From Fixed Tasks to Flexible Production with Robotics

Robotiikan uudet sovellukset vene- ja komposiittialan tuotantoon

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Agenda

- Introduction to AI & Robotics
- Examples and training
- Research at Centria
- Possibilities & challenges

Traditional industrial robots

- Traditional industrial robots perform well when:
  - Environment is controlled
  - Workpiece is known
  - Trajectories are fixed
  - The task is repetitive
  - Tolerances are predictable

- Repetitive, precision work with possible exposure to elements (e.g. welding, material handling, machine tending etc.)

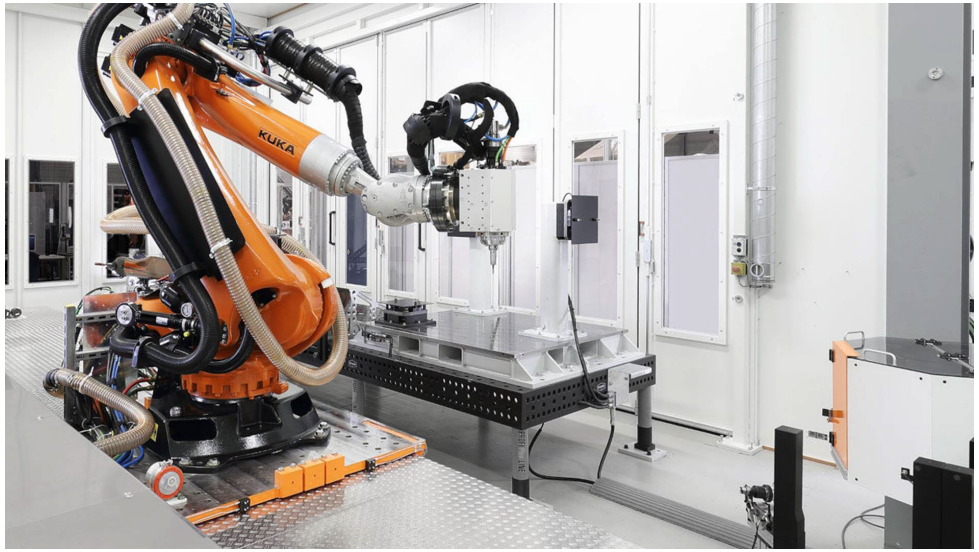


Fig: KUKA

Exceptions

- **What happens if something goes wrong?**
  - **Component is out of position**
  - **Product is defective**
  - **Lighting changes**



Fig: Mercedes-Benz

- **AI & Robotics is used to** *bridge the gap between automation and messy, physical, real-world systems.*

AI & Robotics

- AI & Robotics research allows more complex tasks for robots, increasing their potential
- Autonomous laundry folding
- Mercedes Deploys Its First Humanoid Robots in the Factory



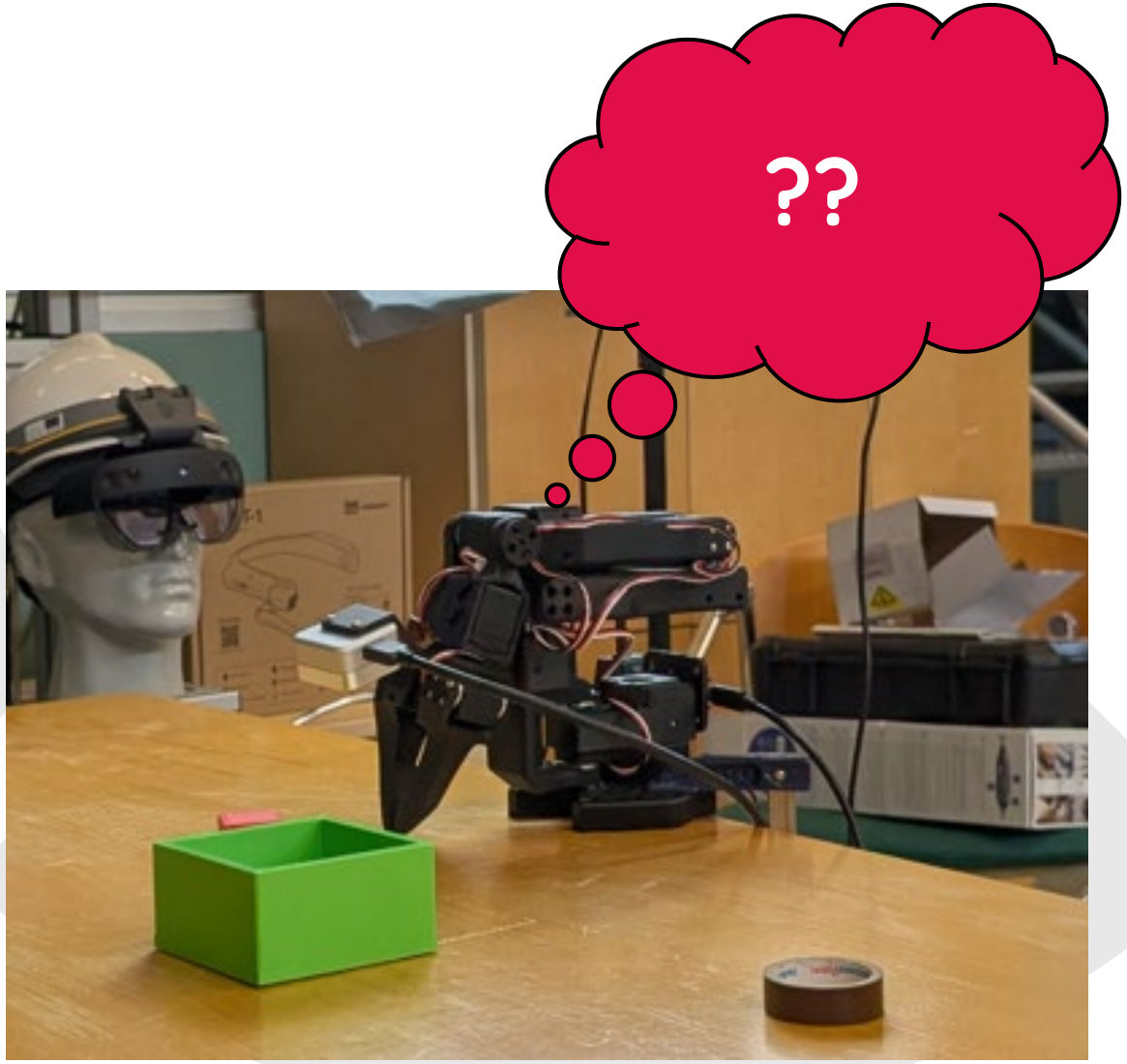
Fig: Physical Intelligence



Fig: Mercedes-Benz

Example: ”Put the red cube into the green cup”

- Traditional robot needs to:
  - Know where the cube is
  - Know where the green cup is
  - Have programmed instructions for moving to the cube and the cup, including parameters such as speed and positioning accuracy (programmer input)
- Take one away, and the task fails!



Example: ”Put the red cube into the green cup”

- This time, the robot is trained to the task using VLAs (Vision-language action model), 50 episodes
- Programmer uses a teleoperated arm to approach the cube, grasp the cube and put it in the cup
- Through training, robot **learns** from example AND **understands** the context and **acts** accordingly



What does AI change in robotics?

- **Perception:** Understand objects, people and surroundings
- **Learning:** Learn and improve from demonstrations, simulation and experience
- **Planning:** Select and execute actions based on context
- **Adaptation:** Recover when objects, tasks or environments change
- **Feedback loop:** Observe → decide → act → adapt

Comparison: Automation vs. Autonomy

Traditional automation	**AI-enabled robotics**	**Emerging physical AI**
Program the robot	Train the robot	General-purpose robot models
Known environment	Changing environment	Open-world environment
Fixed trajectories	Adaptive behaviour	Generalization
One task	Multiple tasks	New tasks
Engineer specifies ”how”	AI learns ”how”	Human specifies ”what”!

- *”Execute a program”* → ***”Observe, decide, act and adapt”***

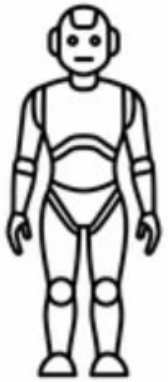
Example: Humanoid robots

Traditional industrial robotics



- Positions and trajectories are programmed explicitly
- Sequence and logic are predefined
- Works best in known, structured environments
- Exceptions often require separate programming
- Changes usually mean reprogramming

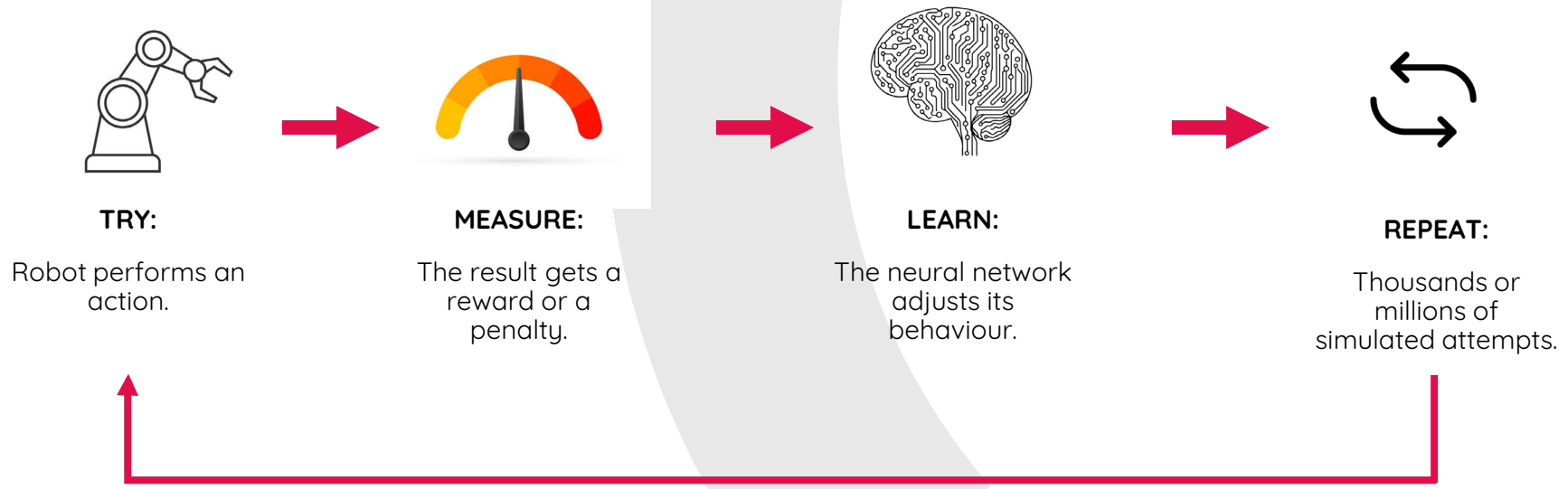
AI-driven robotics



- The goal or task is taught, not every movement
- Perception becomes part of control
- The robot generates and adapts the motion
- Better handling of variation and exceptions
- Learned behavior can improve and scale

- The humanoid robot is just a vessel for expressing complex robot behavior using AI!

How it’s done: Reinforcement learning



- The robot learns to **maximize total reward over time**.
- Good outcomes are rewarded, bad outcomes are penalised.
- Example: teaching an humanoid to reach an object:
  - +5pts: Reach the target
  - +2pts: Stay upright
  - -5pts: Lose balance
  - -10pts: Fall
  - -1pts: Use excessive energy

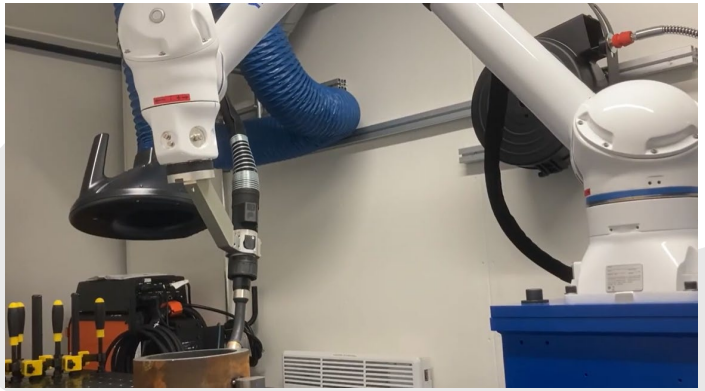
Centria Robo 3D Lab

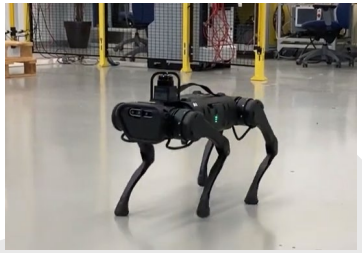
- Centria’s Robo 3D Lab at Ylivieska campus is the most versatile robotics laboratory in northern Finland
- Large selection of industrial, collaborative and mobile robotics
- Digital manufacturing technologies: 3D scanners, 3D printers, VR/AR equipment
- Collaboration through education, projects and paid services









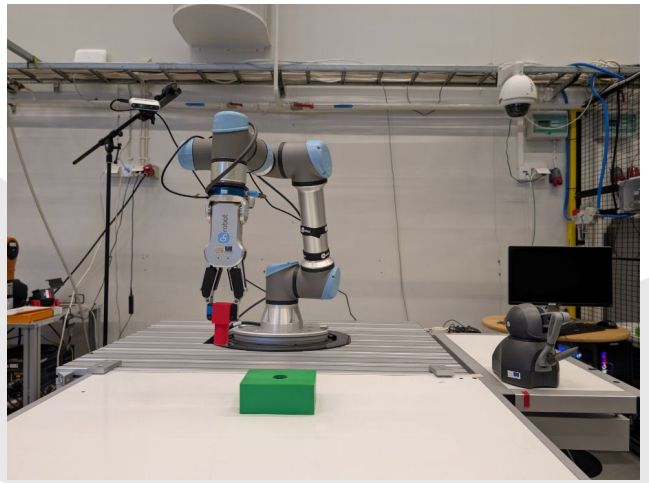




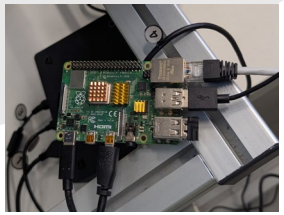
CoRI5.0 - Cognitive robotics initiative for industry 5.0

- Joint project between Centria, SAMK, VAMK and Turku AMK
- Objective: Research, develop and pilot technologies combining robotics and AI, increasing application performance, safety and usability
- Intuitive programming
- Imitation learning
- Enhances in productivity and competitiveness of SMEs

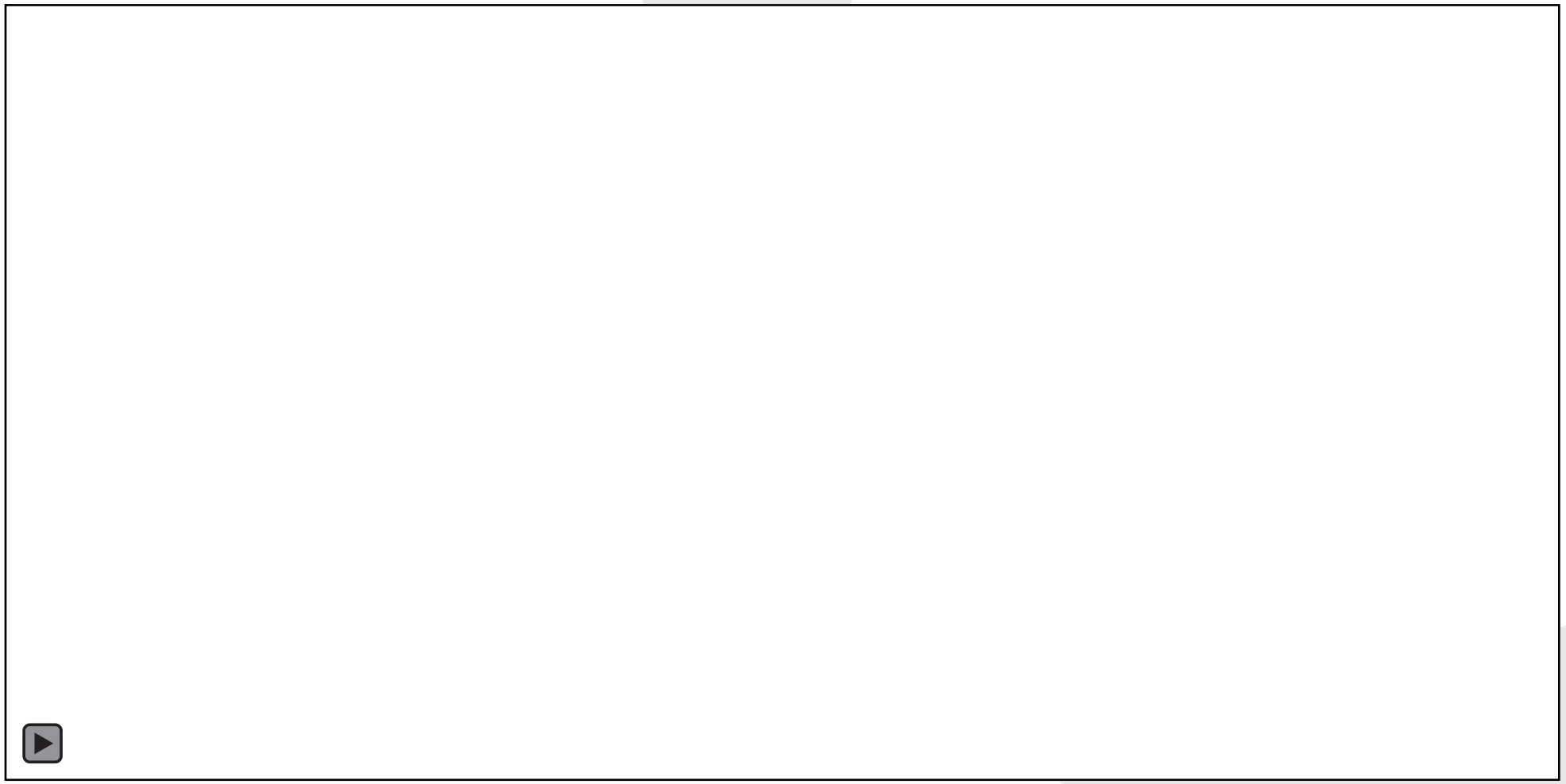




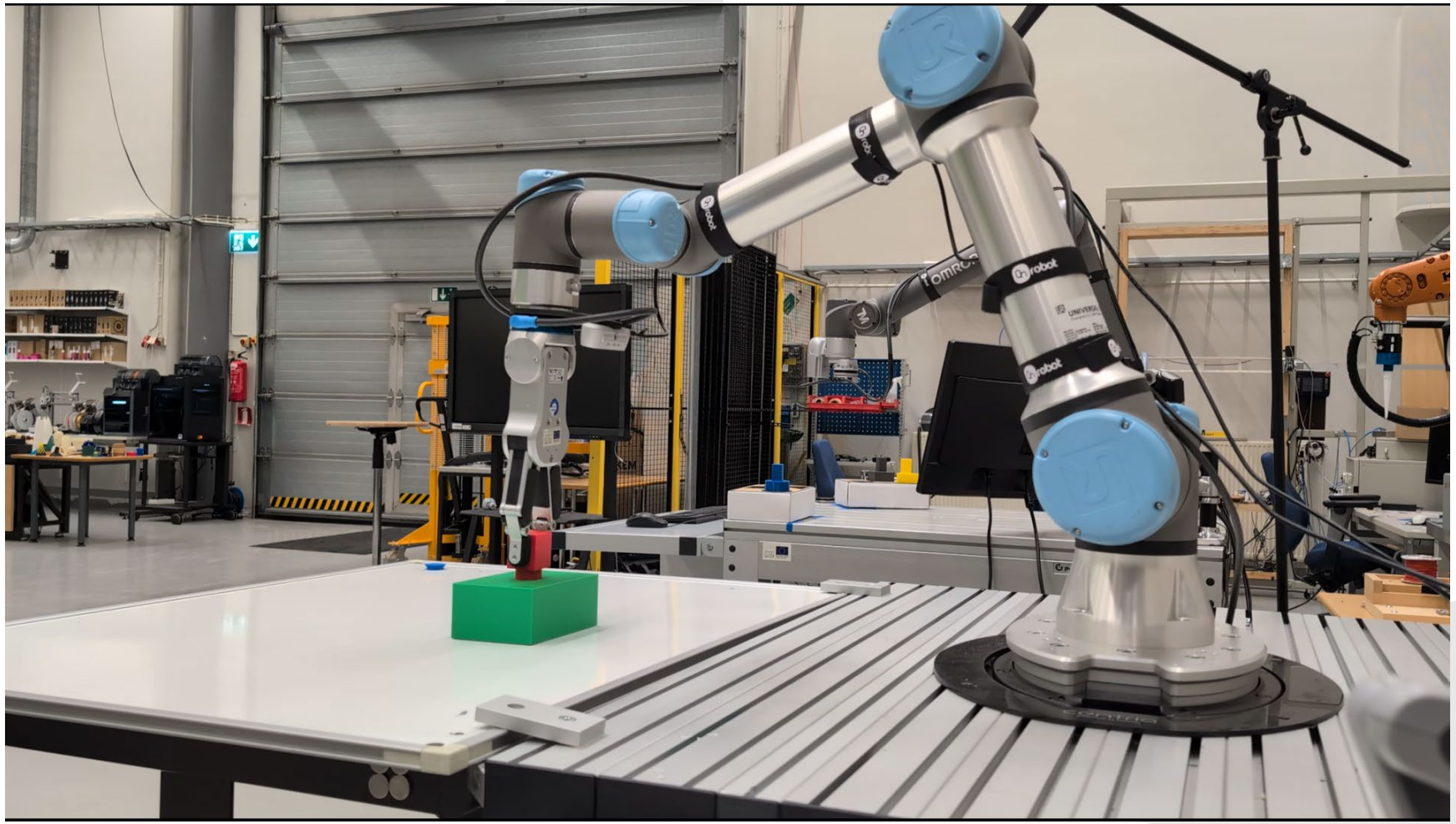




Imitation learning



Policy inference results



What are the possibilities?

- **More flexible manufacturing**
  - Robots can identify changes in environment and adapt to them
- **Human augmentation**
  - Workers may interact with robots more naturally, using natural language, examples and gestures
- **Robots in everyday life**
  - Other ways for robots to assist humans in everyday life emerge through development of AI



Fig: Mercedes-Benz

What challenges remain?

- **Safety**
  - A chatbot mistake causes inconvenience; in robots it may cause **physical harm**
- **Cybersecurity**
  - Connectivity creates large surface area for attackers → turns quickly into physical security
- **Trust**
  - Not just technical reliability, but transparency



Fig: The Asia Business Daily

Thank you!

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References:

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