ROBOPROX

Project Outline

Zdeněk Hanzálek

Industrial Informatics Department, CIIRC, CTU in Prague

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Co-funded by the European Union

MINISTRY OF EDUCATION, YOUTH AND SPORTS

Robotics and Advanced Industrial Production
CZ.02.01.01/00/22_008/0004590

Introduction

Project name:	**Robotics and advanced industrial production**
Acronym:	**ROBOPROX**
Project website:	roboprox.eu
ID code:	CZ.02.01.01/00/22_008/0004590
Supported by:	Ministry of Education, Youth, and Sports CZ (MEYS)
Programme:	Operational Programme Johanes Amos Comenius (OP JAK) Call No. 02_22_008 Excellent Research
Project duration:	06/2023 – 06/2028
Eligible costs:	467,9 mil. CZK
Principal investigator:	prof. Dr. Ing. Zdeněk Hanzálek
Coordinator:	CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE CZECH INSTITUTE OF INFORMATICS ROBOTICS AND CYBERNETICS CTU IN PRAGUE
Partners:	VSB TECHNICAL UNIVERSITY OF OSTRAVA BRNO UNIVERSITY OF TECHNOLOGY UNIVERSITY OF WEST BOHEMIA

Leaders in Systems and Control

Milan Korda, FEE CTU

- data-driven analysis
- prediction & control of nonlinear dynamical systems

Didier Henrion, FEE CTU

- convex optimization
- numerical solutions of difficult optimization problems

Michael Šebek, FEE CTU

- interconnected and modular systems
- modelling, control and optimization of digital materials

Tomáš Vyhlídal, FME CVUT

- time-delay systems
- process control
- vibration suppression of flexible mechanism

Miloš Schlegel, WBU Plzeň

- controller auto tuning
- power control of nuclear reactor
- control systems

Jakub Dokoupil, VUT Brno

- Bayesian approach
- data-informed decision-making
- identification/filtering of complex systems

Leaders in Material Sciences

Jan Zeman, FCE CTU

- computer-aided simulation and design of deformable media with microstructure
- inelastic materials and structures
- models and algorithms

Tomáš Polcar, FEE CTU

- nanoscale material science
- atomistic simulations
- bottom-up material design

Leaders in Robotics

R. Babuška, CIIRC CTU

- ML, adaptive and learning control,
- nonlinear systems
- vision-guided navigation/grasping

Libor Přeučil, CIIRC CTU

- infrastructure-free UGVs and UAVs
- visual properties of the workspace
- robots in logistics

Robert Filgas, IEAP CTU

- Robotic scan of radiation from radioactive contamination

Tomáš Svoboda, FEE CTU

- resilient machines through continuous learning and sensing,
- physics based ML
- whole body sensing

Martin Saska, FEE CTU

- autonomous groups of drones
- mapping/exploration
- inspection, homeland security, disaster

Jan Faigl, FEE CTU

- robotics information gathering
- vision-based navigation in adverse conditions

Leaders in Informatics

Vl. Mařík, CIIRC CTU

- industrial AI
- multi-agent systems
- scheduling
- intelligent systems

Václav Snášel, VSB TUO Ostrava

- metaheuristic algs.
- machine learning
- artificial intelligence

M. Janota, CIIRC CTU

- SMT and SAT
- Formal Methods,
- improving efficiency of solvers by ML

Christoph Kirsch, FIT CTU

- symbolic execution of machine code,
- model checking,
- SMT and SAT solving

Z. Hanzálek, CIIRC CTU

- production planning and scheduling
- discrete optimization
- trajectory planning for autonomous cars

Each group has 5-15 researches.

Many of them are excellent.

I am honored to be in such company and happy to collaborate with all.

Advanced Industrial Production is Hard Work

1990

- we will use offshore production in cheaper countries and we will concentrate on "intelligent work only"

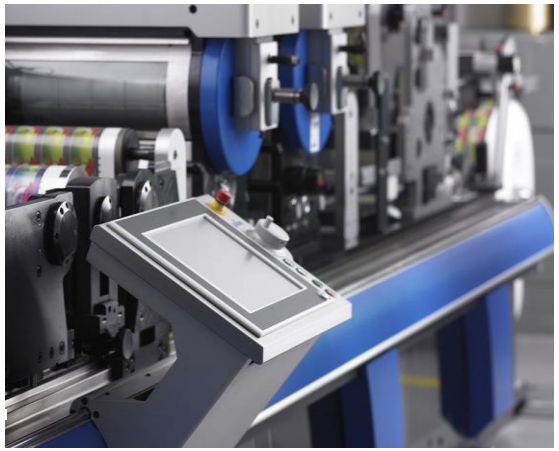
Today

- we know it was a mistake

- we need to have competitive production in Europe

- we need to increase productivity using:
robots,
automation,
optimization algorithms,
new materials ...

Example: Sequence Dependent Setup-times



Small batch size and long setup-times

Constraints:

- Sequence Dependent Setup-times
- Delivery due-dates

Objective: maximize the use of the most expensive printing machines

Traveling Salesman Problem with Time Windows

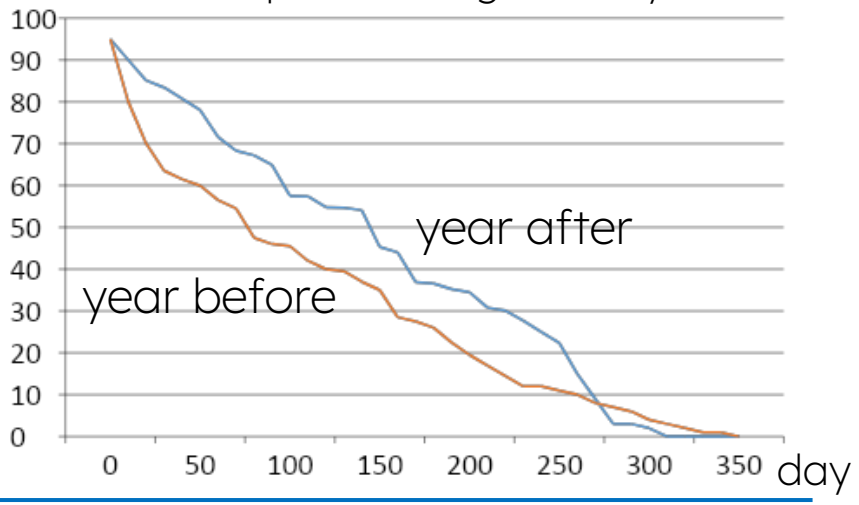
Sales may adjust price and delivery time with respect to actual schedule

No human intervention needed

Machine uptime increase from 30% to 41%

Optimization algorithm -> Plan

Machine uptime in a given day



Another Degree Flexibility

Mike Tyson says: “Everybody has a plan - until he gets hit“.

Manufacturing is hit very often by:

- Machine breakdown
- Material unavailability
- Order with high priority
- Sick-leave of personnel

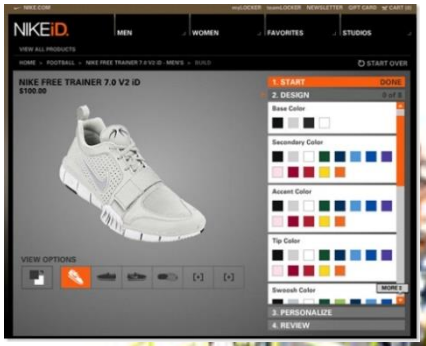
Solution

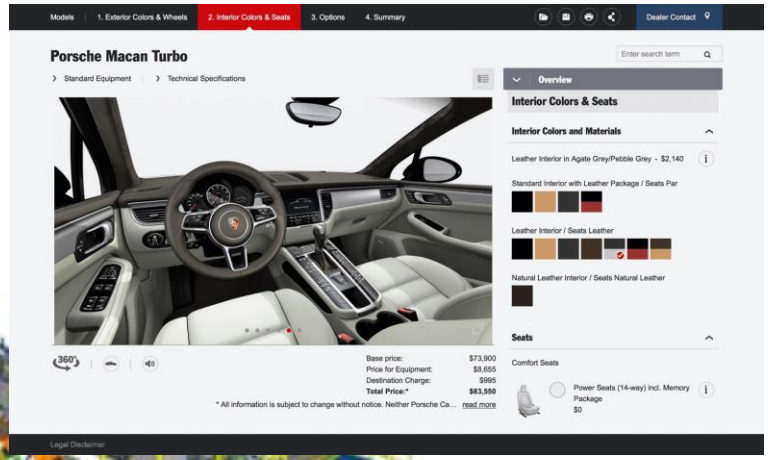
Tight integration with

- office - ERP
- shop floor - MES

Adaptivity, resiliency, autonomy, fast algorithms

Customized Production Needs High Flexibility





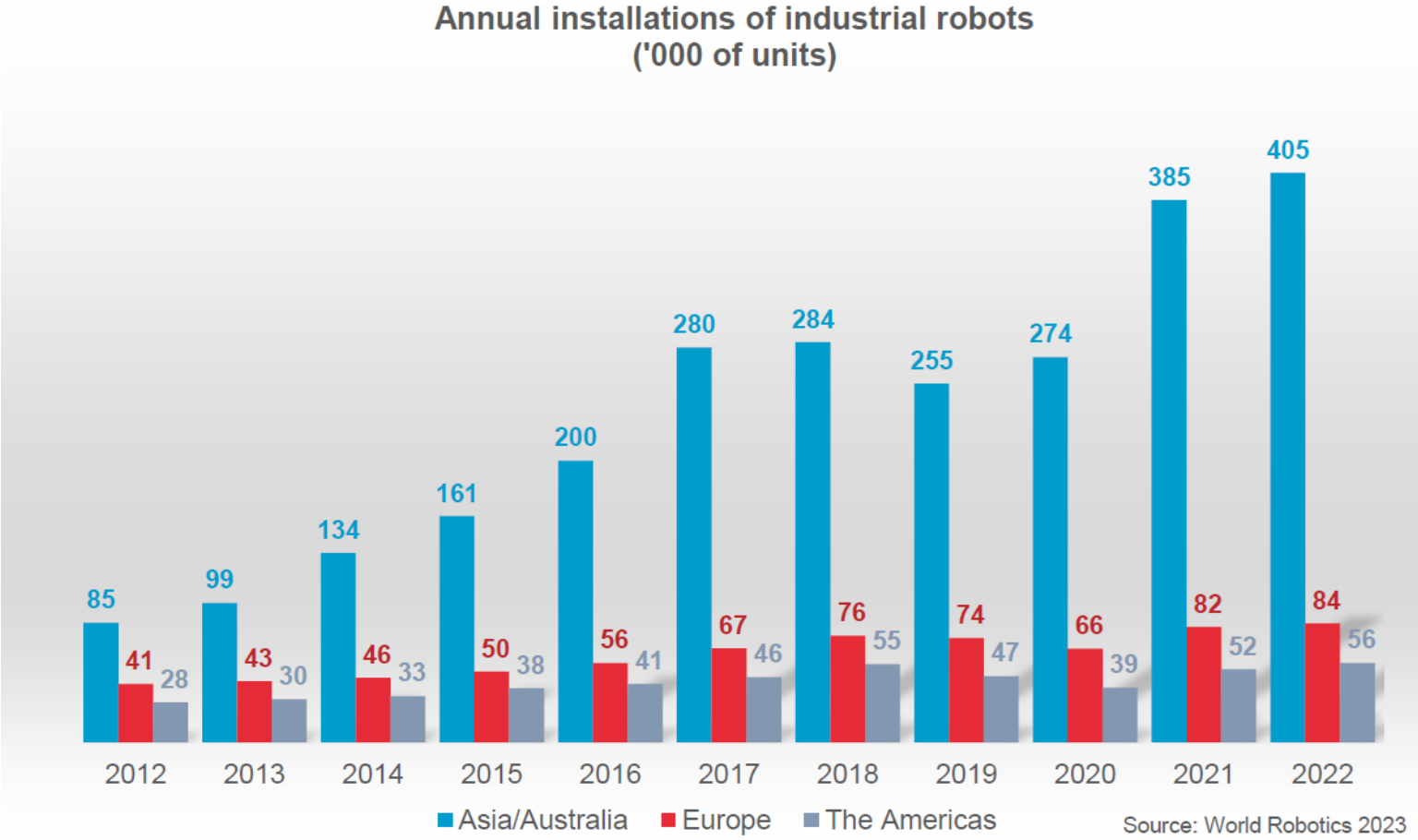
Statistics in Germany 2023 – <u>one e-shop order has 1.6 items in average</u>

Industry 4.0 – customization

Efficiency - we need methods and tools

<u>Robots are prominent solution</u> to replace special-purpose machines

To get production back we need robots, but...



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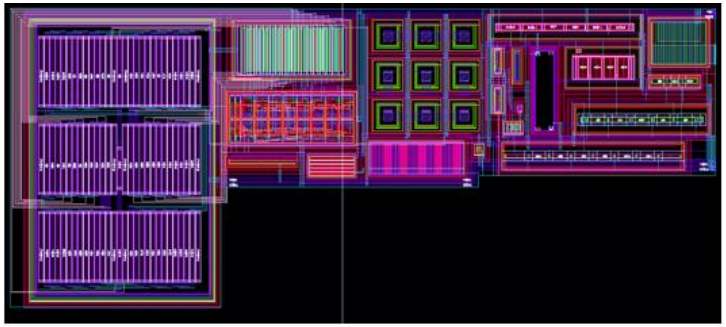
ROBOPROX
www.roboprox.eu

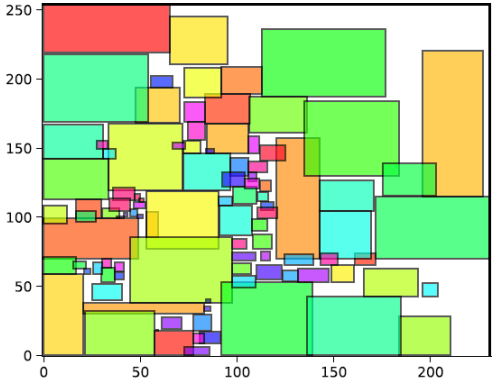
Our approach to succeed

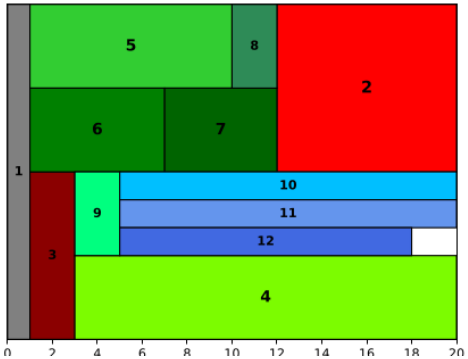
one side: underlying concepts, background theories

other side: matching with application problems

Ex. analog circuit design / floor planning/periodic scheduling







We need to:

have excellent and internationally recognized researchers,

educate a new generation of very smart people,

devise something that is unique in the globalized world,

be fast due to competition, our own finite lives, and future wars

KPIs of Project Success

Some of the expected results:

- 190 journal papers in Q1 WoS AIS or SJR
- 130 conference papers in Core A/A* or Q2 in AIS or SJR
- 20 applied results graded 1 or 2 in Methodology 17+

While looking over the past 5 years of our scientific work, we can make it:

- to concentrate on what is innovative,
- to have a clear target and
- to devise smart solutions.

For the application results we need to:

- have a clear view of the market situation - contact with industry
- find unique problems and/or unique solutions
- be fast
- protect our know-how (patent, reliable partners, ...)
- transfer on early TRL - start specific application projects (like TAČR), collaborate with high-tech companies, create own spin-off companies

ISAB - International Scientific Advisory Board

Members

- Prof. Jan Karel Lenstra, Centrum Wiskunde & Inf., the Netherlands
- Prof. Michael L. Pinedo, New York Uni., L. N. Stern School of Business, USA
- Dr. Ralph Lange, Bosch Research, Germany
- Prof. Albano A. C. R. de Carvalho, Coimbra University, Portugal
- Prof. Wolfgang Wahlster, German Res. Center for AI (DFKI), Germany
- Prof. Toshio Fukuda, Waseda University, Japan
- Dipl. Ing. Arnd Schirrmann, Airbus Defence & Space GmbH, Germany
- Ing. Leoš Dvořák, CEO of R&D Site Valeo, Czech Republic

Role

Advise the PI, Project Board and consortium in increasing the excellence relevant to academia and industry. Evaluate the project results.

Organizational Structure

Bodies

- ISAB - International Scientific Advisory Board
- Project Board
- 2 Work-package leaders
- 13 Research Area leaders
- Women's Forum led by K. Štěpánová
- Project Management Office

Meetings

- Plenary - once a year
- Group leaders - once a quarter
- Project board - once a month
- MPO meetings - once a week