How to apply cognitive abilities in industrial automation and logistics

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Transfer of Cognitive Robotics Research to Industrial Applications
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Market

Low-cost and collaborative robots are the future

„Strong growth in professional service: break-through expected within the next 7 years

• Robotic systems must be low-cost and need to collaborate with the human
• Transparent and secure data exchange and distributed systems
• Robots must handle process and sensor data and prepare/support decision-making
• Classical industrial vision systems need controlled environment conditions, are not able to fulfill the challenges in partially-structured environments

“Easy-to-use systems” are required
3D Perception Testimonial

“3D vision is a disruptive technology that enables robots to operate in a partially-structured environment”.
- IFR Annual Report on Service Robotics

“Perception was the dominating factor separating the winners from the rest of the field in the amazon picking challenge”.
- Henrik Christensen

"If we were only able to provide the visual capabilities of a 2-year old child, robots would quickly get a lot better."
- Rodney Brooks

Sources:
Market demands precise, low-cost robots

3D Vision reduces robot costs

- Many applications require high precision

- High **absolute** accuracy is limited and leads to high robot cost

- Manipulation and grasping require precision **relative** to the work piece

- Robot base and object location remain flexible (no classical teach-in possible or necessary)

„New paradigm change in programming robots“
Cost Reduction and Increased Performance

Holistic development of manipulation and perception

- Traditional application approach: Engineering of individual solutions at high cost

Flexibility and versatility reduces cost

- Some production steps require two arms
- Force sensing and 3D vision are required
- Gripper technology is a cost factor

„Holistic analysis and design of perception and manipulation reduce cost by common building blocks“
Pipeline Including Manipulation and Grasping

**Visual Perception**
- Scene registration:
  - Pointcloud
  - B&W / RGB images
- Scene interpretation:
  - Localization wrt. environment
  - Plane detection (tabletop scenarios)
  - Clustering
  - Object recognition/approximation
  - 3D / 6D object pose estimation (application dependent)

**Contextual information**
- Object model database:
  - CAD model (mesh / object coordinate frame)
  - Semantic annotations (action / restriction areas)
  - Mass / inertial properties
  - Grasp database (gripper dependent)
- Task information:
  - Grasp planning:
    - Known objects: grasp database
    - Familiar objects: grasp adaptation
    - Unknown objects: online grasp planning for the approx. geometry
  - Grasp sorting:
    - Reachability
    - Feasibility for start / goal configuration
    - Grasp quality
  - Task information:
    - Grip specification
    - Required hand / power tools
    - Goal pose / intended use
    - IK / Reachability map of the manipulator
- Supervisory system:
  - Error detection
  - Planning of corrective actions
- Grasp / Motion planning
- Feedback:
  - Visual (Object / Hand tracking)
  - Tactile (gripper)
- Motion planning:
  - Reachability
  - Collision-free path
- Grasp/Manipulation execution:
  - Arm / gripper control

Closure of the action/perception loop
Key Questions

Domain: Industrial Automation and Logistics

• Cognitive technologies introduced into industrial applications?
  • Use of object databases containing geometric information (small data)
  • CNNs for segmentation of data
  • Use of process information for task description

• Major Gaps so far:
  • Programming of tasks (perception/grasping/manipulation) require expert knowledge
  • Robustness and cross-context application is very limited
  • Many “engineered solutions”
Key Questions

Domain: Industrial Automation and Logistics

• Expected cognitive technologies in the next three years?
  • Semantic annotation of objects
  • Novel programming paradigm using relative information and task abstraction
  • Supervisory systems
Thank you.

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