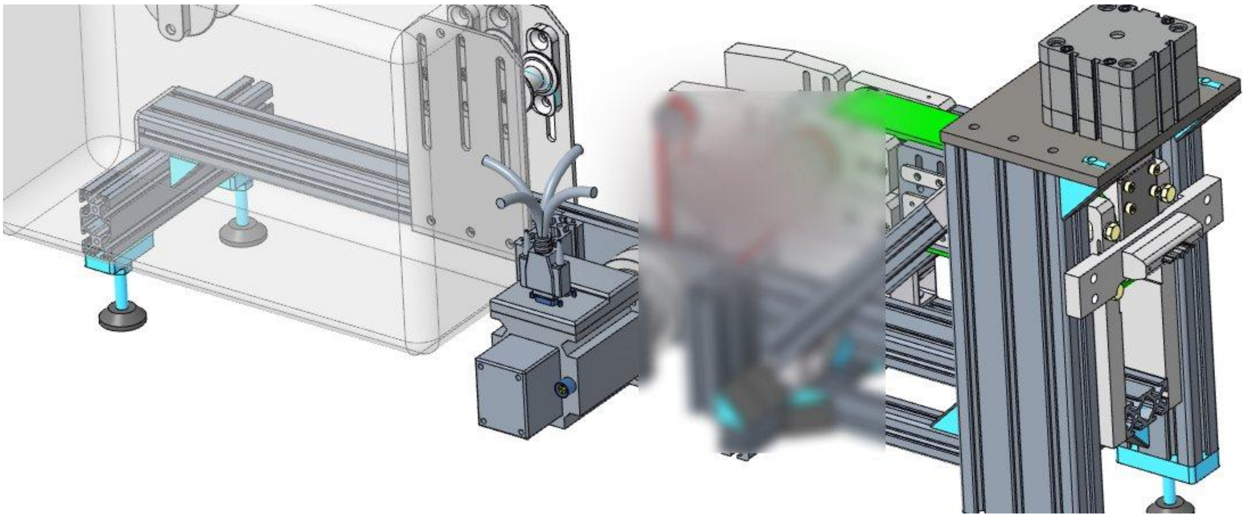


Fig. System for automatic feeding and cutting the rubber profile (to be implemented during 2020)

6.2.7. System for rapid selection and placement of the robot for a defined trajectory

The deployment of industrial and collaborative robots, especially for small companies, is often carried out on their own to reduce overall financing costs. Due to the existence of a large number of possible robots, the selection is mostly made using estimation or experience and the proposed solution is not optimal both in terms of the size (price) of the robot and its location in the workplace (larger built-up area, worse operating characteristics). The aim of the research is to develop an affordable system (software tool) for the recommendation of suitable types of robots with regard to the required trajectory, its optimal placement against the trajectory and also obstacles.

When requesting a suitable robot, all robots in the application database are tested (the database can be easily expanded) and with respect to given boundary conditions (robot manufacturer, robot type, load capacity, etc.) it is automatically verified for each robot whether it can fulfil the specified task to pass a defined trajectory while respecting the maximum possible joint speeds and also not colliding with obstacles in the workplace. The output of this algorithm is not only a list of suitable robots but also a map of each possible location of its base within the workplace.

Generally, there are a large number of possible robot locations, so the system also offers assistance in selecting the optimal variant by evaluating the positions according to several different criteria. The first group of criteria tries to estimate the resulting load on the joints of the robot using kinematic variables, which can contribute to the reduction of electric energy consumption and to a longer life of the robot. Another criterion then takes into account the occurrence of singular configurations of the robot and the last criterion allows the selection of the robot's position with respect to a possible acceleration of the production cycle of the line by accelerating the movement along the trajectory.

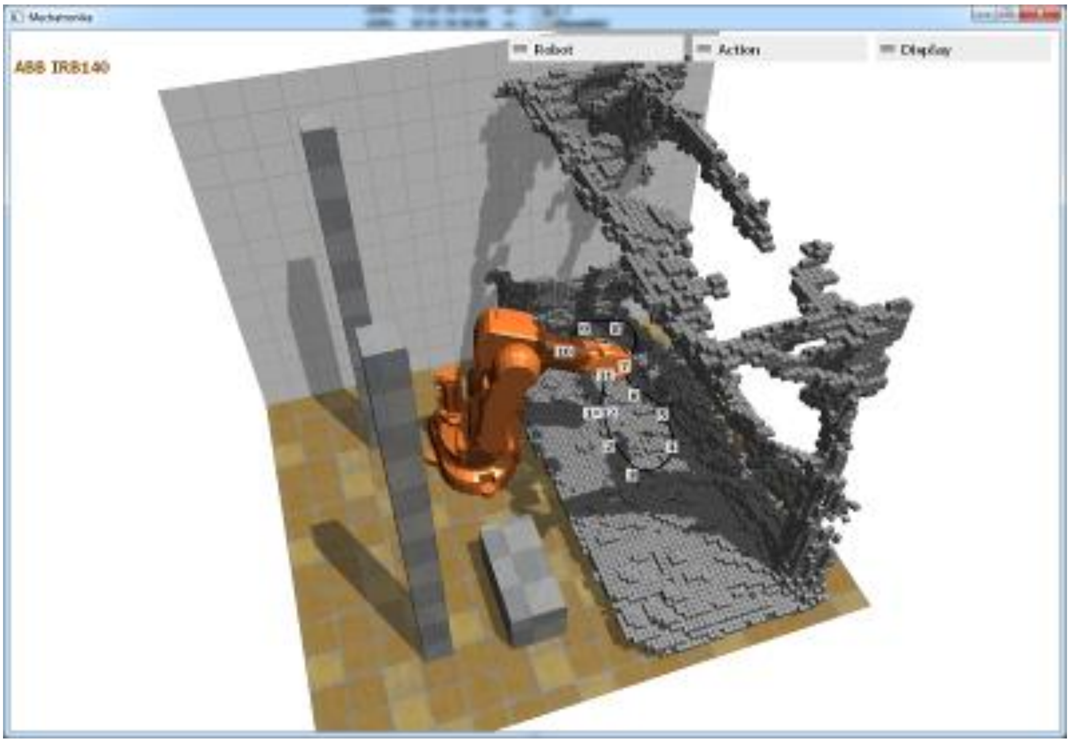


Fig. 3D visualization of the trajectory, the selected robot (here ABB IRB140) and the point cloud of obstacles in the workspace

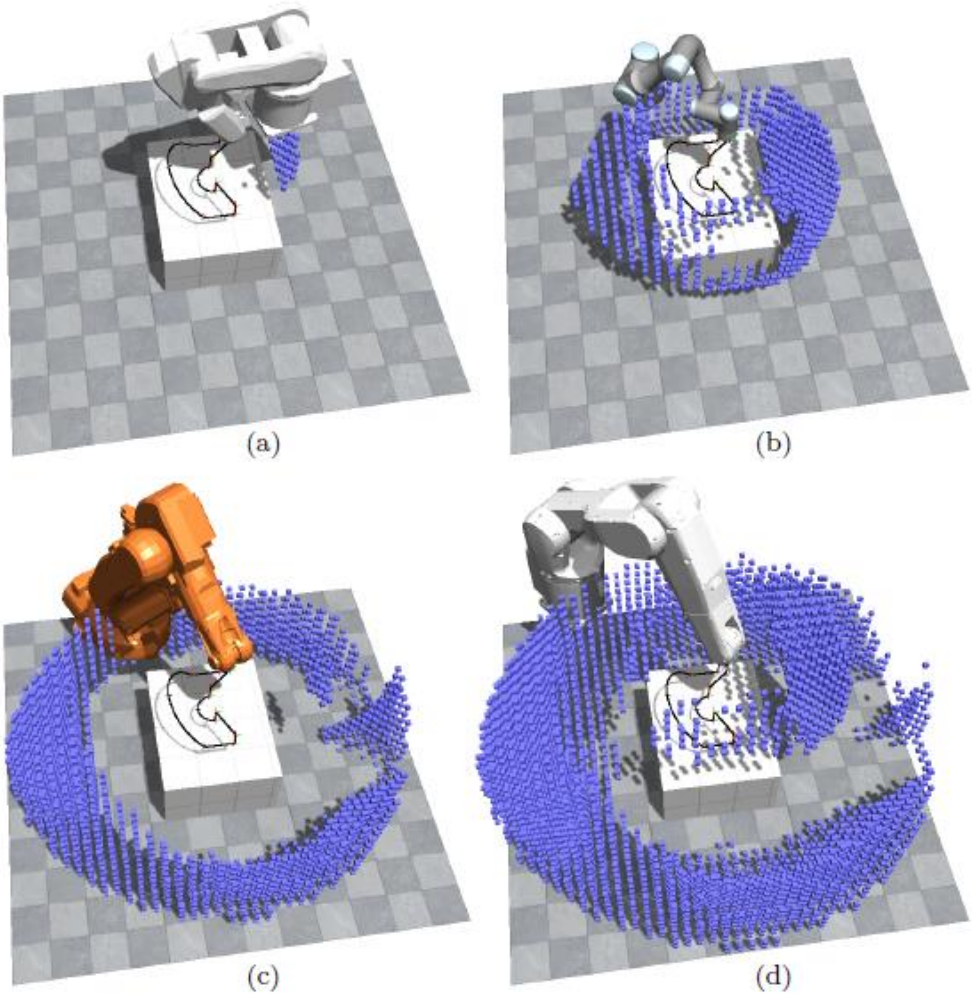


Fig. Example of valid positions of different robots for a simple test workplace and trajectory, robot: (a) ABB IRB120, (b) UR3, (c) ABB IRB140, (d) ABB IRB1200

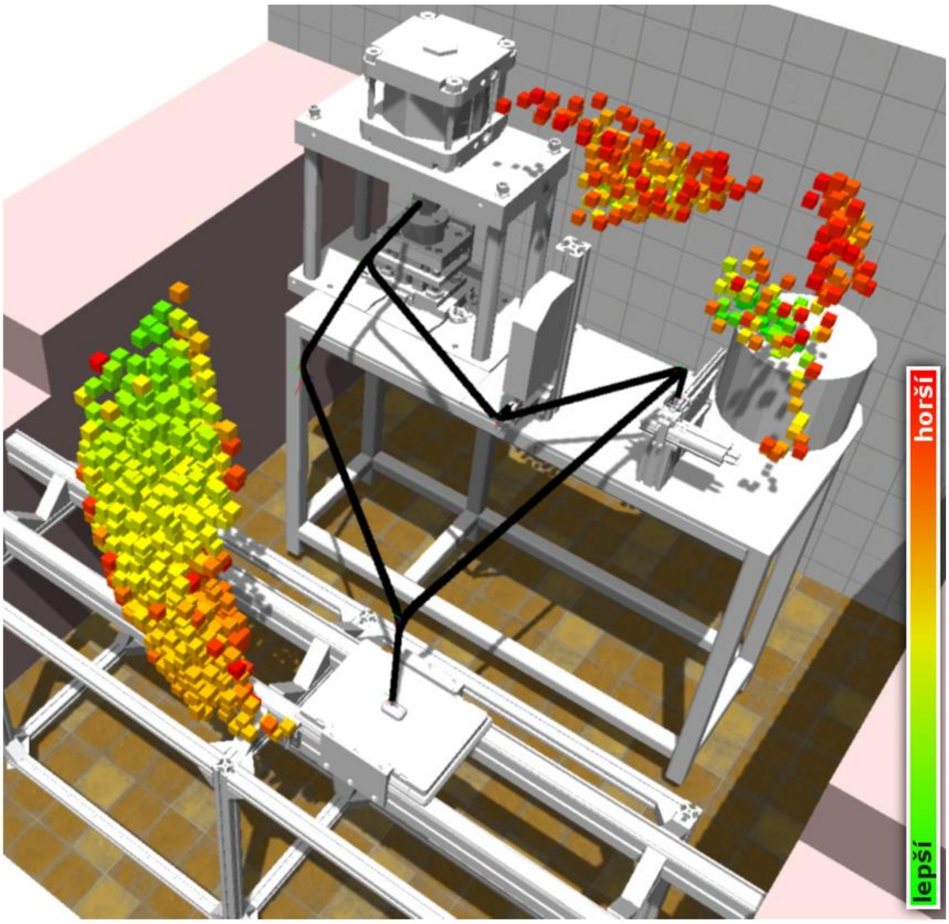


Fig. Example of evaluation of possible placements of the UR10 robot in the workplace based on the criterion of a possible acceleration of the movement of the robot's endpoint (TCP) along the trajectory (in the worst position the robot is already at its limits, in the best position, the trajectory can be accelerated about 1.6times)

6.2.8. System for identifying a part (3D object) based on a 3D scan

The aim of this R&D is to design a system that can create a 3D scan (cloud of points) of a specific physical component and then, by searching for the best match in the database of 3D models, identify which component it is. In order to make it easier to design and test the algorithms for finding a match between a point cloud and a 3D model in STL format when a physical scanner is not yet purchased or manufactured, a system was designed to create simulated (virtual) scans from an existing 3D model component.

The virtual scanning system supports two basic types of scanning. The first method is to use fixed scanners around the scanned part, and the number, location and parameters of the scanners can be freely changed in the application. The second method simulates a rotary scan table on which the part rotates at specified angular increments, and the resulting point cloud is gradually formed by joining the partial clouds obtained by one or more scanners placed around the table. Of course, there is support for simulation of scanner inaccuracy (noise) as well as several possibilities of simulation of damaged component (deformation, breaking of part), which is necessary to verify the robustness of the subsequent algorithm seeking conformity with the model database.

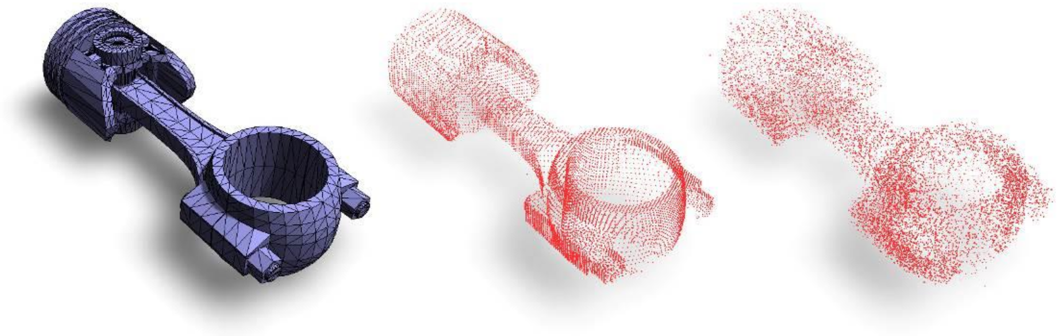


Fig. 3D model of the mechanical part (piston) and its virtual scan with different degree of measurement inaccuracy (0% noise in the middle, 5% noise in the right)

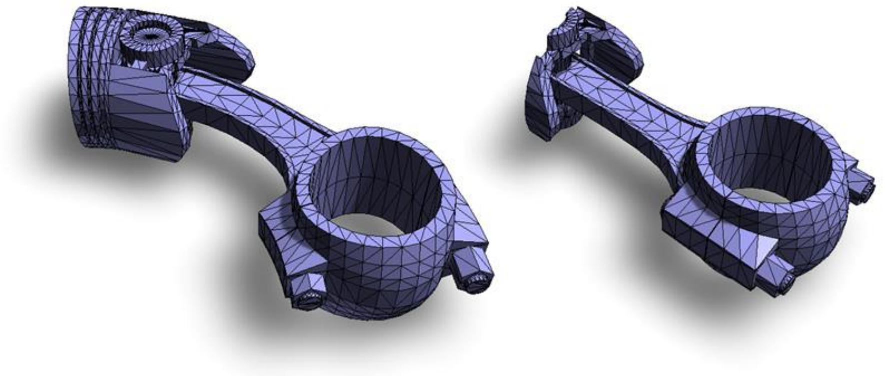


Fig. Demonstration of ability to simulate damaged parts (bent part, missing part)

6.2.9. Dynamic path planning for industrial robot

To solve the problem of automatic adjustment of predefined robot trajectory in the presence of obstacles, ROS framework for trajectory planning - MoveIt was used. As a testing environment, a workplace with robot UR3 was prepared. The workspace is monitored by one depth camera RealSense D435. To enable offline simulations a Gazebo simulation model of the tested workspace was created (3D point cloud data are gathered a virtual camera form the simulation in real-time).

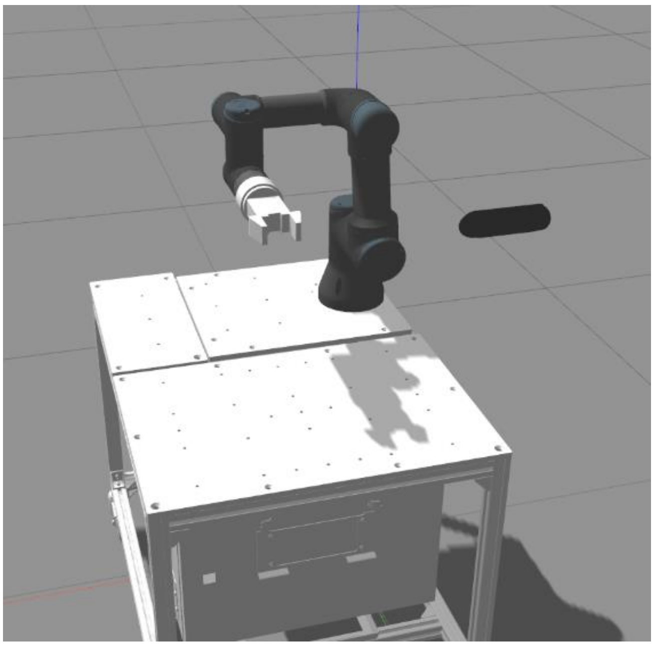


Fig. Simulation model of the tested workspace (Gazebo)

The robot's working environment is represented by a 3D point cloud obtained from one depth camera. MoveIt ensures continuous processing of the 3D cloud: according to the collision volume of the robot, the points associated with the robot's body and its static periphery are removed from the cloud; a voxel representation of space and obstacles - octomap - is then generated from the filtered cloud. The trajectory planning is performed in voxel representation of the environment.

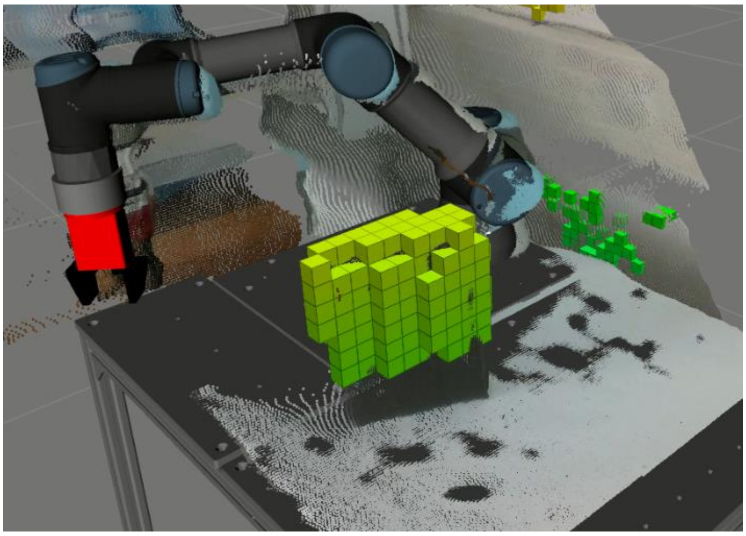


Fig. Representation of robot workspace and obstacles (RViz)

Due to fact that spatial data about obstacles was obtained from a single depth camera, the obstacle mapping information may be incomplete (see Figure - only one side of the obstacle in the robot workspace is mapped in the octomap), which can result in collisions of the robot with a part of the obstacle that is not correctly mapped.

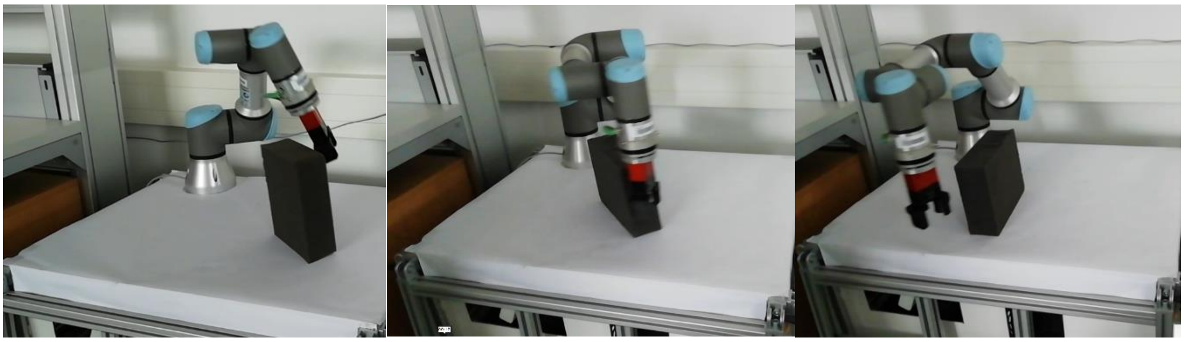


Fig. Collision of the robot with an obstacle

Because utilized RRTConnect path planner is random in its nature, the suggested trajectories are not always optimal. The actual planning does not take place in real-time and the time between the trajectory planning and motion is approximately 1 second.

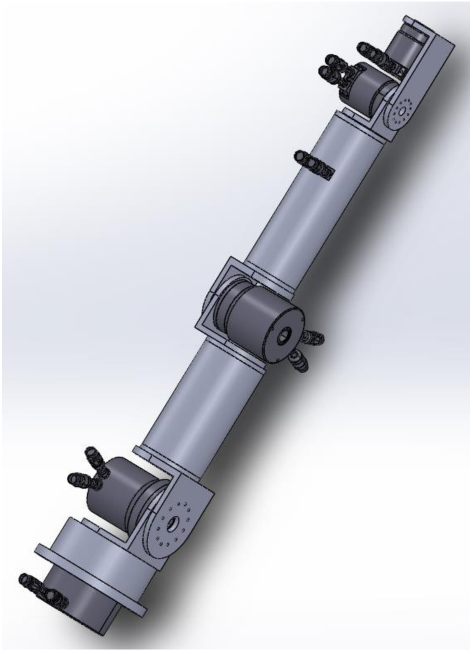
The planning was tested on a simple trajectory from two points - the robot repeatedly moved from the first point to the second and back. The trajectory is planned before each move.

Fig. Two points of the predefined path of the robot

6.2.10. Automatic 3D modelling in SolidWorks

The main outputs are algorithms for automatic selection of power units of industrial robots, manipulators and service robots, based on the course of their load. These algorithms were used in the creation of an application whose output should be not only the selection of suitable power units but also an automatic generation of 3D models used for the creation of own handling superstructures and industrial robots. To this end, a link was created between the newly created application and SolidWorks software, using the appropriate API.
Application for selection of suitable elements of industrial robots and manipulators (left image) and automatically generated 3D model of the robotic arm (right image).

Fig. Application for selection of suitable elements of industrial robots and manipulators



Automatically generated 3D model of robotic arm with six degrees of freedom

6.2.11. Creating 3D models of objects using photogrammetry technologies and 2D laser scanner

Within the "*Search platform focused on Industry 4.0 and Robotics in Ostrava Agglomeration*" project, a scanning device was designed, manufactured and commissioned, enabling the creation of 3D models of existing objects. This device allows the use of photogrammetry technology and 3D laser scanner. Available Open Source software tools are used to process cloud points obtained when scanning the objects.

3D scanner model (left), the 3D model obtained with a laser scanner (centre) and the 3D model obtained with photogrammetry technology (right)

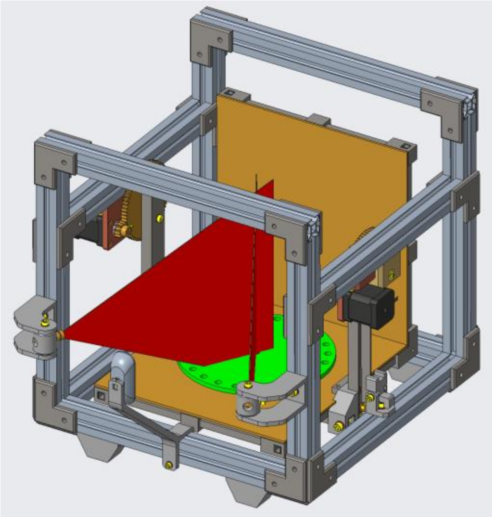


Fig. 3D scanner model

3D model obtained using a 3D laser scanner

3D model obtained using photogrammetry technology

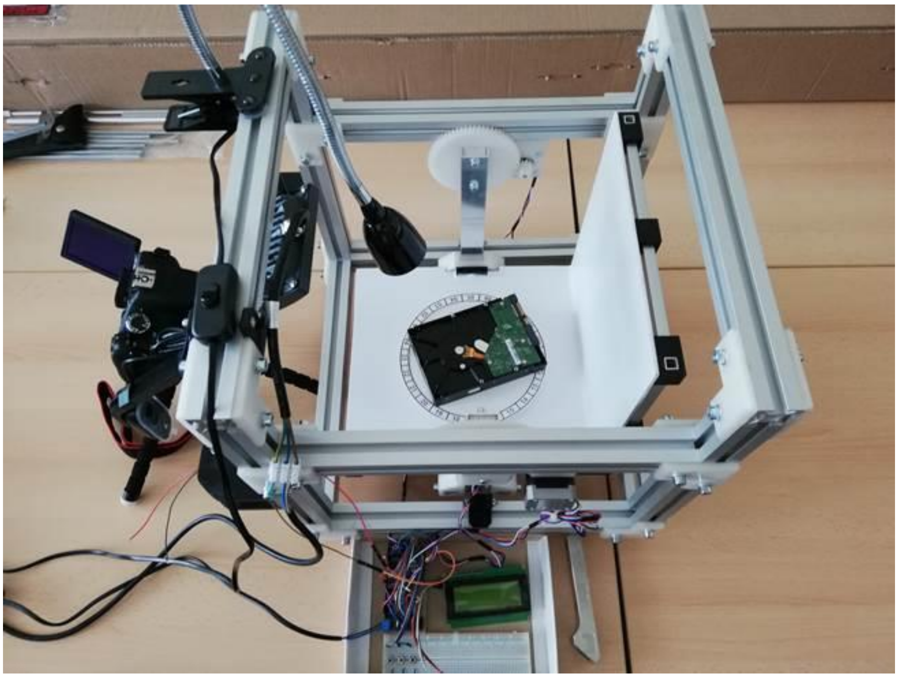


Fig. Realized 3D scanning device

6.2.12. Kinematic structure generation using gradual elimination of DOF

Related to the development of methods for generating kinematic structures of robotic manipulators based on a given task, an algorithm was developed that uses calculations from analytical geometry to build robot kinematics. The algorithm is gradually adding actuated modules to the end-effector, which is moving on a given trajectory. Each added module has its own coordinate system, which in motion creates its own trajectory. The type and position of the modules are optimized in order to remove at least one degree of freedom from the newly created trajectories. New trajectories are created by gradually adding new modules, each with a lower degree of freedom, up to a point where no degrees of freedom are left, and no motion is possible. The last module becomes the base of the robot, which is rigidly connected to the environment, for example, bolted to the floor.

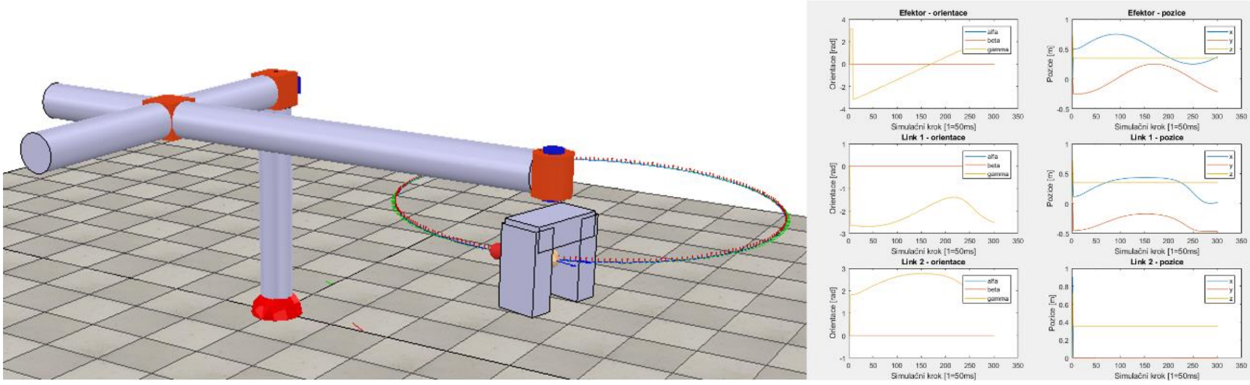


Fig. Robotic manipulator with three degrees of freedom and its trajectory (left), the gradual lowering of the degree of freedom (right).

This method worked for geometrically simple trajectories. The generalization of this method for more complex trajectories was not researched.

6.2.13. Using genetic algorithms in design and optimization of mobile robot kinematics

As part of the development and study of machine learning techniques in the field of evolutionary robotics, simulations and modifications of an existing mobile robotic system at the department were carried out. It is a four-legged robot equipped with twelve servomotors built into the 3D printed plastic part. A simulation model in program V-rep was created for this mechanism. The model can be remotely controlled, and the length of its legs can be adjusted as a parameter. The parameters of this model, especially the length of the individual leg segments, were optimized using a genetic algorithm in MatLab. The optimization task was to minimize the overall load on the mechanism's motors while walking and maximizing the speed of the robot's movement. The resulting kinematics of the simulated mechanism will reduce the engine load by 17%, while walking in the same conditions. The mechanical design of the real robot was modified, according to the optimized kinematics. Tests with the original robot configuration and the new kinematic configuration have shown that the optimized design has 24% less current consumption when walking under the same conditions.

Fig. Real test model of walking robot

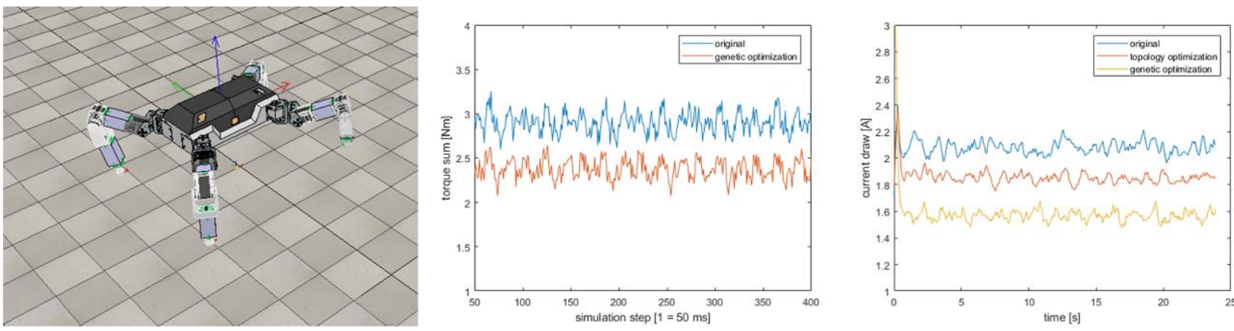


Fig. Simulation model of the robot in the optimized configuration (left), measurement results from simulation (middle), measurement results from the test of the real system (right).

The optimization parameters were defined as the lengths of the second and third segments of a leg and the movement velocity of the robot in the X axis. The graphical interface of the Optimization Toolbox was not used to run the genetic algorithm, but the ga() function was started directly in the main script, which then controlled the actual function, that communicated with the simulation software.

Parameter type	Name	Limits	Unit
Input	front leg - 2nd segment length	<0 0.5>	m
	front leg - 3nd segment length	<0 0.5>	m
	rear leg - 2nd segment length	<0 0.5>	m
	rear leg - 3nd segment length	<0 0.5>	m
	movement velocity	<0 1>	m/s
Output	Average motor torque	-	Nm
	Reached distance	-	m

Tab. Optimization parameters

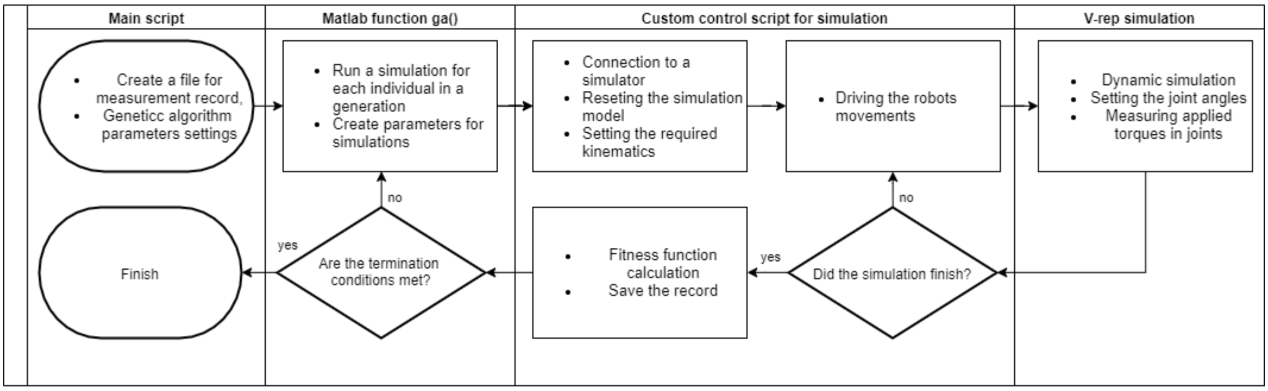


Fig. Flowchart of simulation model optimization method

6.2.14. Determine the position and rotation of the gripper object using 2D line sensors

The output is to find the rotation parameters of the manipulation object (OM) in the effector. For applications where the OM is not oriented in the grip, it is necessary to determine the exact position and rotation of the OM in the gripper to insert the OM into another technology. The robot with OM moves into a scanning cell equipped with 2D line sensors, where a cloud of points is created.

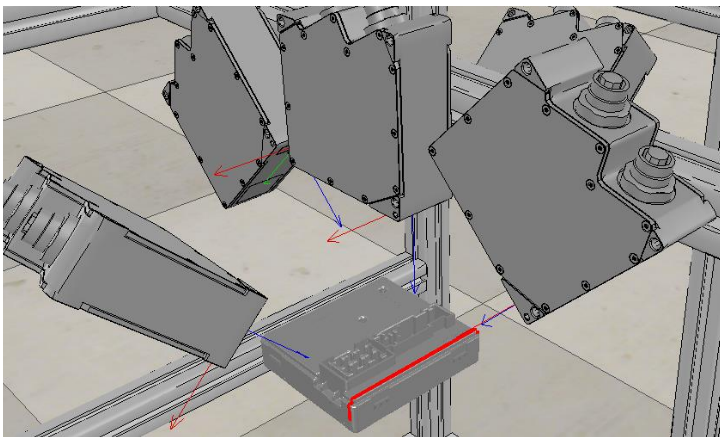


Fig. Cell equipped with sensors

Using the ICP algorithm, the working scan is compared with the calibration scan and the rotation of the OM in the gripper is calculated. The correction data is sent to the robot to correctly insert the OM into the next technology.

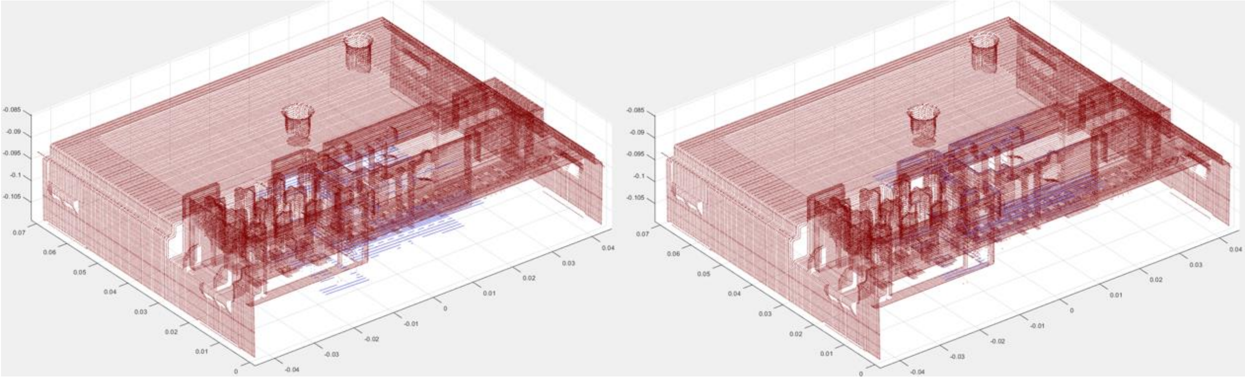


Fig. Scanned clouds (left), clouds after transformation by ICP algorithm (right).

6.2.15. Research of methods for assisted assembly with collaborative robot

For intuitive communication between the robot (collaborative) and the machine operator, a system for recognizing objects of interest within the robot working environment and a system for detecting operator's gestures for interaction with the robot are being developed. Identification and location of points of interest are performed by a neural network.

Fig. Localization and description of selected points of interest (screws)

Several systems based on analytical image processing, neural networks or patented solutions of specialized solutions have been verified for the detection and localization of the hand in 3D space. Each approach has its advantages and disadvantages, so a fusion of multiple principles is used for detection. Calibration between individual systems and the speed of the whole system is important.

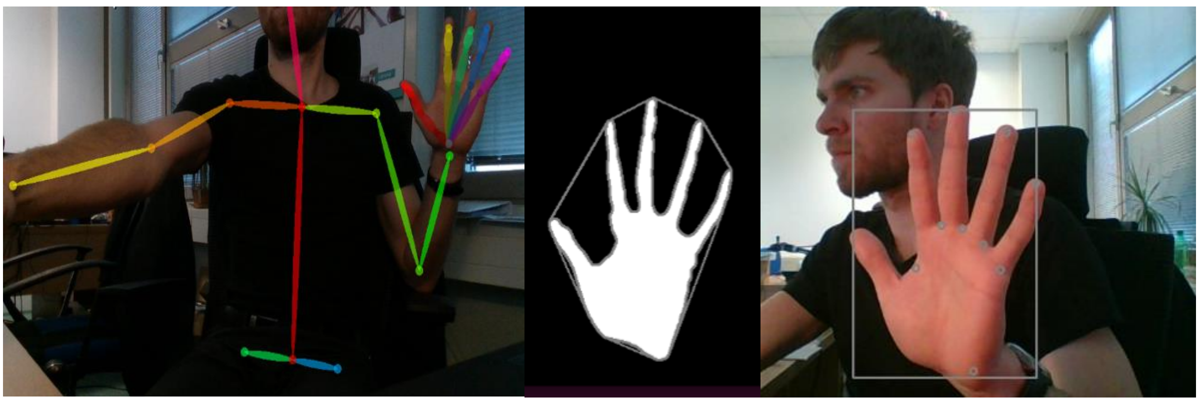


Fig. Testing localization using the OpenPose library (left) and own design of hand localizer

Hand localization was tested using neural network algorithms based on OpenPose library, and further by the development of own application based on OpenCV library functions and hand detection by LeapMotion sensor data processing library.

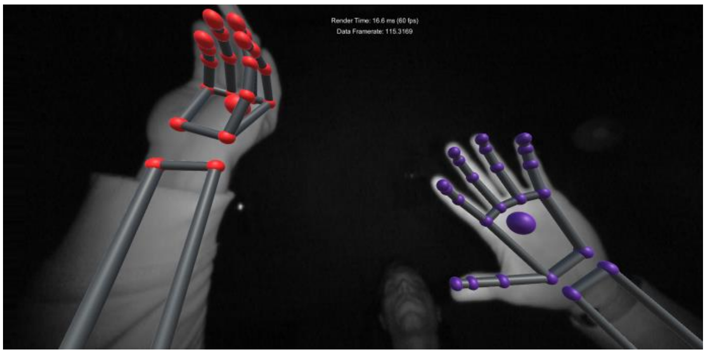


Fig. Hand detection by LeapMotion sensor

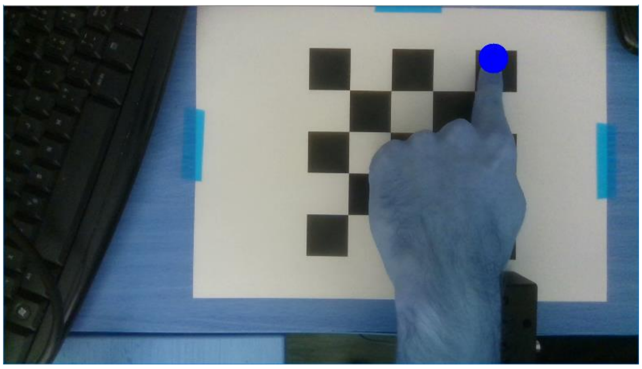


Fig. Calibration of 3D sensor and 2D camera (augmented reality)

The designed system enables interactive cooperation between the robot and the operator, which guides the robot to the position of the part / technological operation by simple gestures.

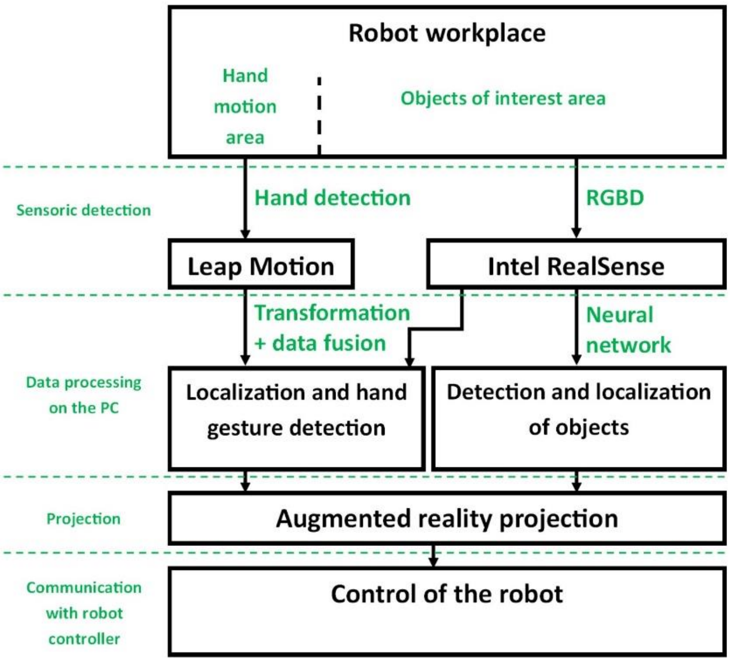


Fig. Diagram of the application

The result of the research will be the design of suitable sensor placement for scene and hand detection, as well as a robust localization system based on the fusion of data from several sensors and subsequent projection of the acquired data and creation of control commands for the robot.

6.2.16. Optimization of robot consumption

In collaboration with the Faculty of Electrical Engineering and Computer Science, joint research (launched in 2018) is conducted to optimize the robot's consumption by adjusting its trajectory (taking into account the technology requirements). During the year 2019 several optimization algorithms for the given task were tested. Testing was carried out on a real UR3 robot and its simulation model. The result is a PSO optimization algorithm. Solvers: Assoc. prof. Bobovský, Ph.D., Ing. Tomáš Kot, Ph.D., Ing. Šafařík, Ph.D., Mgr. et Mgr. Papřok, Ing. Vysocký, prof. RNDr. Snášel, CSc., prof. Dr. Ing. Novák.

6.2.17. System for real-time measurement of industrial robots consumption

Within the Mechatronics project, a system was developed to measure the consumption of electronic equipment (e.g. industrial robots or machines) during its working cycle. Obtained data can be used e.g. for verification of simulations related to the optimization of industrial robot consumption.

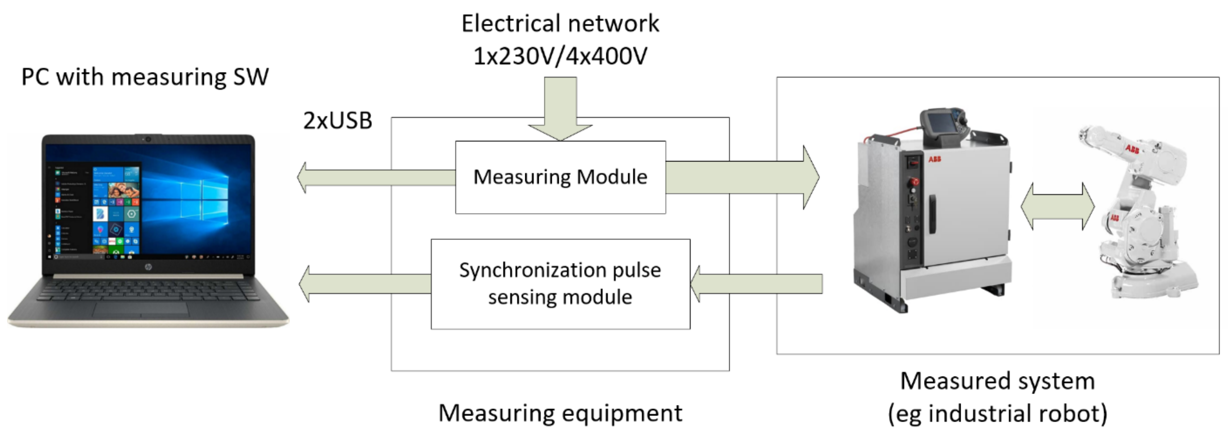


Fig. Measuring equipment diagram (specifically with ABB IRB140 robot)

The system is equipped with power metering which can be operated in both single-phase and three-phase modes. At the same time, the system includes a module for sensing the synchronization pulses generated by the measuring device (e.g. DIO from the robot controller), by means of which it is possible to synchronize the measured values with specific sections of the performed trajectory.

In the case of a suitably selected trajectory, using this measuring system, it is possible to create a so-called Energy Map of a specific robot, which can serve as a basis for placing the robot in the workspace with regard to more energy consumption (and associated lower stress in the joints).

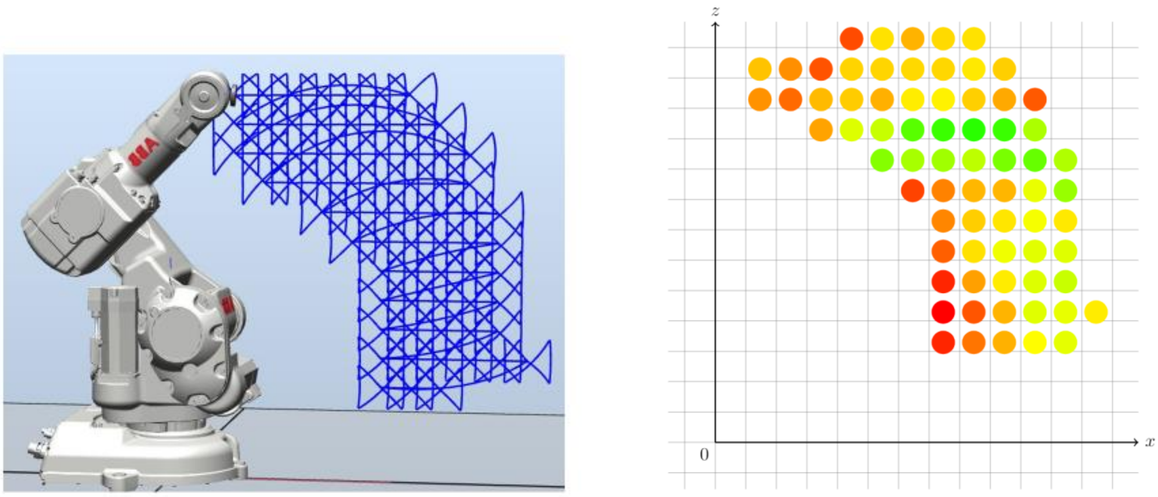


Fig. Demonstration of energy map for ABB IRB140 robot

The figure above shows the trajectory (left) used to create the energy map (right) of the ABB IRB140. The areas marked in red represent a higher energy load to perform the trajectory. In green areas, the same trajectory is done with less consumption.

6.3. Finished projects

The following text briefly presents some interesting projects solved in recent years at the Department of Robotics.

6.3.1. Safety Ambient Monitor - SAM

The two – years project SAM – Safety Ambient Monitor have been solved during 2014 – 2016 and co-financed from the European Regional Development Fund and the state budget of the Czech Republic. Project title: Pre-seed activities VŠB-TUO II – Safety. Reg. no.: CZ.1.05/3.1.00/14.0316.

SAM is a pocket system used to monitor and evaluate temperatures and other risk factors affecting firemen or other rescue team members.

The device increases the health safety of rescuers during fires and explosions and in other dangerous situations. During an event, a person using this device is constantly monitored via sensors. Data from the sensors are continuously monitored by a high-performance processor that, if necessary, sends out an alarm and notifies the user to take relevant steps to reduce the risk of bodily harm. Measured data can be wirelessly transmitted to the commander.

http://robot2.vsb.cz/sam (in English)

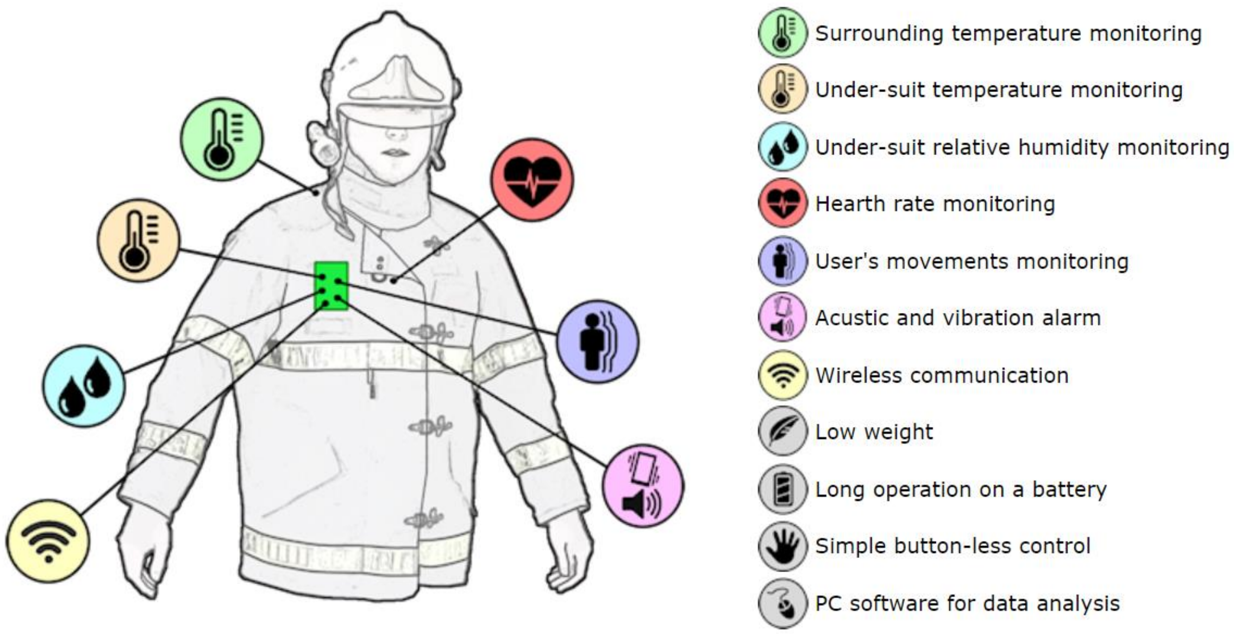


Fig. SAM functionality

Fig. SAM – unit and Commander´s tablet

6.3.2. TeleRescuer

The focus of the project “System of the mobile robot TeleRescuer for inspecting coal mine areas affected by catastrophic events” (supported by European Commission research fund Coal and Steel No. RFCR-CT-2014-00002 was the development and realization of a system for virtual teleportation (virtual immersion) of rescuers to the underground areas of a coal mine that have been closed due to a catastrophic event within them. It was an international project managed by a consortium composed of the Silesian University of Technology (Gliwice, Poland), the VSB - Technical University of Ostrava (Ostrava, Czech Republic), the Universidad Carlos III de Madrid (Madrid, Spain), COPEX (Katowice, Poland), Simmersion GmbH (Groß-Siegharts, Austria), and Skytech Research (Gliwice, Poland) during 2014–2017 years. The one of the most important task there was safety requirements related to working at a coal mine with the hazard of an explosive atmosphere. There are some limitations related to the ATEX standards (EN 60079-0, Explosive atmospheres – Part 0: Equipment – General requirements).

The TeleRescuer robot (see figure below) consists of the main chassis with four independent tracked arms (eight motors, gears, motor controllers, batteries, and the main control system are placed in a flameproof housing), a sensory arm with a sensory head, a 3D laser scanner unit, and a mote deploying subsystem (motes are small Wi-Fi repeater modules). Every subsystem has its own independent power supply. The budget of this project was about 2,5 M Euro.

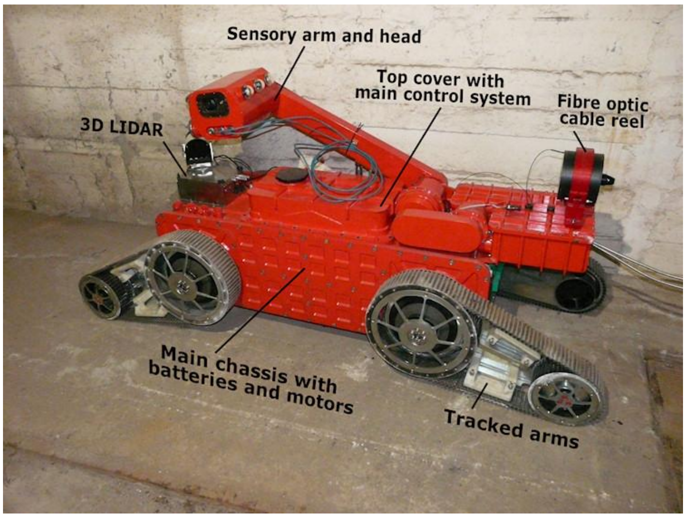
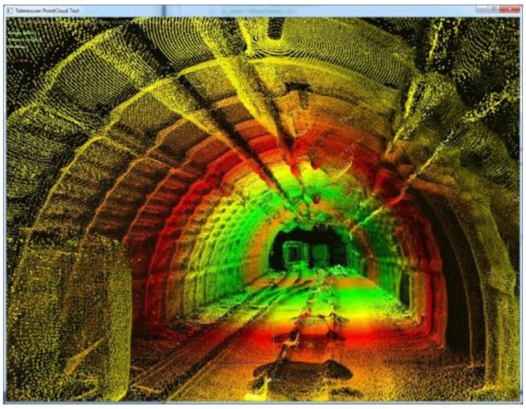


Fig. TeleRescuer—main subsystems and 3D map of Coal mine corridor



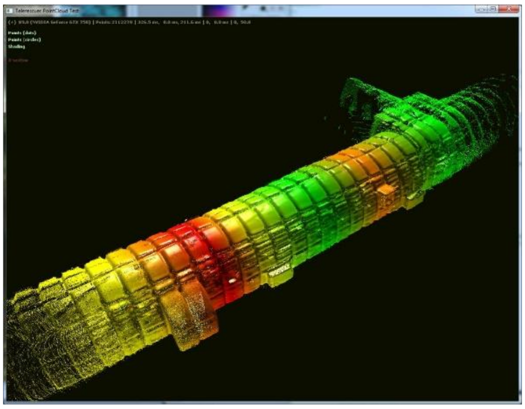


Fig. Visualization of coil mine corridor 3D map – points of clouds

http://robot2.vsb.cz/telerescuer (in English)
http://www.telerescuer.polsl.pl/ - official web

6.3.3. HARDY

Hardy is a remotely-controlled multipurpose service, emergency and rescue mobile robot designed for manipulations with objects of up to 300 kilograms of weight and also for other fire brigade and reconnaissance tasks. It is meant for use it emergency situations where a direct intervention of human rescuers or firemen is not safe. The robot is able to extinguish fire with a stream of water, with remotely adjustable shape of the stream. The mobile robot consists of three main parts: a robust chassis providing perfect stability and maneuverability, a manipulation arm with high load capacity, and a multipurpose effector with three adjustable gripping fingers and integrated water jet.

The robot was designed and developed in cooperation of: Strojírny Třinec a.s., Fite a.s. and VŠB – Technical University of Ostrava, Department of Robotics as part of project FT-TA5/071, supported by the Research and Development Program of the Ministry of Industry and Trade. Dimensions 3100 x 2060 x 2910 mm, Weight: 4500 kg.

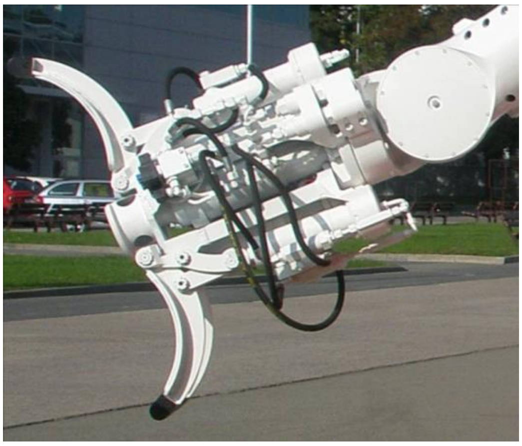


Fig. Robot Hardy (left), Robot gripper without shields with the integrated water nozzle (right)

6.3.4. TAROS

The Tactical Robotic System – TAROS is a military mobile robot developed in VOP CZ company with the cooperation of the CAFR consortium (*Centre for Advanced Field Robotics*), where Department of Robotics is the co-founding member. The Department of Robotics solved the design of a special robotic arm and gripper (7DOF) with control of grasping force and advanced control system with utilizing virtual reality. The part of the system is the real-time anti-collision system of the robotic arm and the robot body.

https://www.youtube.com/watch?v=nRejyA3d8bM&t=10s

Fig. Mobile robot TAROS

6.3.5. DETECTOR

The DETECTOR (systems of 3D cameras and SW) is able to detect cardboard boxes within a shipping container. Boxes can have different shades of brown colour, labels and they can be in various conditions. The detector returns positions and orientations of the boxes and selects the best box for robotic unloading.

Fig. HW and SW system for recognition of boxes in a container. Digits indicate the proposed order of collection.

6.4. Newly submitted projects

Name	Period	Budget (Euro)
Safety of collaborative robots (*with Faculty of Safety Engineering)*	2020-2022	300k
Digital twins of robotic systems and their verification II	2020	40k
Low cost technology	2020 - 2021	100k

6.5. New laboratories, equipment

The laboratories of the Robotics Centre underwent a major modernization in 2019. The entire work area was cleared, the floor was repaired and new robotized workplaces were installed.

Fig. View of the Robotics Centre laboratory

The ABB IRB1600 workstation is equipped with a torque sensor on the robot flange and a rotary positioner with rotation about a vertical axis. The workplace is designed for lighter machining operations by a robot such as deburring, grinding, polishing, or milling into soft materials.

Fig. Machining robotized workplace with robot IRB 1600

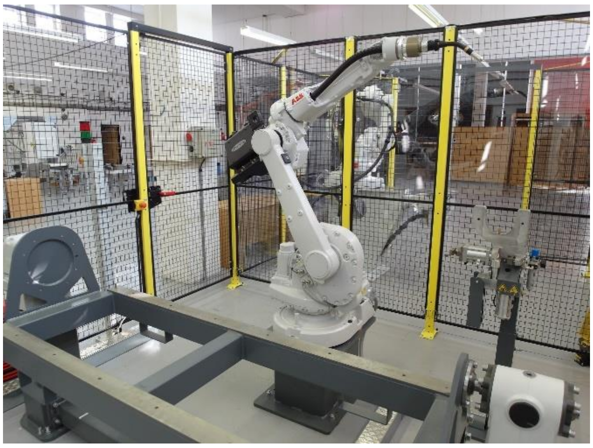


Fig. Giant. "Welding" robotized workplace with IRB 1660ID robot and positioner

The ABB IRB1660ID robot workstation (see Figure) is a simulation of the arc welding workstation. It is equipped with a rotating positioner for clamping the weldment. Since we are not allowed to weld at the robotics centre, the workplace is supplemented only by a dummy welding machine and the actual welding process will only be simulated at the signal level on the robot controller. Importantly, we have a robot with a welding accessory that allows the manipulator endpoint to move more smoothly along a defined trajectory, which is important for technologies such as arc welding, painting, glue application, surface activation, etc.

Fig. Robotized workplace with a pair of IRB 1200 robots without fencing

The ABB IRB1200 robotic workstation (consist of couple robots) - see figure above - is an example of how industrial robots can be used in collaborative mode, without fencing while guaranteeing robot and operator workspace separation. When a person approaches the robots, they slow down and if they move closer, the robots will stop safely. Collaboration is also understood to be a collaboration between robots, so they are equipped with multi move and their movements can be fully coordinated with each other. Other manipulation tasks, such as standard robots, will be realized at this workplace. The modular design of the base clamping plates allows verification of their optimal placement with respect to the task being performed.

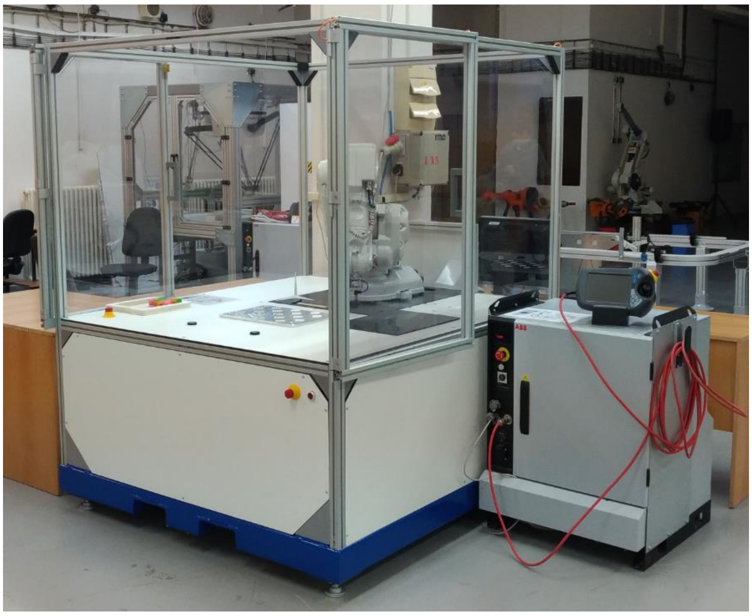


Fig. Teaching cell with 2nd generation IRB 140 robot

Based on the very good experience of teaching on the realized teaching cell, two other modifications were implemented with minor modifications. These cells will make it possible to teach larger groups of students much more efficiently within laboratories. This year, our older IRB 140 robots were serviced at the ABB repass centre (Ostrava - Hrabová) and were sprayed with the current corporate colour.

In addition, a new 3D printer Stratasys Fortus 450mc was purchased. It is a production system using additive FDM technology. The printer was delivered including a system for removing washable support materials and in a configuration that allows to produce prototype parts from all currently available building materials for FDM 3D printers.

3D printer Fortus 450mc

7. COOPERATION IN SCIENCE AND RESEARCH

7.1. Cooperation with entities in the Czech Republic

Within the framework of research and development in the field of service robotics, the Department of Robotics cooperates with leading robotic research workplaces in the Czech Republic:

- The Czech Technical University in Prague,
- CIIRC – Czech Institute of Informatics, Robotics and Cybernetics,
- Brno University of Technology,
- University of Defence, Czech R.
- VOP CZ (Military repair company), Czech R.
- Energy In, s.r.o.
- Vitesco Technologies (Continental),
- Brose,
- Hella
- Škoda Auto,
- Brano,
- Varroc,
- Robotsystem,
- and others…

7.2. Cooperation with entities abroad

- UC3M, (Madrid, University), Spain – Robotics
- SkyTech Research, Poland – Robotics, Mechatronics
- Shenyang Aerospace University, China – Robotics, Laboratory
- Silesian University of Technology Gliwice, Institute of Fundamentals of Machinery Design – Robotics, Mechatronics, research and educational stays
- IT University of Copenhagen, Robotics, Evolution, and Art Lab, Denmark – robotics, stays
- Universitat Innsbruck, Joanneum research – Robotics – stays
- Technical University of Košice, Slovakia, Mechatronics, stays

8. PROFESSIONAL ACTIONS

8.1. Conferences and Workshops

- Germany, Stuttgart
    - ROS Industrial Conference 2019
    - 10. – 13.12.2019
    - Topics: new packages for ROS/ROS2; achievements in realization of EU financed ROS projects; examples of ROS applications for industrial systems; simulation SW for ROS.

- Robotics Summit & Expo 2019, Boston, USA

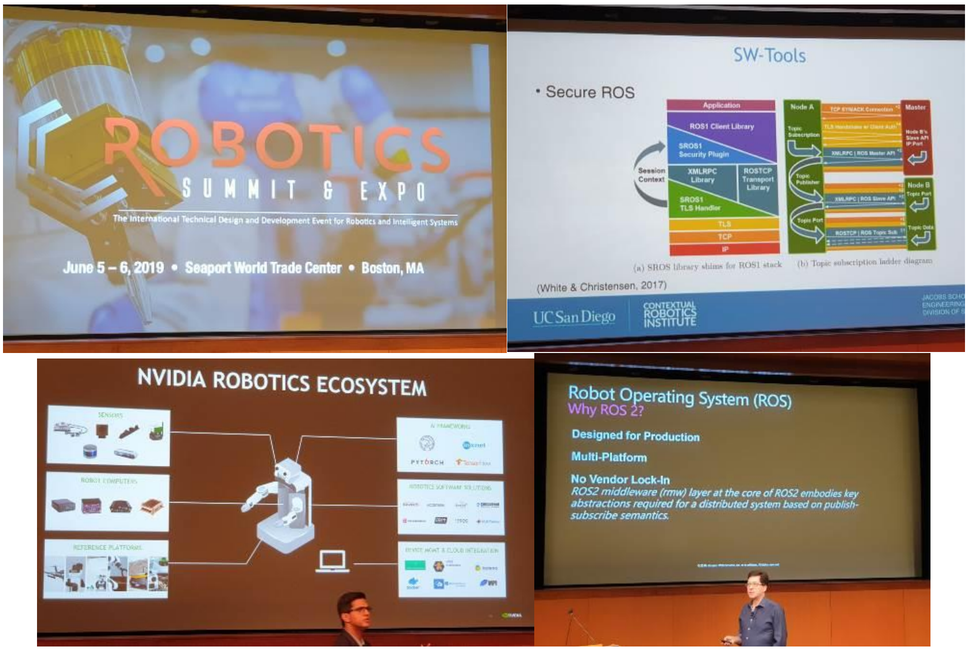


Fig. Robotics Expo 2019, Boston

- MESAS 2019, (Modelling & Simulation for Autonomous Systems Conference) Palermo, Italy - NATO Modelling & Simulation Centre of Excellence
  Robert Pastor, Daniel Huczala, Aleš Vysocký, Petr Oščádal, Jakub Mlotek, „*Modular rover design for exploration and analytical tasks*".

- Luxemburg,
    - A Czech-Luxembourgish Robotics Day
    - Presentation: *Robotics and Mechatronics. Research Cooperation in between research groups and industry: Key Infrastructure and Equipment needed*
    - 13. – 15. 5. 2019

Fig. Participant of the robotic day in the atrium of the Czech Embassy in Luxembourg

8.2. Other actions

Fig. ***NATO days 2019***

Fig. MSV International Engineering Fair Stand of VŠB-TU Ostrava

Participation in the **European Rover Challenge (ERC) 2019** – the 14-member RoverOva team of doctoral, master and bachelor students has participated in the international robotics competition in Poland for the second time. They managed to raise their fifth place last year (out of a total of 65 teams) to the podium this year and took bronze medals from the competition. The student-developed vehicle is called K3P4, which must be reminded of not only the droid of the well-known film series but also the numerical designation of our department.

They compete in four practical tasks, presentation skills, and also in the processing of documentation for the robot. The ERC has been held in Poland since 2014 and is supported by the European Space Agency (ESA). Practical demonstration tasks take place in an environment that resembles conditions on the surface of the Moon or Mars. Vehicle operators cannot have visual contact with the rover and all communication must be provided by the control system. K3P4 is thus controlled by teleoperator based on visual subsystem and sensor information while performing tasks such as rugged terrain, soil sampling, and handling objects and equipment. In addition to teleoperator control, the robot must also be capable of autonomous control. Competition website: http://roverchallenge.eu/

Web pages of the team: http://rover.vsb.cz

Fig. ERC 2019 – robot K3P4

Fig. Robot K3P4 (model 2019) and team

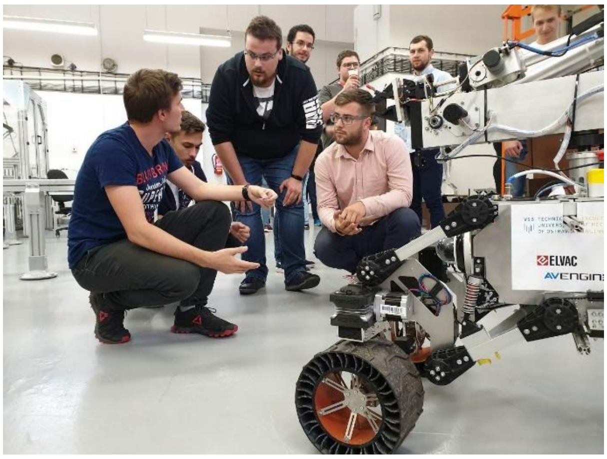


Fig. Field Day - Intended for Presentation of Field for New Students 3rd year Bc. and getting students to know each other between years.

Fig. Representatives of our department participated with the K3P4 robot on the Space Industrial Day

At the Department of Robotics there were several excursions for primary and secondary schools:

Fig. Excursions for primary and secondary schools

9. PUBLISHING ACTIVITIES

The current overview of publishing activities is available at:

http://robot2.vsb.cz/publications/