Advanced Autonomous Robotics

from Research to Applications and Industry 4.0

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Intelligent and Mobile Robotics (IMR) and
Center for Advanced Field Robotics (CAFR)

Czech Institute of Informatics, Robotics nad Cybernetics (CIIRC)
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About us

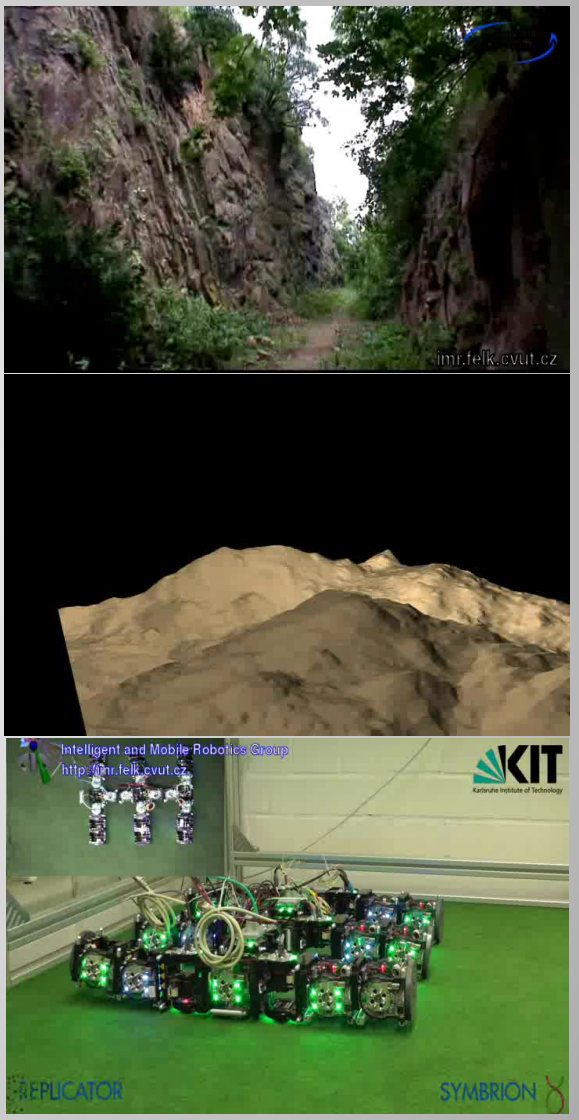
Intelligent and Mobile Robotics laboratory, since 1993, http://imr.ciirc.cvut.cz

Focus on **basic and applied research** in the fields of:

- **Autonomy for mobile robots of UGV and UAV** type in general, i.e.:
- **Robot navigation** for **indoor** and **outdoor**
- Autonomy for human-oriented and **uncontrolled environments** with uncertainty, high complexity and for infrastructure-free cases
- Advanced **planning and scheduling** for robotics
- **Swarm** and **collective robotics,** HRI and co-work, hybrid human-robot systems

With **application** outcomes through **Center for Advanced Field Robotics** (CAFR), since 2012, http://cafr.cz

- Strong links to other CZ robotic labs and industry



Why autonomous systems?

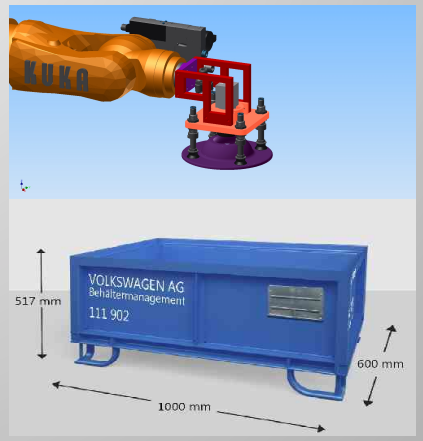
- **Ability to handle uncertainty**
  unexpected situations resolution, handles incompleteness of the environment description, its' structure and constraints
- **Adaptation to varying conditions, learning and system scalability**
  readiness to adopt to task complexity, scalability, runtime task and performance optimization
- **Open decentralized (on-board) control and operation in communication inaccessibility**
  system control independent on communication, temporary and autonomy long-term autonomy
- **Human-oriented environment capable**
  high structural complexity, variation over time, indoor/outdoor and natural/urban/production kinds
- **No need for environment infrastructures**
  no external support systems for navigation, very flexible and ready to handle variations in the workspace

Success stories, examples

- **Safe automated storage and logistic systems** (EC project Horizon 2020, SafeLog): Advanced solution to human-robot safety and collaboration in logistic setup, advanced planning and scheduling for logistic problems

- **UGV autonomy for complex-structured and infrastructure-free environments** (VOP CZ, Taros): Autonomous navigation of UGV based on onboard sensors (vision) in any-kind environments. Localization, mapping and path planning for transportation, surveillance and inspection and exploration tasks.

- **Smart bin-picking** (Škoda Auto, B3P): Advanced sensory data processing, development and prototyping of robust bin-picking and general manipulation of objects.



Next generation safe logistics

Project H2020 SafeLog: **Advanced safety and task planning for automated logistic systems**

- Allows safe human entrance and collaboration in the warehouse in operation
- Novel approaches to “anytime“ approx. solutions of NP-complete planning problems

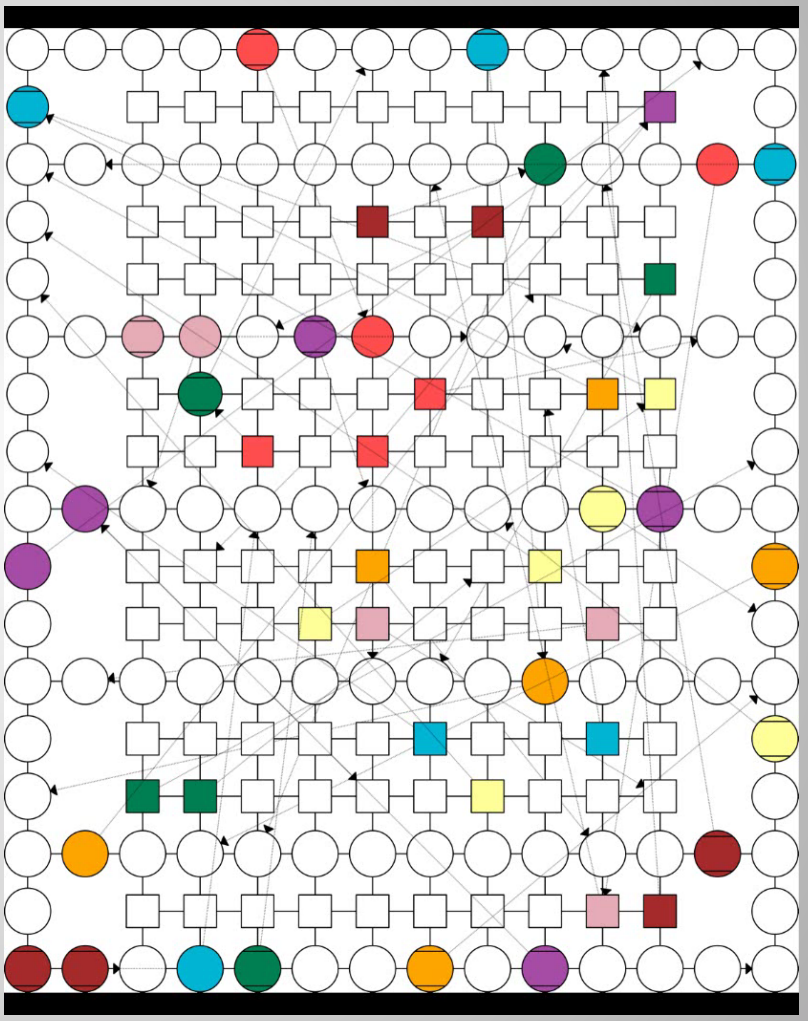
Advanced and safe logistics

The safe logistics concept: **Human-robot collaboration/coexistence**

Planning for complex problems

Efficient logistic concept: **Steady runtime optimization**

- **Everlasting optimization** of the fleet scheduling& planning in a warehouse with an in mission human
- **Order of the problem, NP-hard**
  - 10.000+ warehouse positions
  - 1.000+ transport robots
- Update of an „any time“ approximate **solution required in real-time** (within 1 sec)



Autonomy and navigation

TAROS: **Autonomous navigation of unmanned mobile robot** in complex and uncontrolled (unknown/varying) and infrastructure free environments (for VOP CZ)

- Relies on observable environment features
- Active and passive sensing (vision), RGB camera and/or depth from LIDAR)

Major features of the solution:

- No infrastructure needed (GPS-dark areas, no navigation markers, or other instalations)
- Extremely robust to environment look variations
- Provides collision-free navigation in between given locations and path planning and scheduling

Prospective application field of the technology:

- Autonomous transportation systems for uncontrolled environments (indoor and outdoor.
- Autonomous inspection systems (security and safety systems, production and technology surveillance, etc.
- Servicing of variable areas (storage spaces, warehouses, public spaces, malls, etc.)

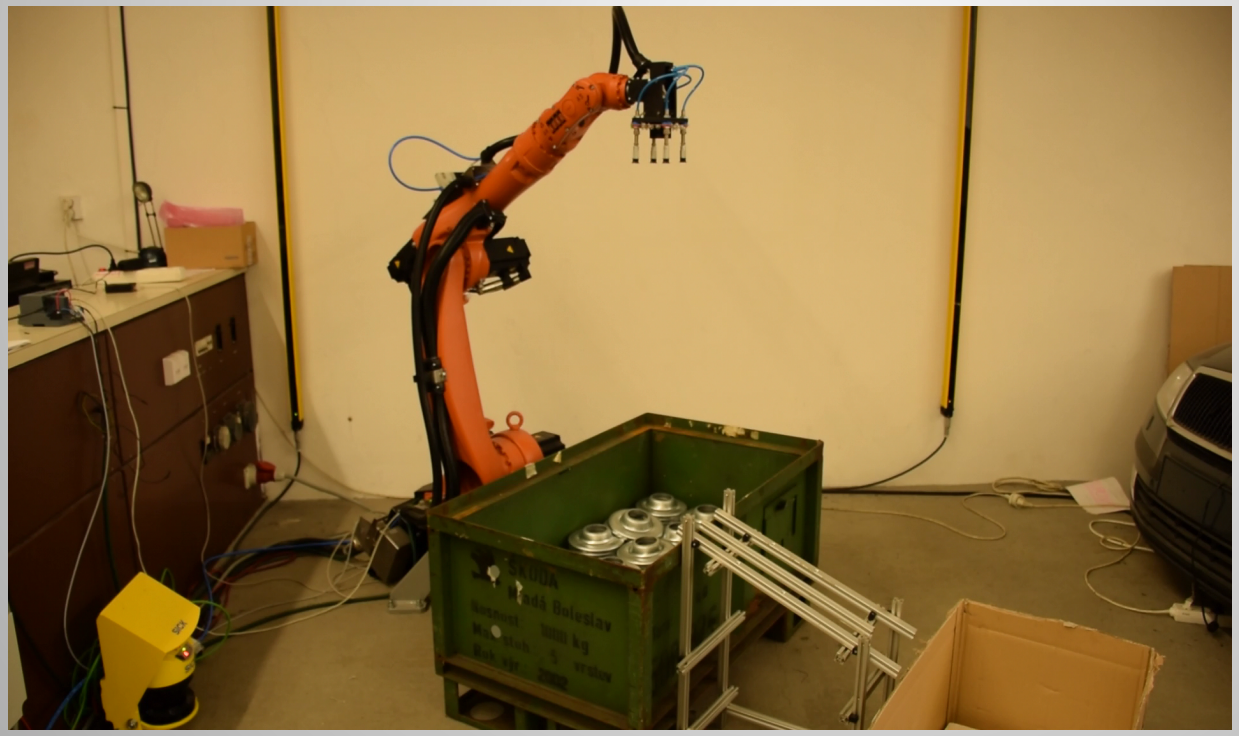
TAROS6x6: **Vision-based autonomy for infrastructure-free spaces**

the Mule scenario (for VOP CZ)

Smart bin-picking

Project: **Smart bin-picking** (for Škoda Auto a.s.)

- Picking of unevenly laid parts from transportation bins, feeding assembly lines
- High precision vision-based manipulator guidance in 3D and pick-planner system.
- Novel approach to image processing using NN and DL brings high robustness and variability of the solution
- Optimized costs



Thank you for your attention

Questions?

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Autonomy and navigation

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