Intelligent and Mobile Robotics

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Robotics and Machine Perception

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TECHNICO
architects & engineers

About us

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

Focus primarily on **basic and applied research** in the field of **autonomy for robots** (UGV, UAV and manipulators) i.e. general:

- **Robot navigation** for **indoor** and **outdoor,** infrastructure-free and life-long autonomy
- Autonomy for human-oriented and **uncontrolled environments** handling uncertainty and high complexity cases..
- **Robot sensing** and environment modeling
- 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 major robotic labs and industry in CZ and worldwide

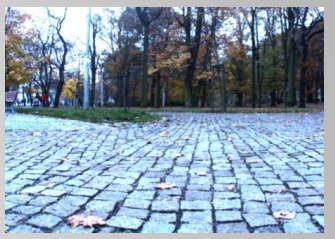
Why AI & autonomous systems?

- **Ability to handle uncertainty**
  resolution of unpredictable situations, failure detection and recovery, improved runtime performance @ incompleteness of description or uncertainty in the environment
- **Adaptation to varying conditions, learning and system scalability**
  improves performance/adopts task complexity, scalability, runtime task and performance optimization, readiness for operation in indoor/outdoor and natural/urban/ production kinds of environments
- **Human-oriented environment capable**
  enables efficient HRI**,** variation of the workspace over time, uncertainty
- **Infrastructure-free operation**
  no need for external support systems for navigation, very flexible and ready to handle changes in the workspace
- **Open decentralized (on-board) control and operation in communication inaccessibility**
  system control independent of communication, temporary and long-term autonomy

Some selected research topics...

Visual navigation using embedded scene look

- Relies purely on scene look (monocular RGB/Y camera)
- Builds visual maps using stable descriptors found in scene images
- Visual descriptors represented by either by robust image features (i.e. SURF, SIFT..) working with intensity images, or DNN that comprise **intensity properties of the scene image(s)** and their **topology**.
- Highly robust to scene look variations -> well treats diversity of the same scene, excellent method for incompletely known and varying environments
- Enables performance self-diagnostics via measuring of information flow from the scene



Large and sparse spaces navigation

LArge**MA**ps **concept for representation of large environments with uncertainty**

- Elaborated primarily for **outdoor navigation in large and sparse environments**, along roads/streets (urban and roadmap alike environments)
- Ready to handle infrastructure-free and stepwise buildup, capable of reasoning about the environment

- Transition/connectivity graph concept: Combines "**place recognition**" and connectivity between unique places maintained by **place-to-place transitions**
- Efficient representation: Places described by embedded visual words - image features and their structures

Prospective application field:

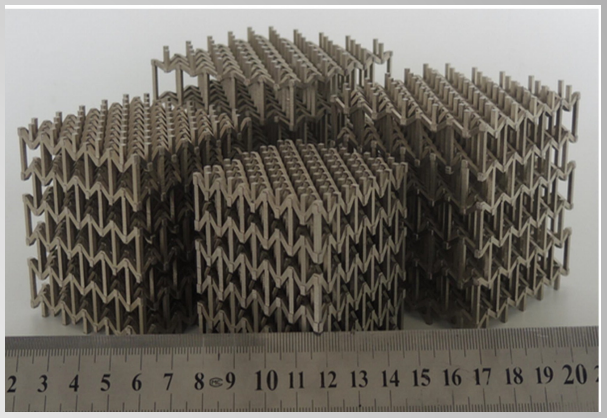
Localization and navigation without GNSS for any-kind (and complex) terrains/environments

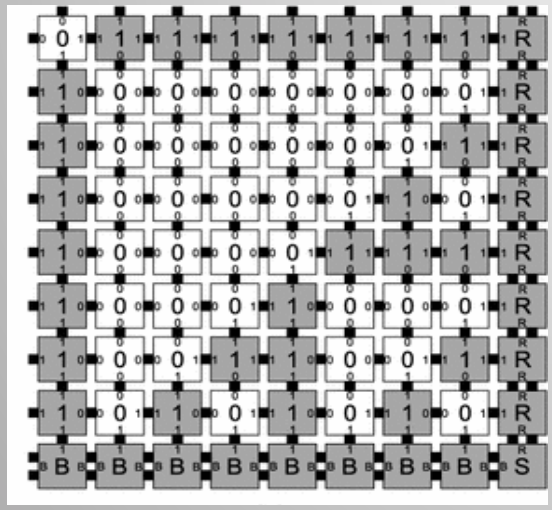
Allows implementation of teach-and-repeat navigation principle

Non-periodic materials

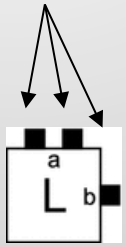
Non-periodic and metamaterial self-assembly

- Materials with yet new mechanical properties, similar to Wang tiling, application in construction and mechanical computing systems
- Methodology for generation of tile sets with plausible properties
- Elaboration of material self-assembly methods and tools





Surface property coding (glue)



Tile of type L (one cell of material)

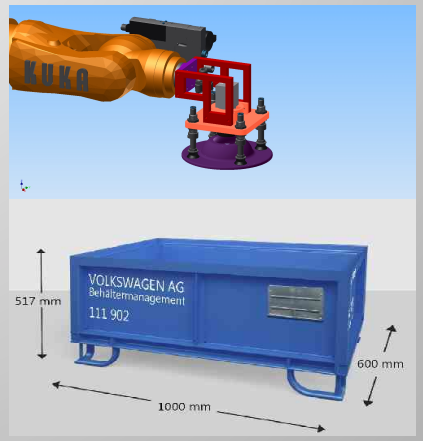
Selected applications and success stories

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



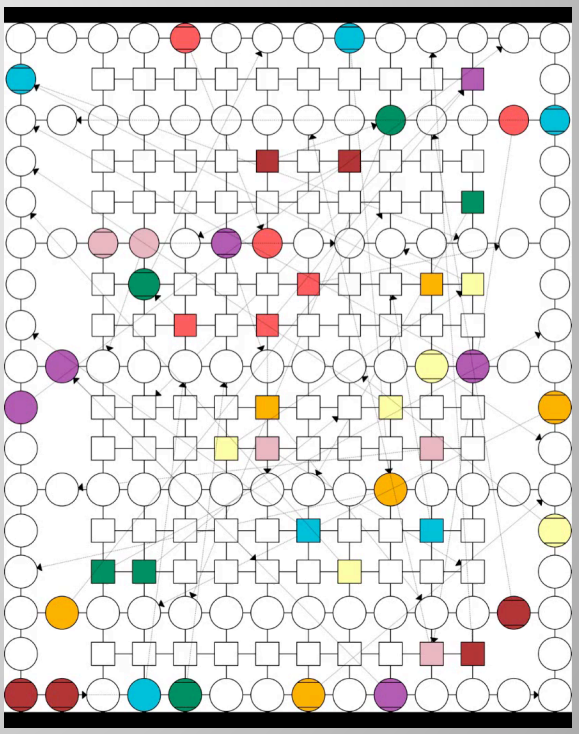
Robot autonomy and HRI in logistics

Advanced safety and task planning for automated/robotic warehouse systems (project H2020: SafeLog)

Next generation safe logistics

SafeLog approach:

- Allows **safe human presence and collaboration** in a warehouse in operation via new safety concept
- Novel methods for steady optimization through “anytime“/real-time approx. resolution of **NP-hard planning/routing problems**
- **Incorporated uncertainty** through human presence; intention prediction (hidden Markov models)



Infrastructure free navigation

UGV autonomy and navigation

for **infrastructure-free**, complex and **uncontrolled environments**
(project VOP CZ, TAROS 6x6)

- Relies on observable environment features only, no GNSS or other infrastructure needed
- Primarily passive sensing (vision), RGB camera and/or depth from LIDAR
- Capable of handling very large and sparse environments

Prospective application field of the technology

- Autonomous **transportation systems** for any-kind environments (indoor, outdoor, natural/ urban)
- Autonomous **inspection systems** (security, safety and surveillance systems, etc.)
- **Service systems** in variable areas (warehouses, public spaces, shopping malls, etc.)
- Applications for **Smart Cities,** autonomous cars (valet parking)

Smart bin-picking

Project Skoda Auto, Lego (SmartBinPicking, Pick&Place)

- Automated picking of unevenly laid parts from bins, sorting/feeding assembly lines
- Vision-based manipulator guidance in 3D and pick-planner system.
- Novel approach to image processing using (D)NN, high variability of the solution
- Optimized solution costs

Thank you for your attention!

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