Czech Institute of Informatics, Robotics, and Cybernetics

Lenka Lhotská

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CIIRC
Czech Institute of Informatics,Robotics, and Cybernetics
Czech Technical University in Prague

CIIRC, ČVUT

Content

- Overview of CIIRC research departments
- Biomedical engineering research topics
- Industrial research
- National Centre for Industry 4.0
- Recent results of industrial research

Czech Technical University in Prague (Established 1707)

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Czech Institute of Informatics, Robotics and Cybernetics (CIIRC)

- **Based on experience – a new Institute of CTU established in 2013**
- **CIIRC should play the role of the national center of excellence in the subject fields**
- **8 research programs - departments:**
  - Robotics (Prof. Václav Hlaváč)
  - Intelligent Systems (Prof. Vladimír Mařík)
  - Industrial Informatics (Prof. Zdeněk Hanzálek)
  - Industrial Production Control (Prof. Michael Valášek)
  - Cyber-Physical Systems (Prof. Michael Šebek)
  - Cognitive Science and Biomedical Engineering (Dr. Lenka Lhotská)
  - Assistive Technologies (Prof. Olga Štěpánková)
  - Research Platforms: Center of Applied Cybernetics (Prof. Vladimír Kučera)

- **The goal: State-of-the-art, competitive and self-sustainable institution**

Brief overview of biomedical engineering research of the CogSys Dept.

Lenka Lhotská
+ 9 researchers + 10 PhD students

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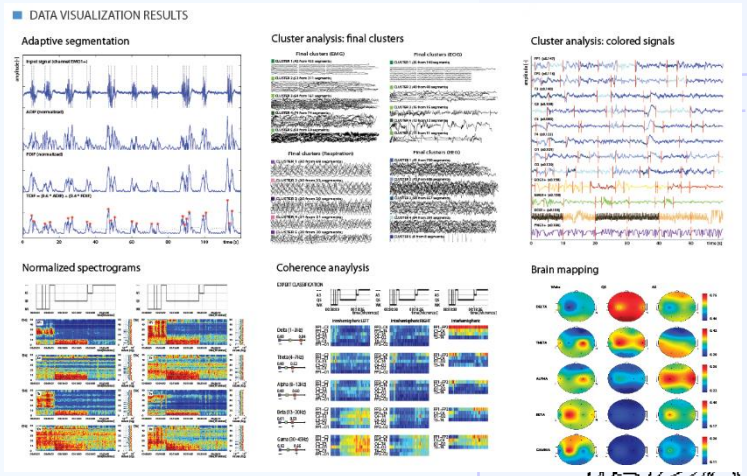
Main topics

- **Biological signal analysis** (ECG,EEG,DBS,CTG,EMG) for diagnostics and therapy
- **Advanced ICT solutions:** *design&implementation of* clinical support systems – tele-care and tele-rehabilitation - assistive technologies (alternative actuators for handicapped persons, companion robot)
- **EyeTracking**
- Development of new **AI tools for data analysis**
- **Cognitive modeling**

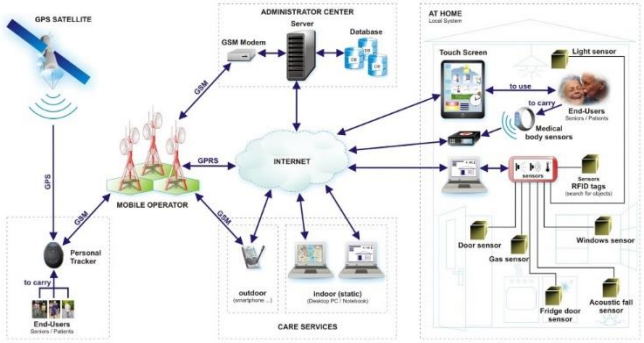
Biological signal analysis

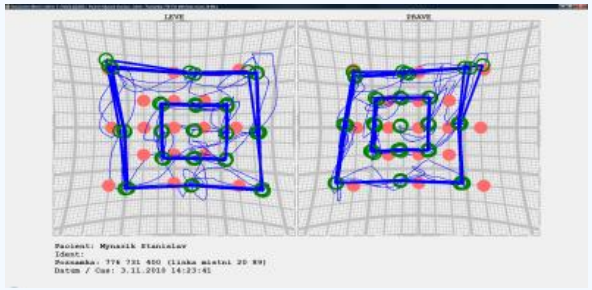
- **Cardiology**
  - **Holter ECG**: creation of beat-templates for further rule-based diagnostics
  - **Intracardiac atrial EGM**: used to select best spots for ablation
  - **Body surface potential mapping (BSPM)**: non-invasive diagnostics of the heart based on maps resulting from 128 ECG-electrodes grid
  - **Cardiotocography (CTG)**: prediction of fetal hypoxia based on fetal heart rate and uterine contraction signal
- **Neurology** (EEG, MRI, ..)
  - Longitudinal data of Alzheimer patients
  - Deep Brain stimulation data analysis
  - Patterns of unintentional movements

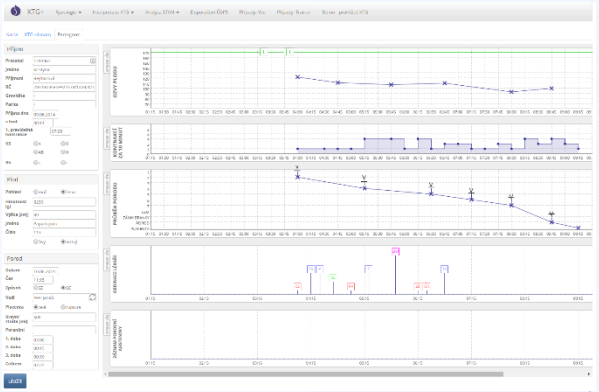


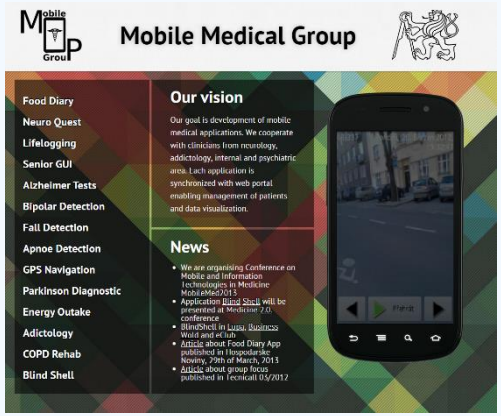
Advanced ICT solutions for clinical support and personal health

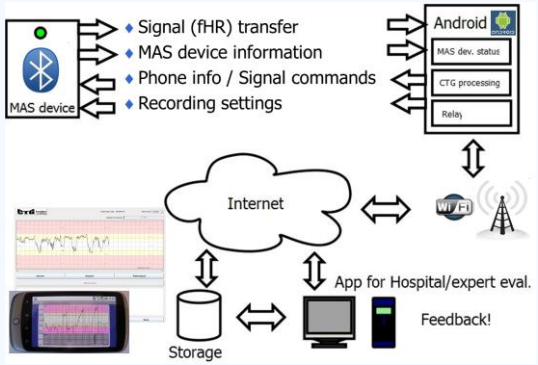
- Electronic partogram and teaching tool for obstetrics (CTG+)
- ICT diagnostic tools (strabismus, dyslexia, ..)
- Tele-rehabilitation(balance,eyes, ...)
- Mobile personal health

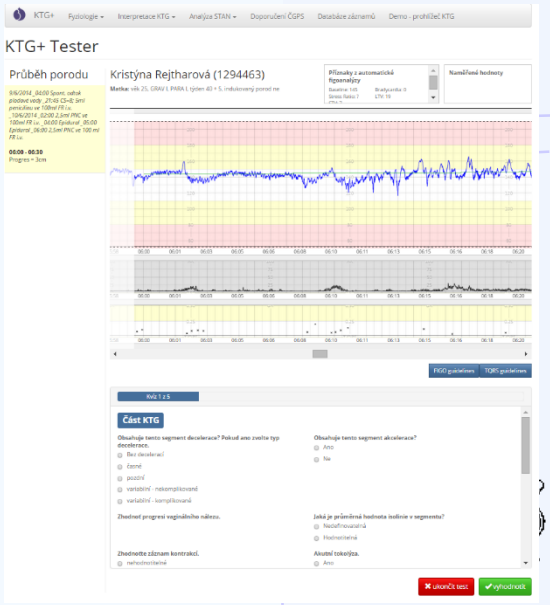






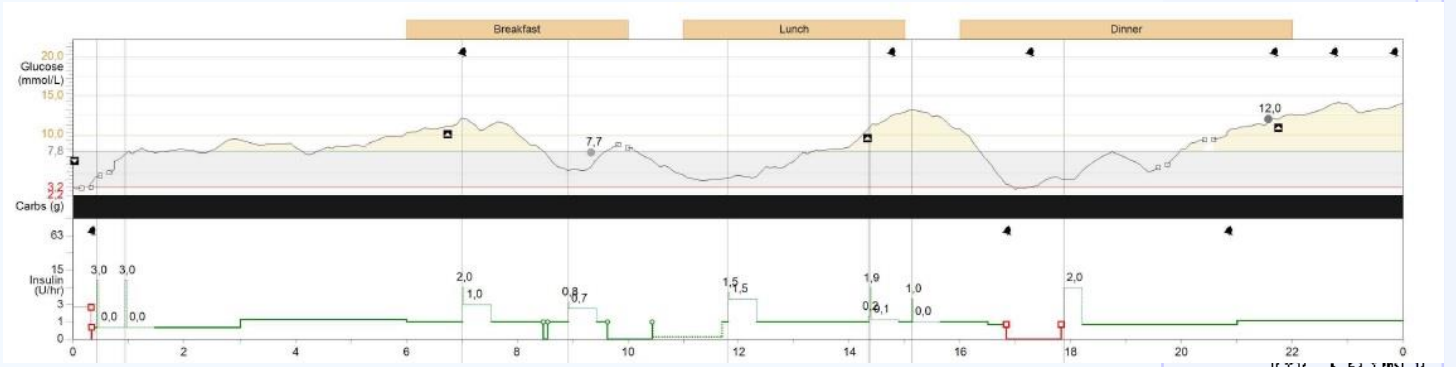




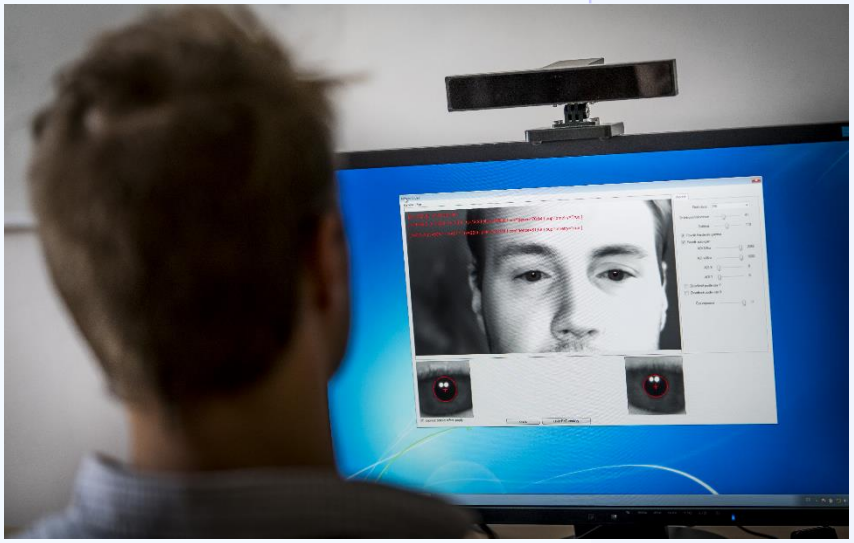


Advanced ICT solutions for clinical support and personal health

- Recommendation system for diabetic patients
  - type 1 – treatment – insulin injections
  - type 2 – diet, medication, insulin
  - serious problem – 347 mil. people worldwide have diabetes
  - goal of the treatment – re-establish full normoglycaemia
  - requirement – relevant input data
    - continuous glycaemia monitoring
    - food
    - physical activity



EyeTracking



- Both head-mounted and distant tracker
- Recording software
- Visualization software
- Evaluation software

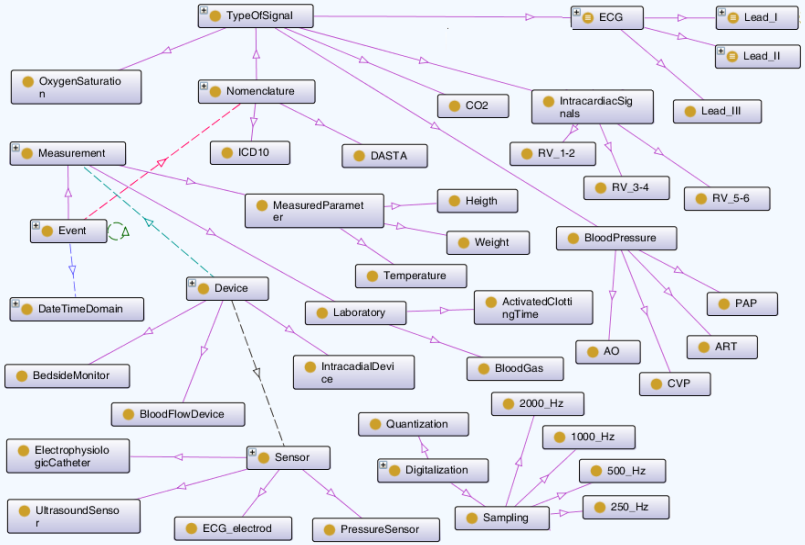
EyeTracking

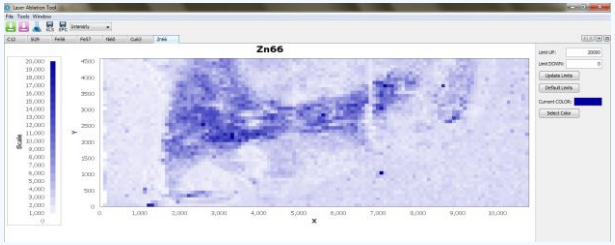
Projects and applications

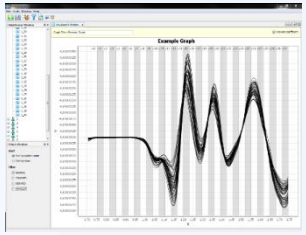
- Control of computer only by eye movements.
- Early detection of dyslexia in preschool children using characteristic features of eye movements (disturbance of normal patterns).
- Application of eye tracking technology to testing of (working) competencies - test environment for effective assessment of selected skills and competencies

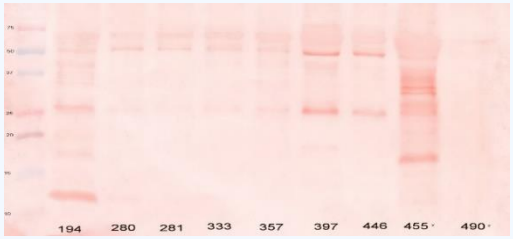
Development of new AI tools

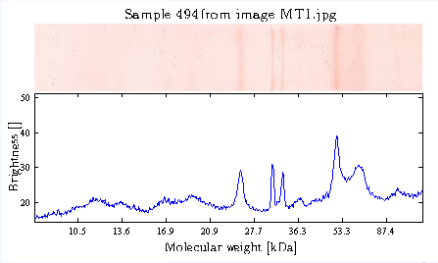
- Intelligent data collection (ontology support, ..)
- Data analysis and fusion
- Complex data visualization











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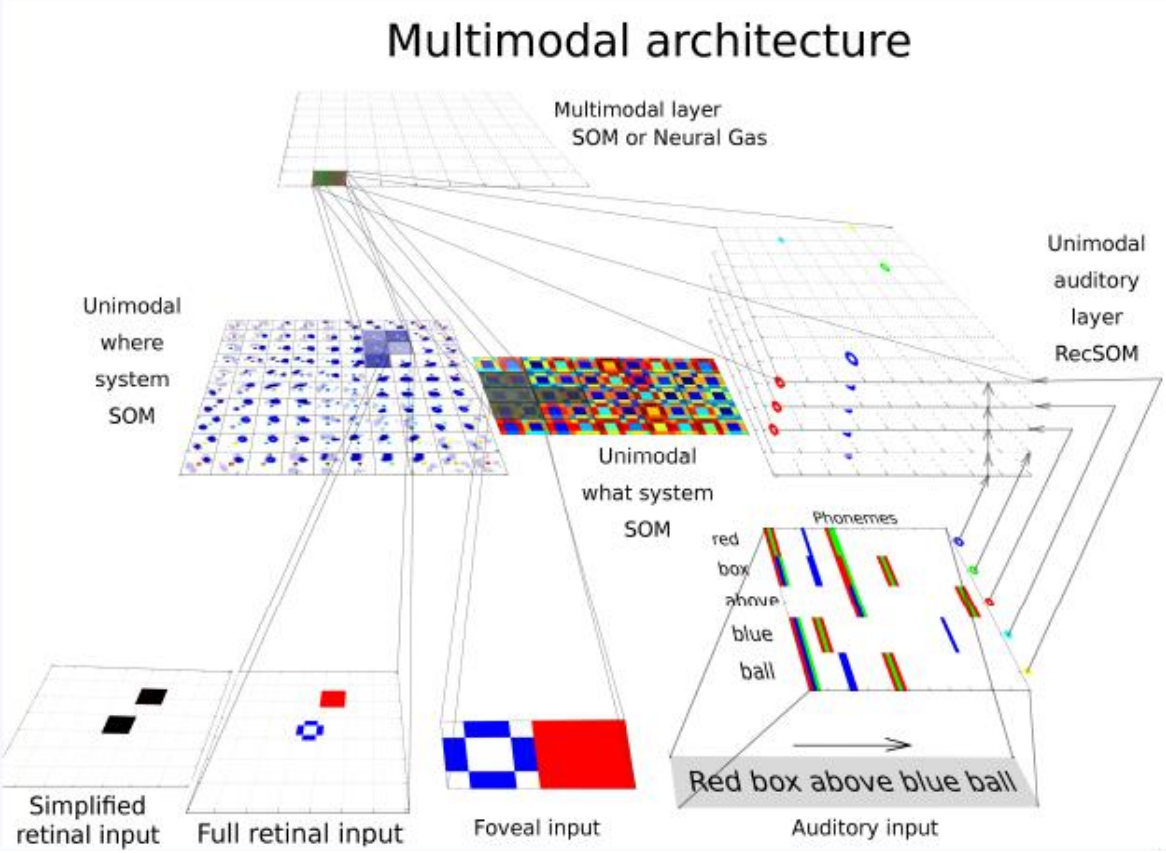
Cognitive modeling

- Approximation to human cognition
- Based on fusion of psychological and AI approaches
- Goal: Robots with human-like cognition and learning
- *Deep NN for knowledge representation, anomaly detection, …*



Czech Institute of Informatics, Robotics and Cybernetics - CIIRC

- **Center of Research Excellence: Linking excellence with applicability and applications of results**

- **16.000 sqm, 350 researchers in 2020** (joint research teams with 5 faculties, teams the Academy of Sciences, National Center for Applied Cybernetics)
- **National Center** – linkage to TU Brno, West-Bohemian University Pilsen, TU Ostrava, TU Liberec
- **Joint research Labs** with the **leading Universities** (RWTH Aachen, Vienna Univ. of Technology, ...)
- Towards integrated **education of Ph.D. Students**, e.g. in the fields of Industry 4.0 or/and Complex Systems – together with TU Brno
- Efficient **Technology Transfer Unit**
- **Incubator of start-ups** (15-20)
- Joint labs with **global companies** (Siemens, IBM, HP, Rockwell Automation, Eaton, Schneider, ABB, Festo…)
- **National Research Hub for Society 4.0 (Triangle: Industry 4.0, Smart Cities, and Energy 4.0)**

Key industrial project activities of CIIRC

Coordinator of the national **Center of Applied Cybernetics** (Center of Competence of the Technology Agency) **(Prof. Vladimír Kučera)**

AI4REason: ERC project aimed at automatic logic reasoning **(Dr. Josef Urban)**

ARUM (EU 7FW IP) and DigiCor (H2020): planning and scheduling system for **Airbus Industries (Prof. Vladimír Mařík)**

FUMA: large project in image processing for **Missile Defense Agency (MDA) (Prof. Václav Hlaváč)**

RA-DIC: Big Data in Industrial Automation **– funded by Rockwell Automation**

TRADR: Human-machine Cooperation in Robotics **(EU 7 FW project)**

SAFELOG: Advanced Robotics – Human/Robot Interaction (EU Horizon 2020) **(Dr. Libor Přeučil)**

UPDRIVE: Cars without drivers (EU Horizon 2020)

Similar projects with **Porsche Engineering, Volkswagen, Eaton, Ford, Seznam, RWE etc.**

National Centre for Industry 4.0

- Academic institutions
- Industry leaders
- Associations and Innovation Centers

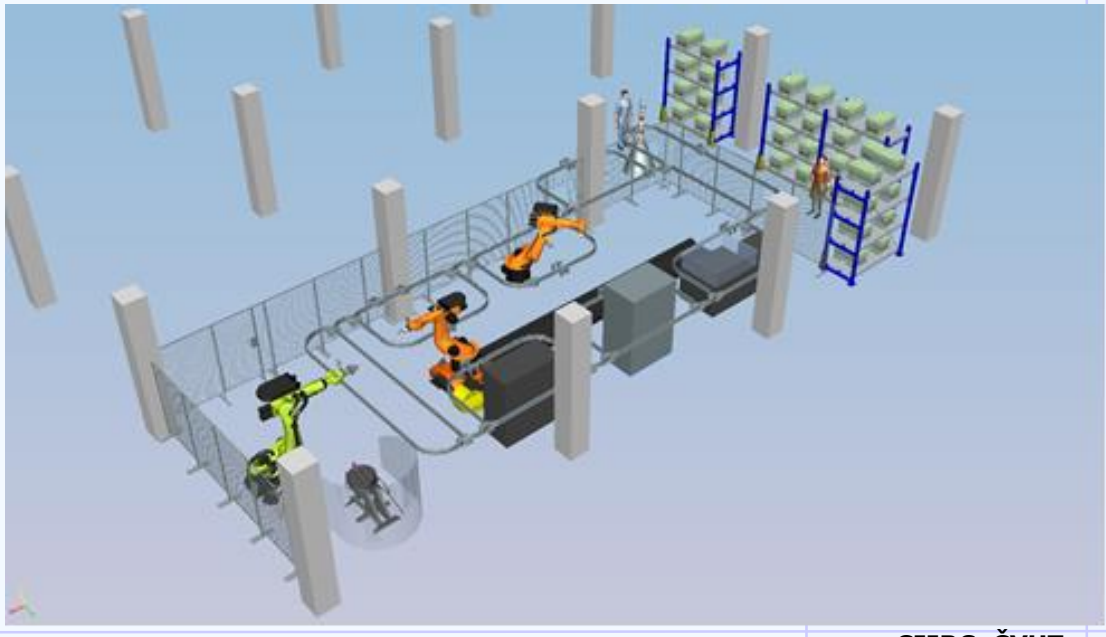
NCP4.0

- Bottom-up approach (versus Top-down in the case of Alliance Society 4.0)
- Complementary part to the Alliance Society 4.0
- Technology solution oriented

- Public – Private Partnership
- Open platform for cooperation and synergies

Testbed at CIIRC Czech Technical University

- ✓ **The very first testbed for Industry 4.0** in the country (support by **Siemens** and **Škoda VW**, and some Czech SMEs) – under construction
- ✓ **Particular goals:**
  - ✓ **Industrie 4.0** compatible solutions for **SMEs**
  - ✓ **Interoperability** of Czech-made machine tools and SW solutions with Industrie 4.0 facilities
  - ✓ Creating community of companies, direct contacts of **SMEs with global players**



Testbed at CIIRC

- **Set of**
  - Approx. **20 machine tools** (drilling machines, lathes, up-to-date turning centers)
  - Specific machines (e.g. **3D additive printing devices** for plastics and metal components)
  - Approx. **15 collaborative robots** of different nature and from different vendors (Kuka, ABB, …), part of them **shared with DFKI in Saarbruecken**
  - **Industrial automation equipment** like PLCs incl. design SW from different vendors (Siemens, Rockwell Automation, Schneider…)
  - **AGVs for transportation purposes,** some of them equipped by robotic arm with changeable heads
  - Easy-to-restructure flexible **conveyor system**

Heavy machine tools will be located **in the basement,** so the testbed will be organized **in two floors with lift transfer of semi-products**, the lift will be operated **by intelligent AGVs**

4 Examples of CIIRC Results

ARUM Project – Basic Facts

- **ARUM – Adaptive Production Management**
  - Large-scale European Integrated Project (2012-2015)
  - 14 partners from Europe
    - Czech Republic (2x), Germany, England, Portugal, Greece, Russia
  - Total budget: 11,5 M€
- Main coordinators
  - Project coordinator: AIRBUS
  - Technical coordinator: **CIIRC** & Certicon a.s.

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- **Airplane assembly ramp-up**
  - Assembly of highly complex and individualized products
    - 3-5 milions of parts – manual assembly
  - Focus: production scheduling in ramp-up phase
  - Frequent disturbances halt production
    - Missing resources (delayed deliveries of parts)
    - Non-conformities (defects, quality issues, dimensions..)

- **Airbus A350 XWB fuselage assembly line in Hamburg**
  - Several assembly stations, 90 workers with tablets
  - Semi-finished product equipped with different components
    - Thousands of workorders, jobs and dependencies
  - **The assembling process speeded-up by 12-15%**
  - **Continuation: contracted research and the follow-up H2020 EU project DIGICOR (7 mil. EUR)**

Professor Vladimír Kučera has resolved a long-standing open problem of linear systems theory – decoupling by static state feedback.

Decoupling is a problem of compensating a given system in such a way that each system output can be independently controlled by a corresponding system input.

The earliest known investigation of system decoupling dates back to 1934, a state space formulation of the problem appeared in 1964, and a solution for square and invertible systems followed in 1967. The general case of right invertible systems, however, has withstood all past efforts to obtain a solution.

A solution of this very complex problem is presented for the very first time.

Excellent result of the students' team – Dr. Jan Šedivý

University competition "Alexa Prize" – the best conversation **supported by Amazon** by the amount of $ 2,5 mil. approaches the final.

110 university teams all over the world competed trying to develop a machine able to conduct a concentrated and interesting dialogue with people, to talk about popular topics for 20 minutes

Semifinal for 10 of 110 teams ended on Aug. 15, 2017, the individual bots were evaluated anonymously

Three teams got to final stage:

CIIRC (system Alquist)

Washington University, Seattle, USA

Heriott-Watt University, Edinburgh, UK

Final result: CIIRC 2nd place

Conclusion

CIIRC

- Dynamic, young research institute
- Financed from research projects and contracts (only)

Active membership in international associations and networks

- **EERA** (European Energy Research Alliance)
- **CLAIRE** (CONFEDERATION OF LABORATORIES FOR ARTIFICIAL INTELLIGENCE RESEARCH IN EUROPE)
- **ELLIS** (European Laboratory for Learning and Intelligent Systems)
- **IFMBE** (International Federation of Medical and Biological Engineering)
- **EFMI** (European Federation of Medical Informatics)
- **ISfTeH** (International Society for Telemedicine and eHealth)

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