Robotic assembly and manipulation – a reality

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OMRON

Profile

- 40000 employees worldwide
- Top 100 Global Innovators

Blood pressure at home

2016: OMRON Adept Technologies

2018: New research centers

- OMRON Research Center of America (San Diego)
- OMRON SINIC X Corporation (Tokyo)

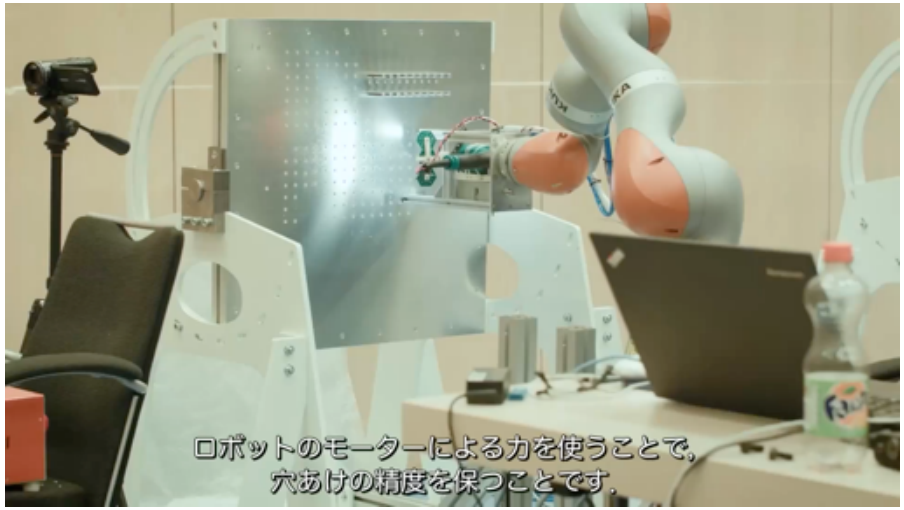
Automated ticket machines

Factory automation

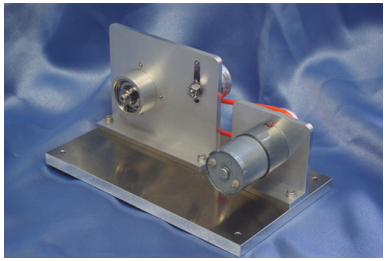
Table tennis robot Image:Engadget

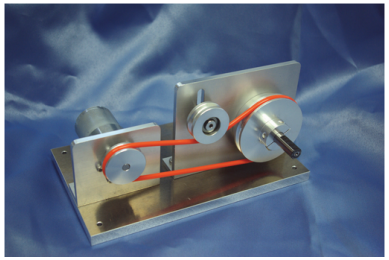
Self-introduction

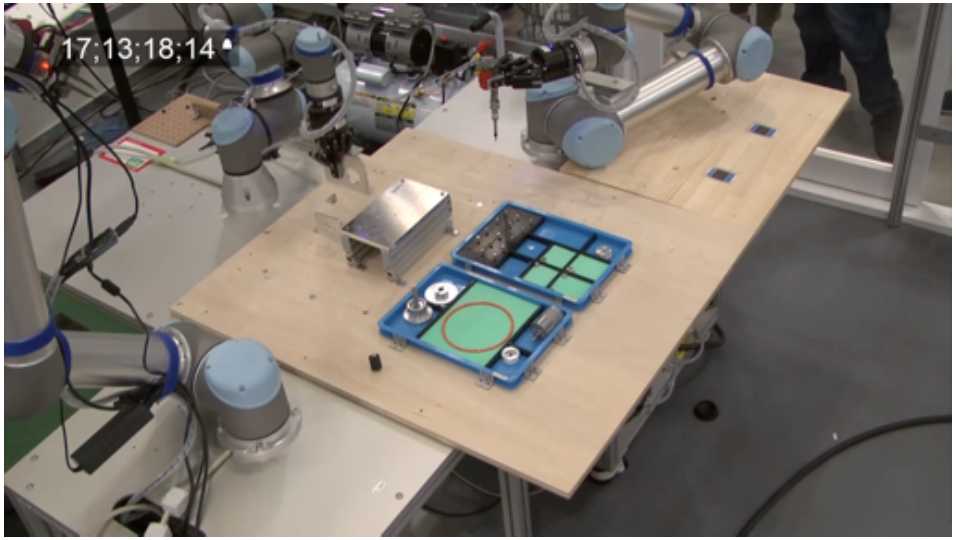
Airbus Shopfloor Challenge 2016 (1st place)



Amazon Robotics Challenge 2017 (6th, Finalist)







World Robot Summit Assembly Challenge 2018 (4th place, SICE Special Award)

Agenda

1. World Robot Summit 2018

2. Difficulties

3. Conclusion

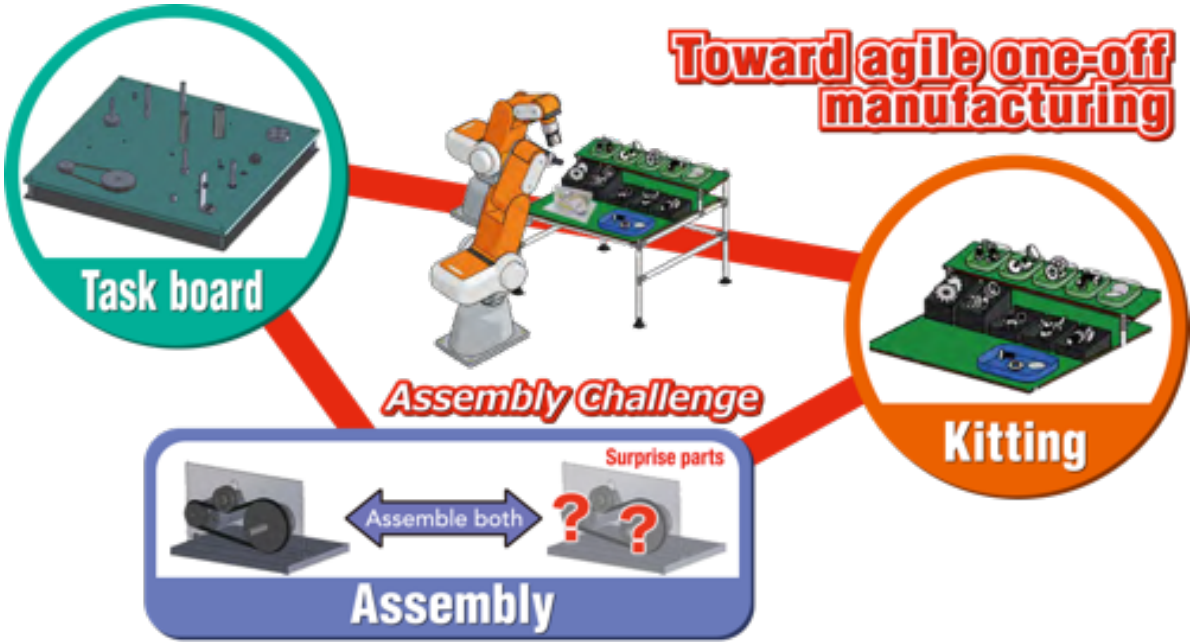
Also see:

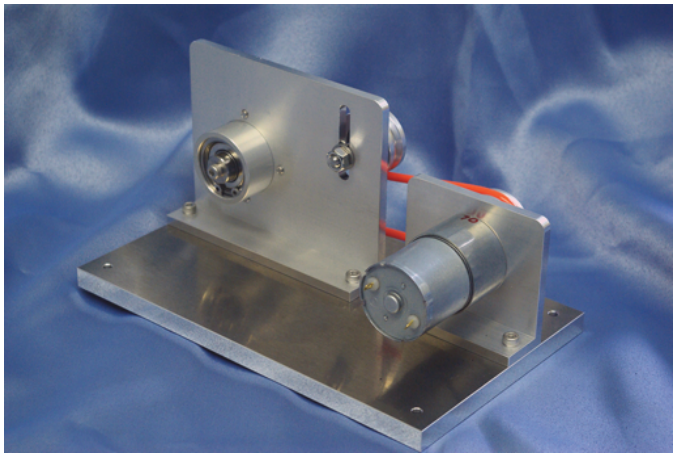
Von Drigalski, Schlette, Rudorfer, Correll, Triyonoputro, Wan, Tsuji, Watanabe; Robots Assembling Machines: Learning from the World Robot Summit 2018 Assembly Challenge; Accepted for publication in Advanced Robotics

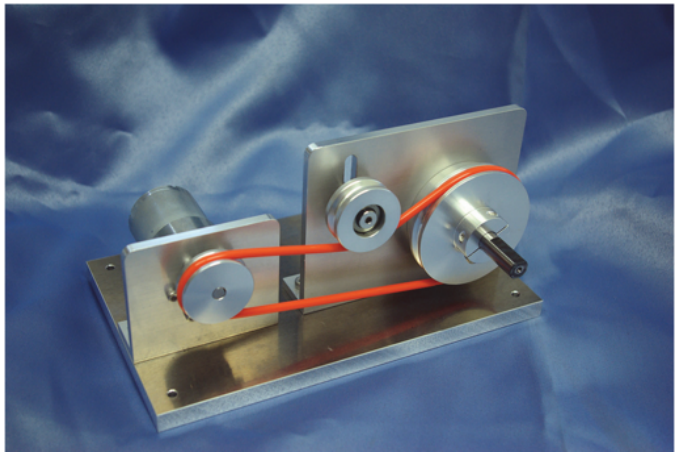
→ https://arxiv.org/abs/1911.05884

World Robot Summit Assembly Challenge

World Robot Summit

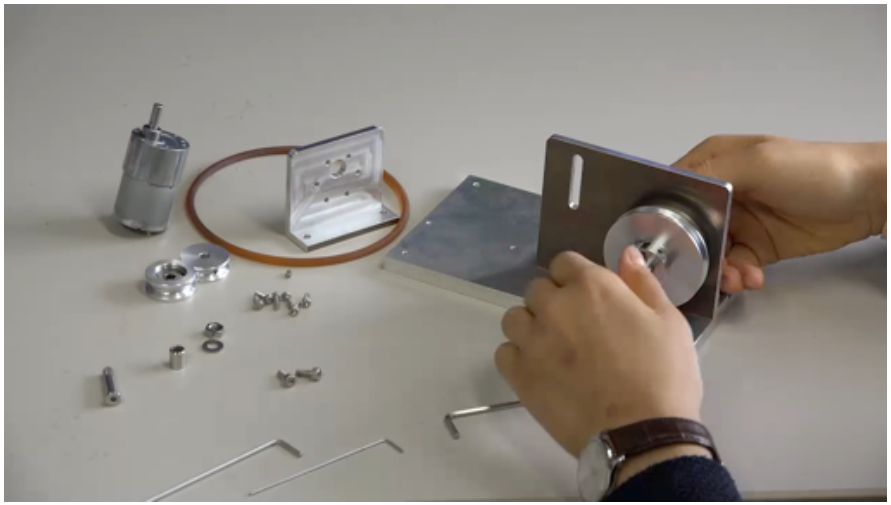


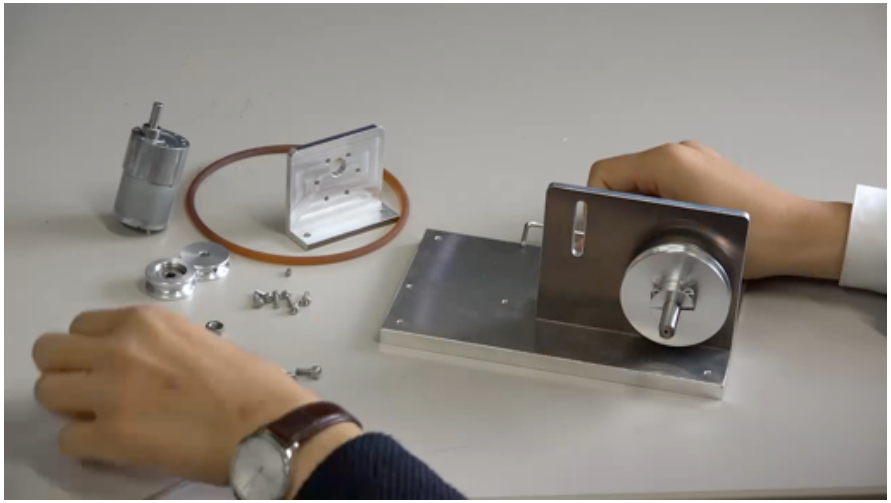


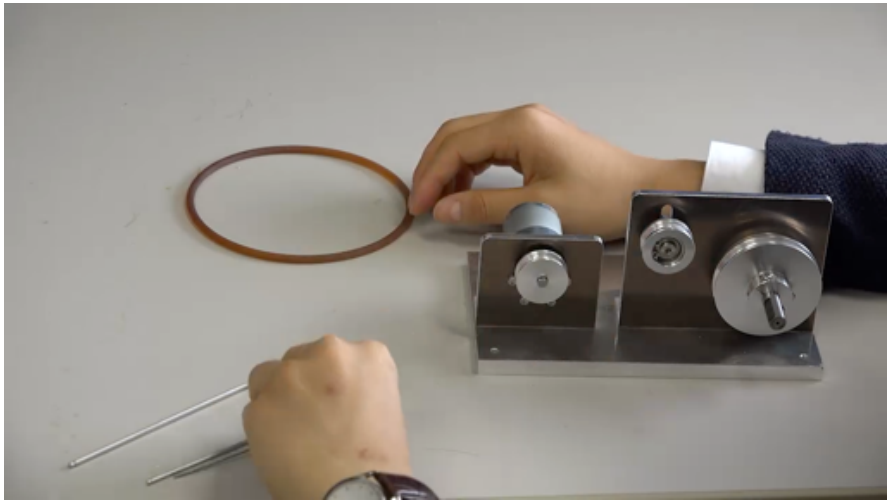


World Robot Summit Assembly Challenge

Human demonstration

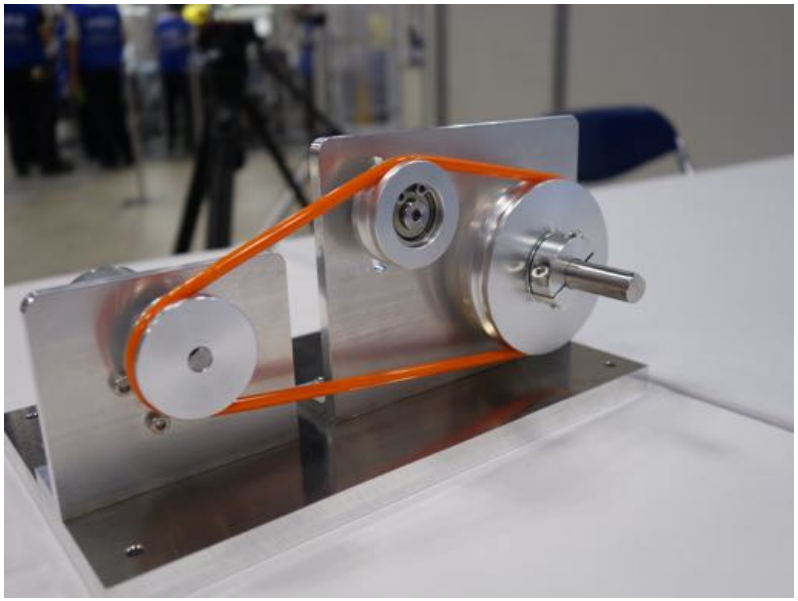


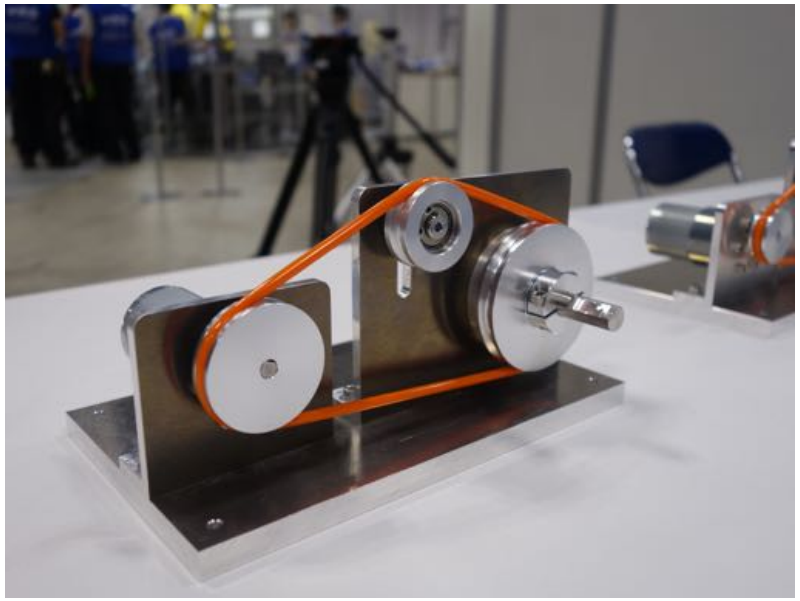


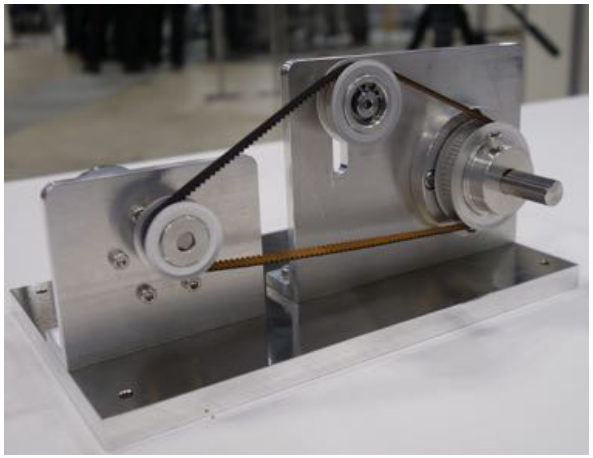


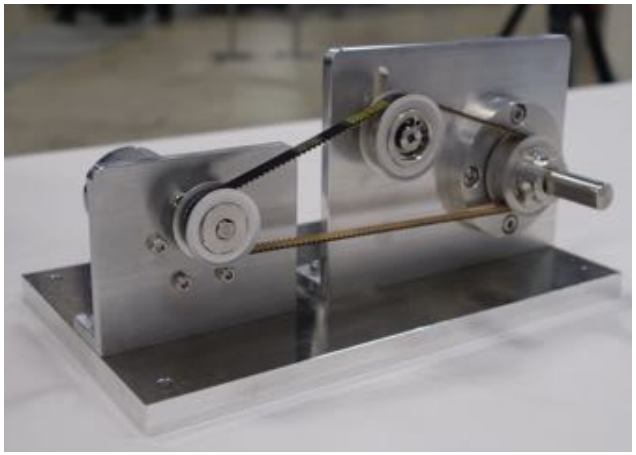
Surprise parts

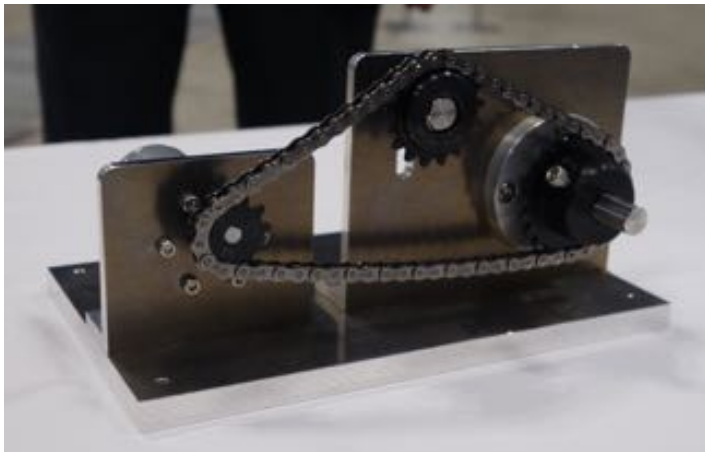
Announced 1 day in advance







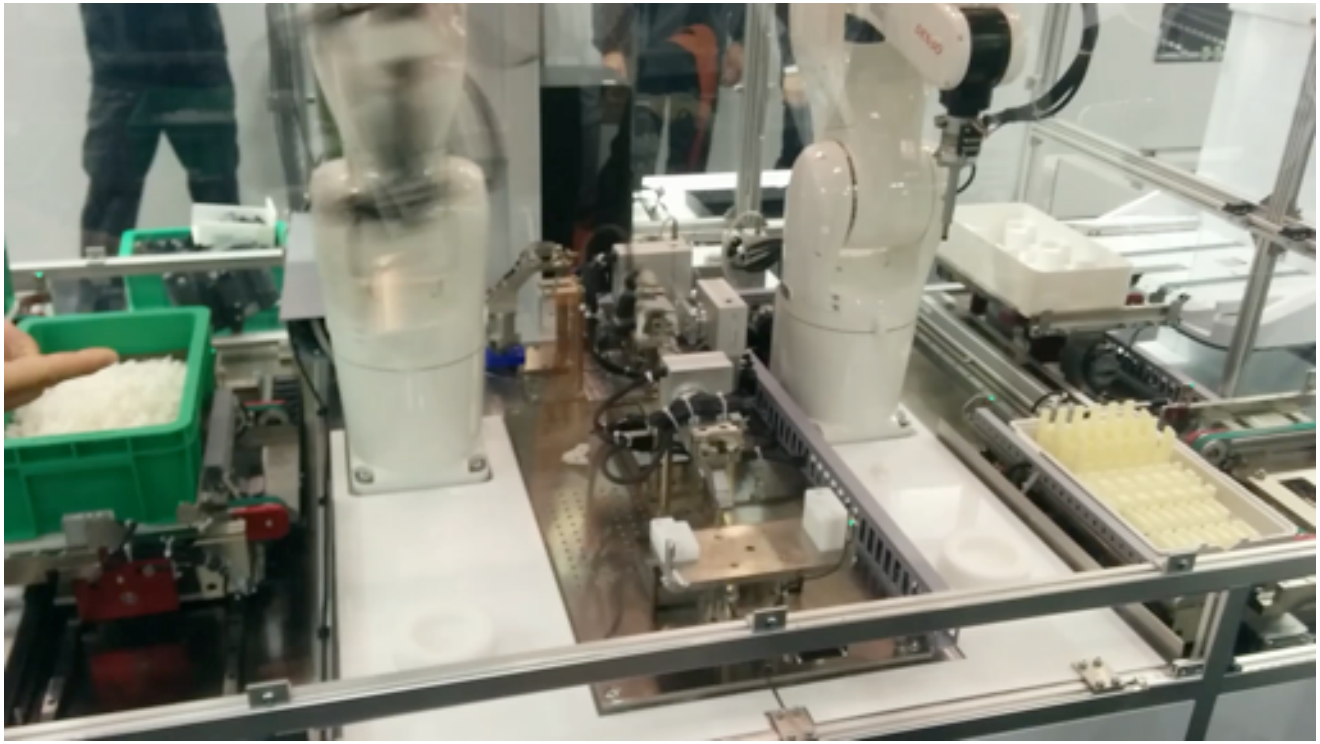




World Robot Summit Assembly Challenge

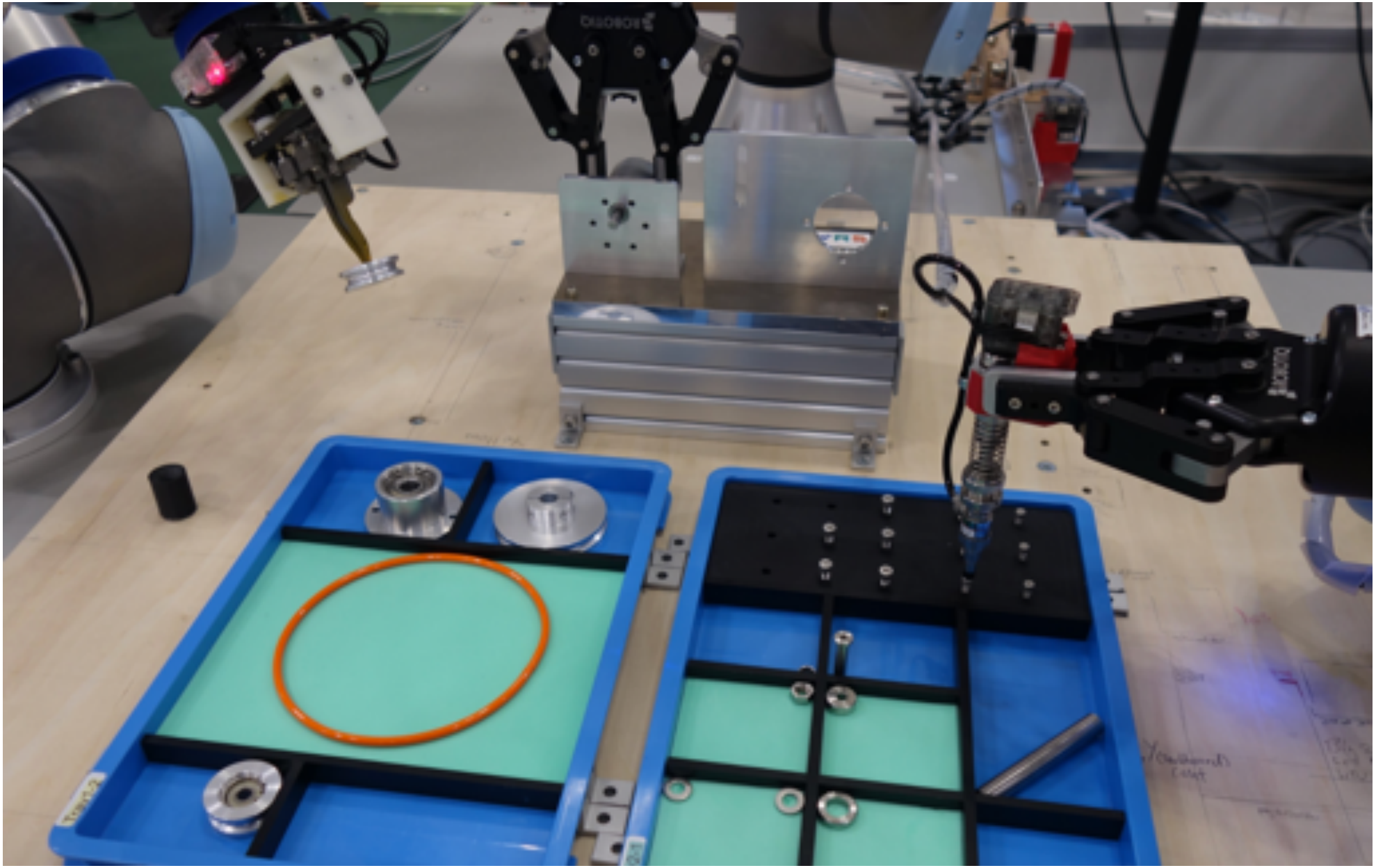
State of the art

- Task is separated into small, teachable sub-units
- Specialized jigs are used to position parts and ensure known state
- Inflexible, high engineering cost, long changeover times

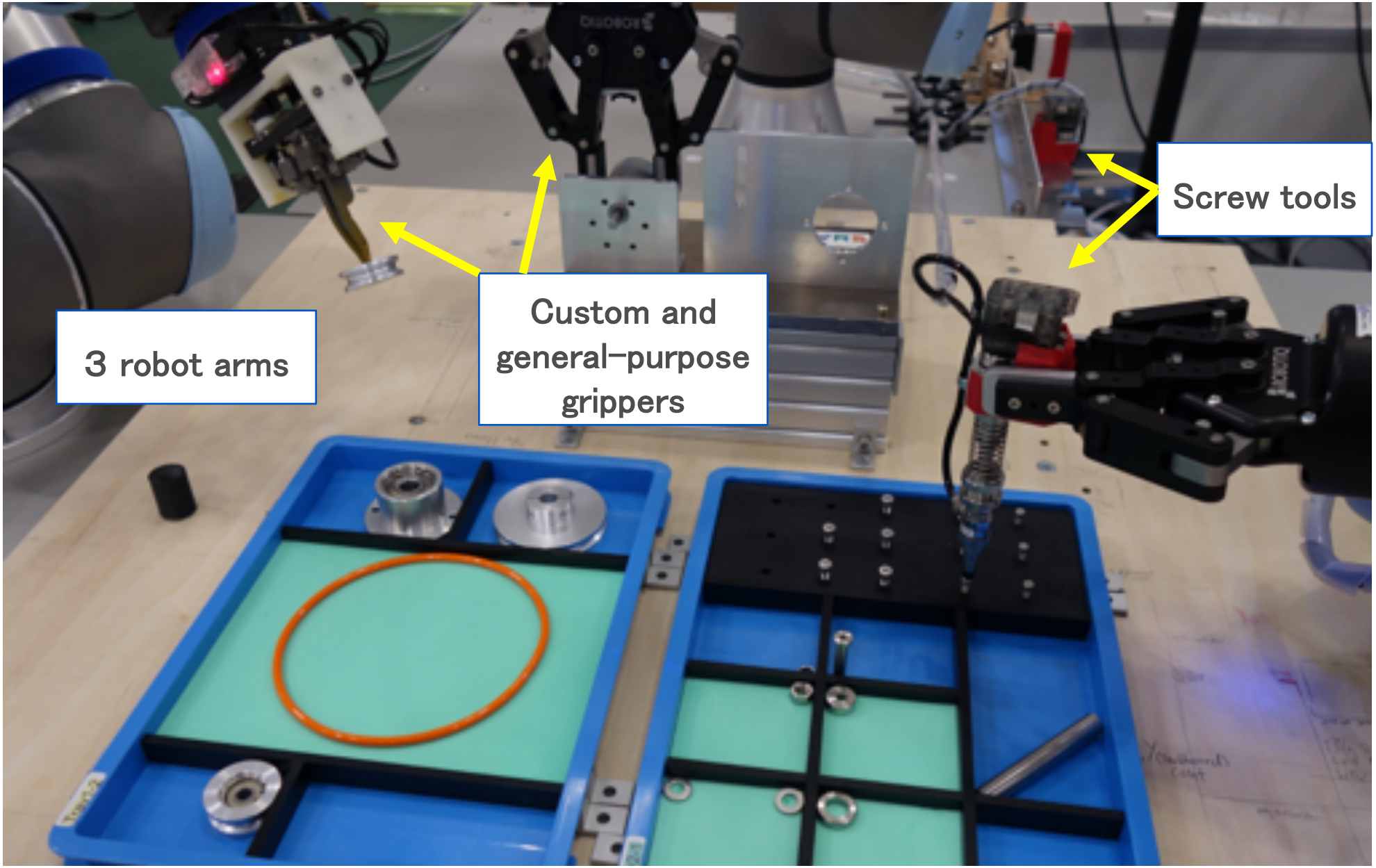


iREX 2017

System



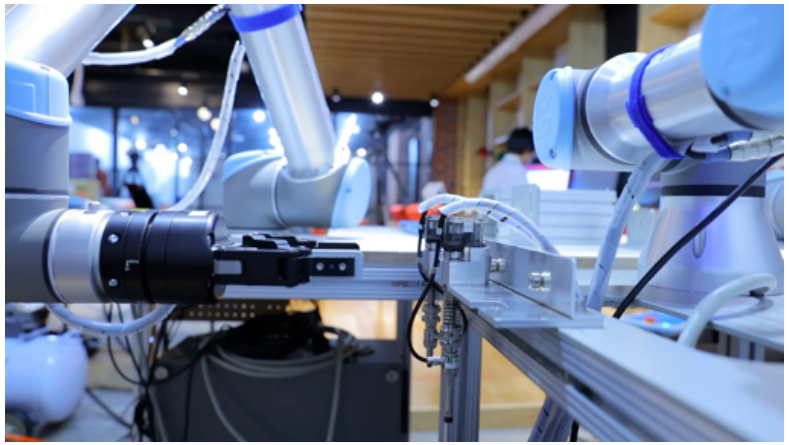
System



System

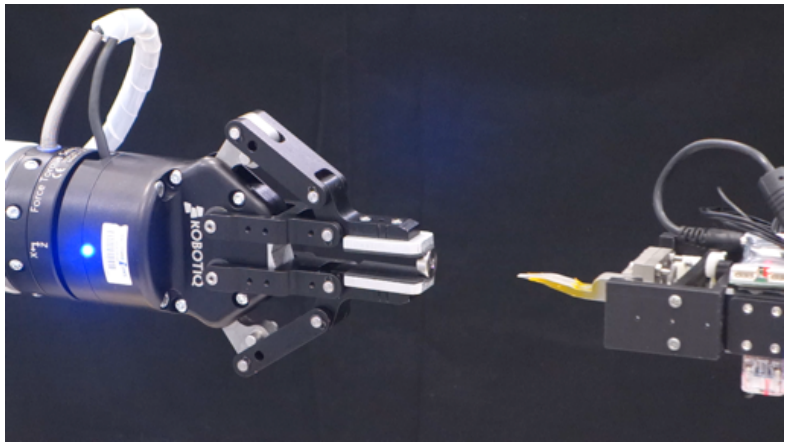
Flexible tool use without tool changers

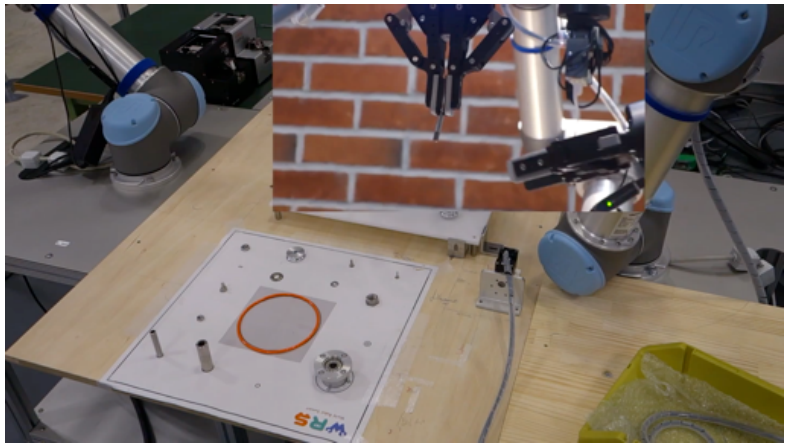
(SICE Award)



Compliance

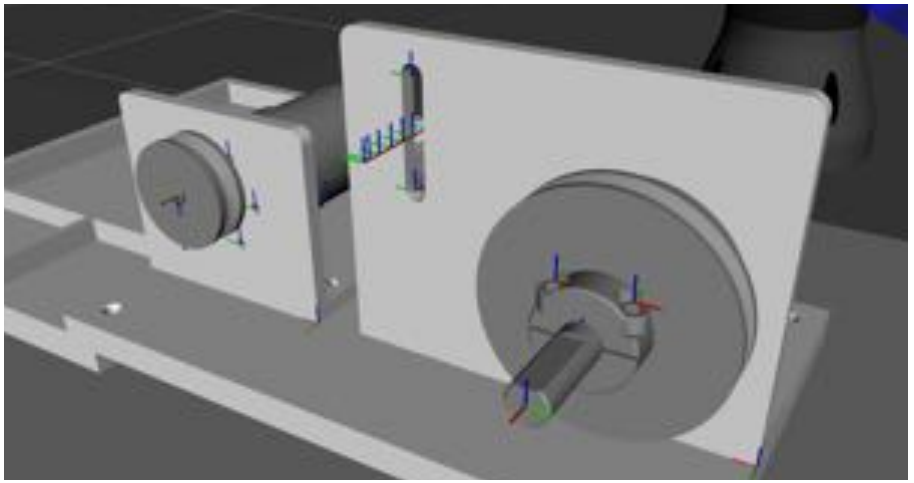
Jigless part centering





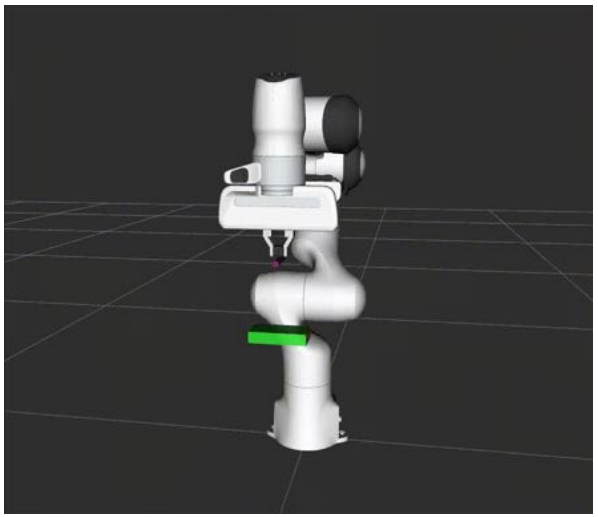
Public ROS code

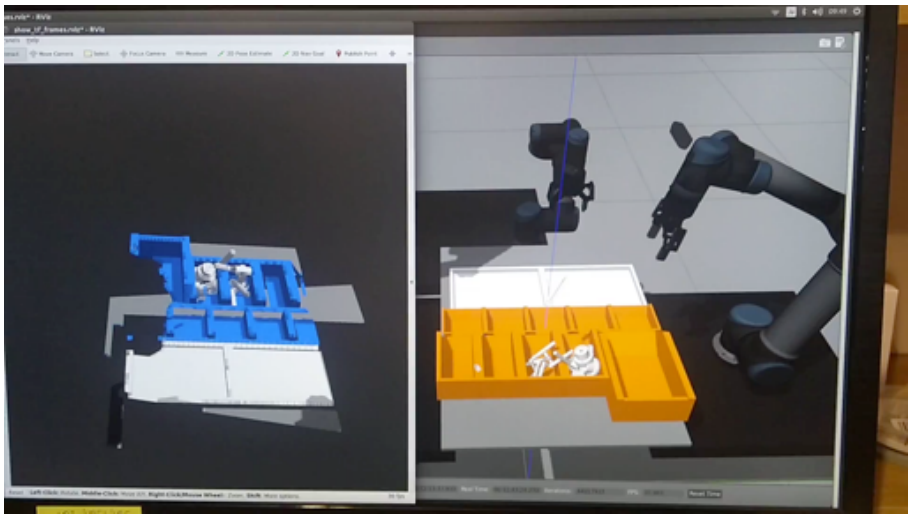
1. Assembly generator
2. Multi-robot configuration
3. Task instructions



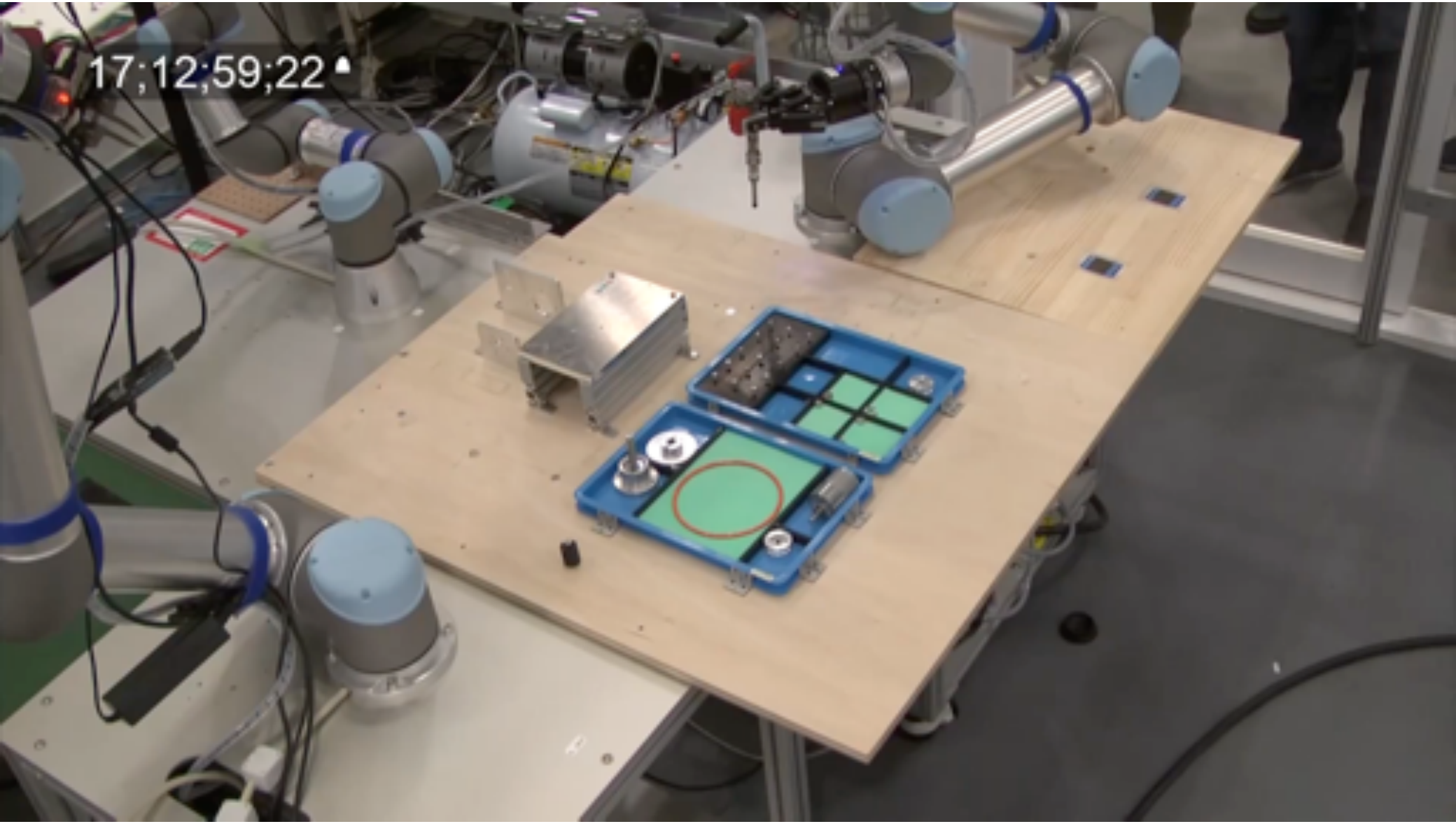
All code public:

github.com/o2as/ur-o2as

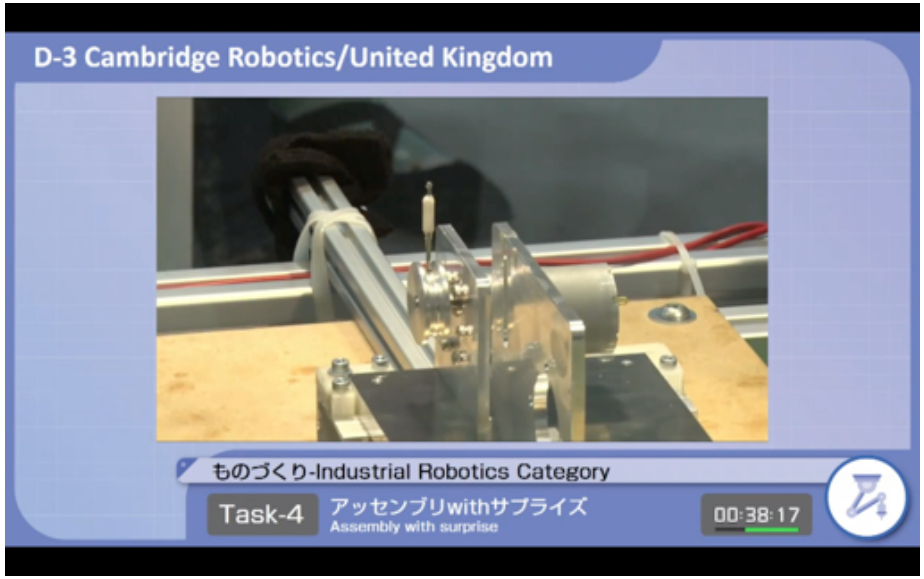


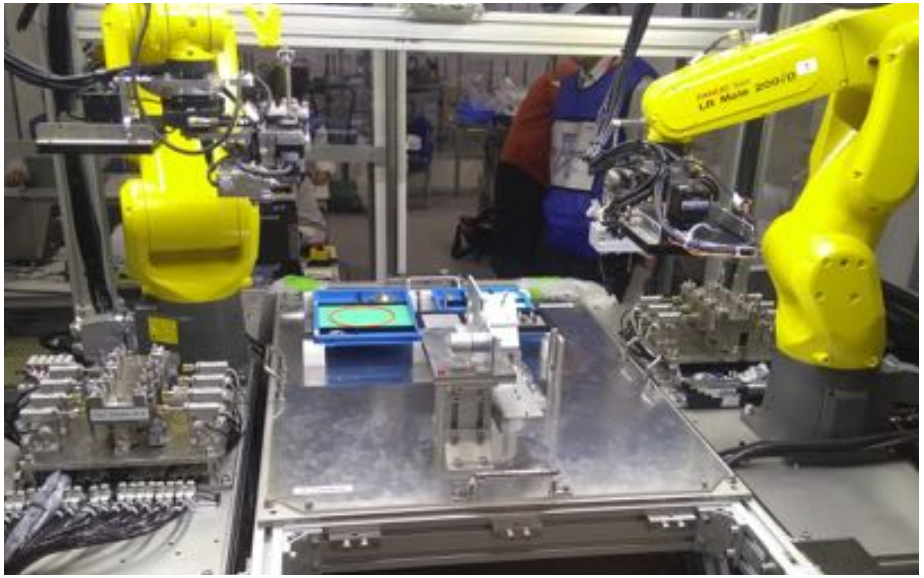


Result

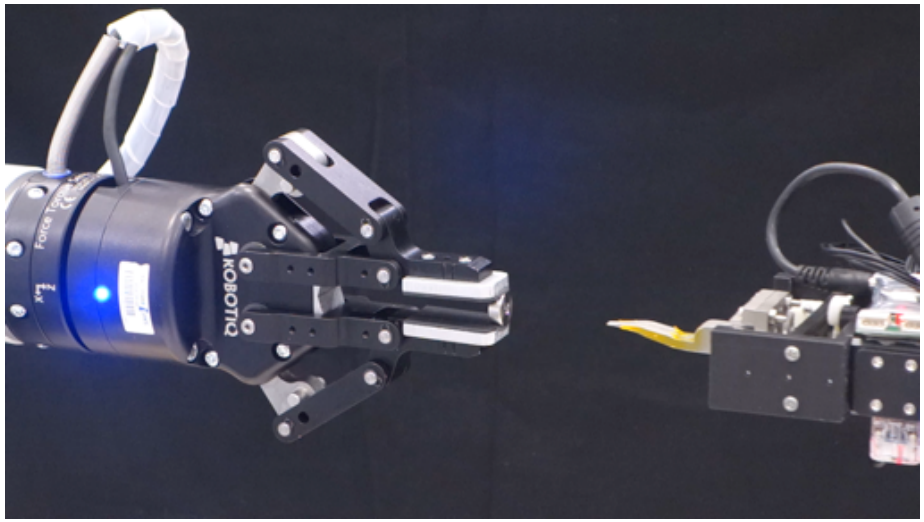


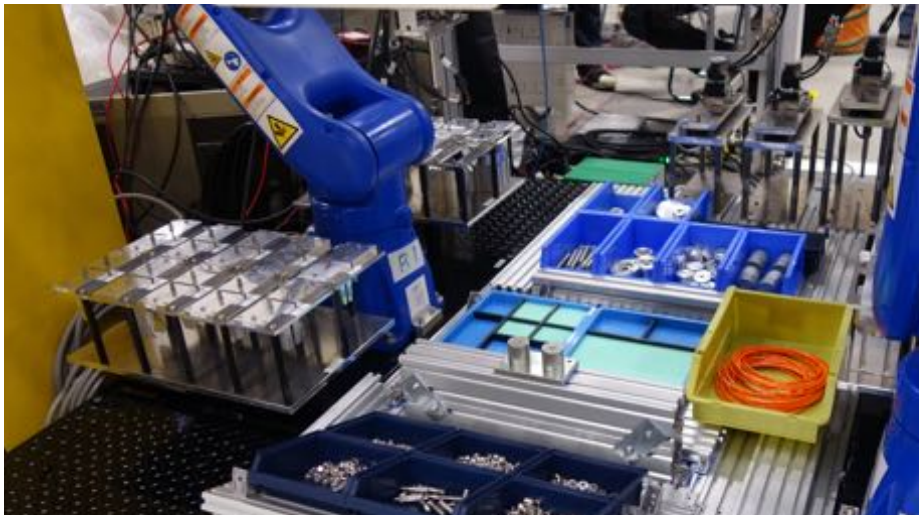
Strategy differences



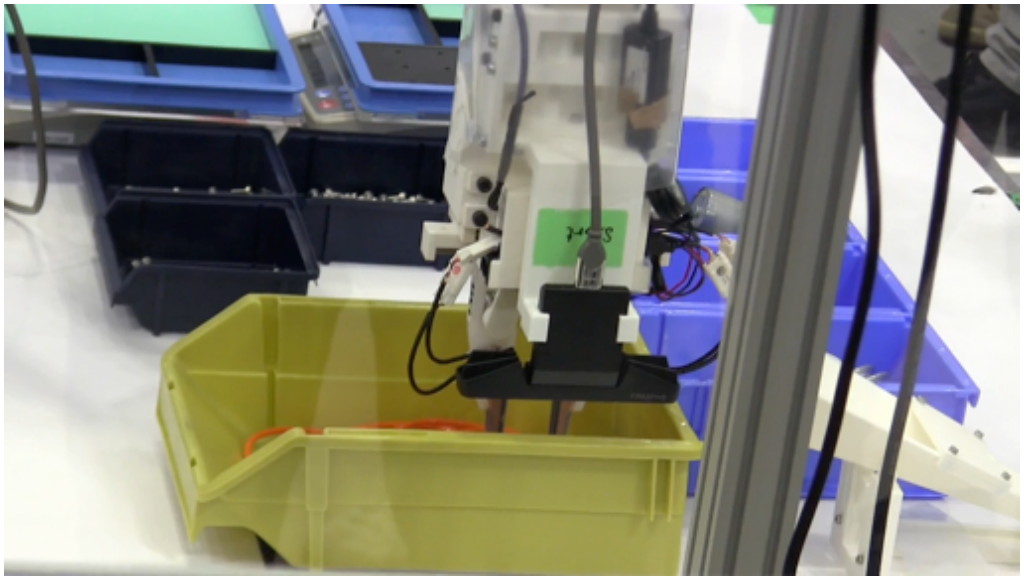


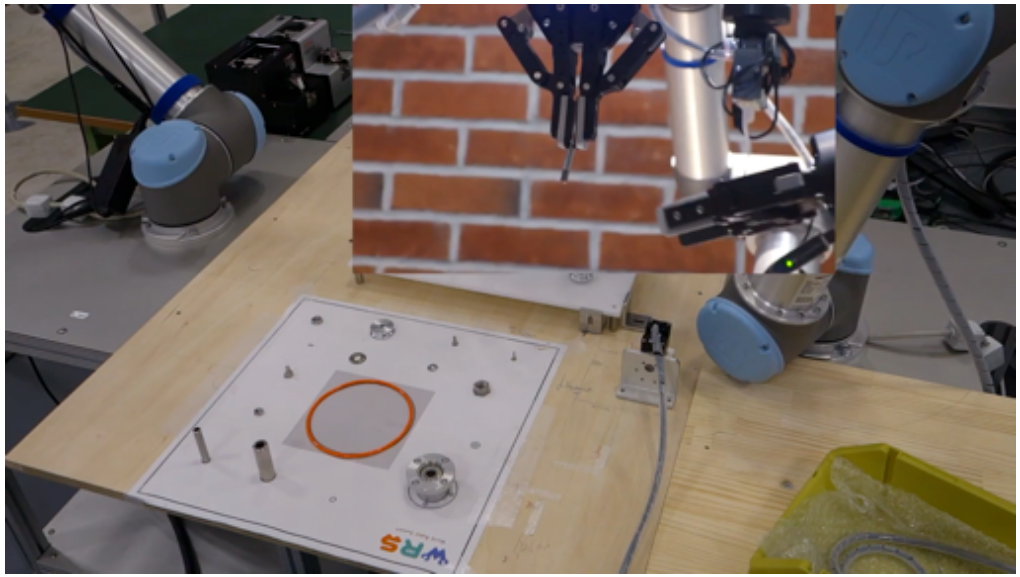
vs





Flexibility vs Specialization





2. Difficulties

1. Assembly code construction very labor-intensive
   - No “sensible” way to instruct robots

2. Hard to deal with uncertainty
   - Success checks
   - Error recovery

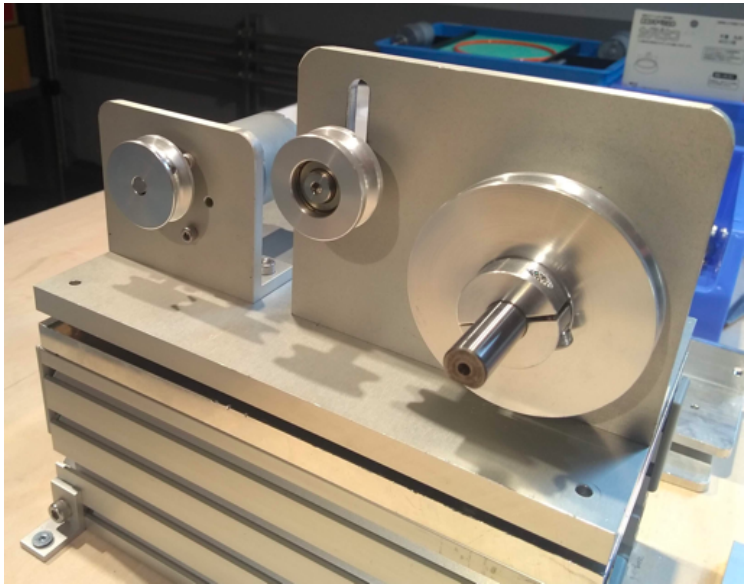
3. Calibration
   - Sub-mm accuracy required

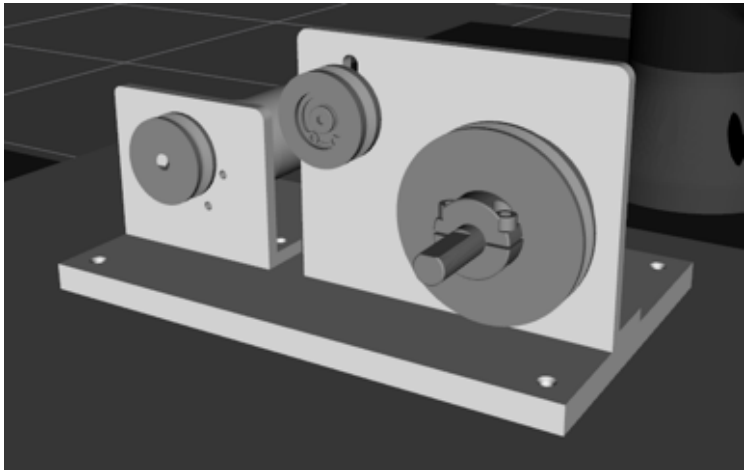
Instruction generation

- How to achieve this without explicit coding or demonstrations for every assembly step?

- Does it require semantic scene understanding?

- What is the easiest way to bring this to users or into automated routines?





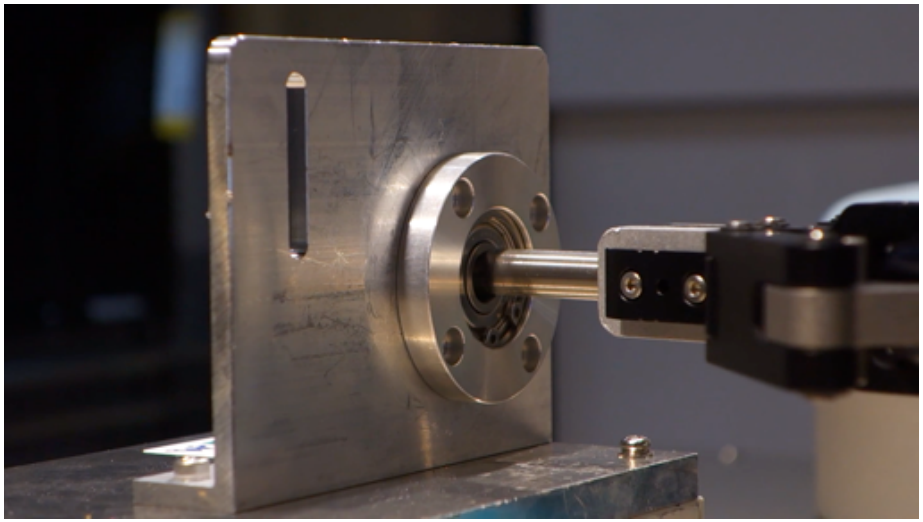
What was desirable:

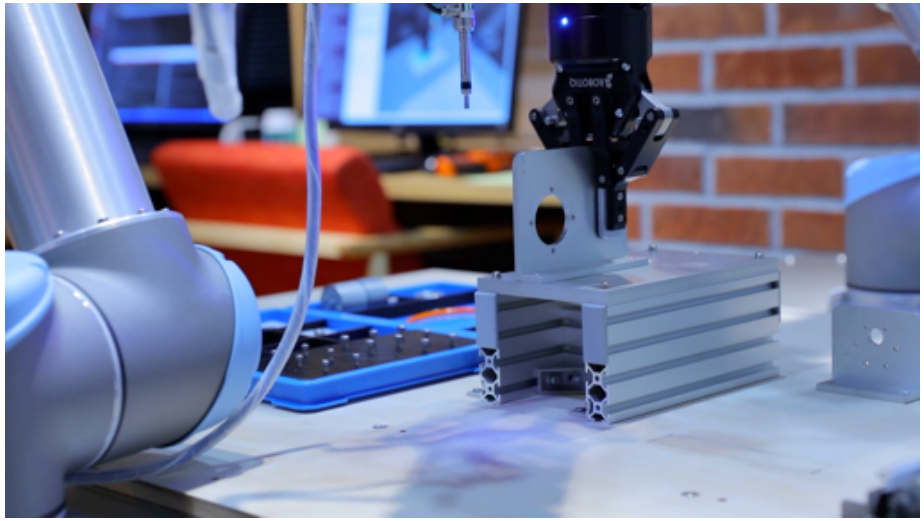
1. A visual success check
2. High certainty (if necessary from multiple views)
3. With easy setup (!)

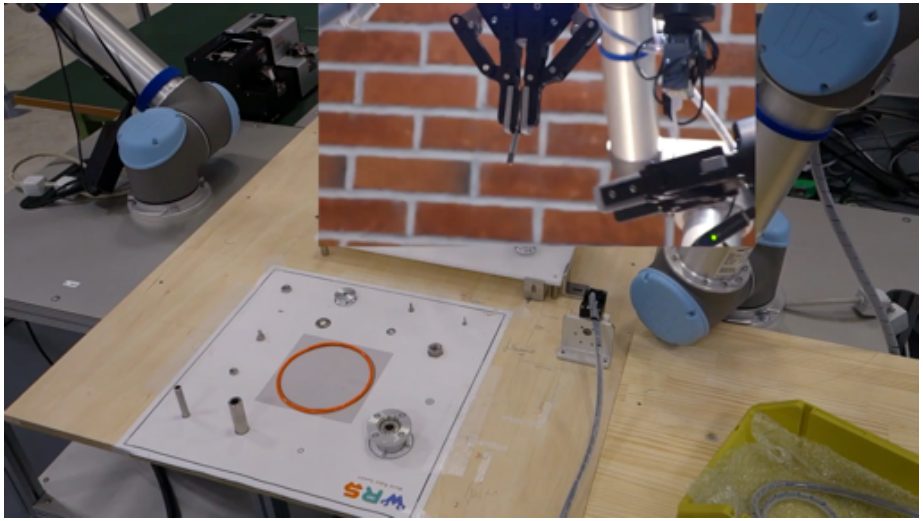
Effects of small uncertainties

- Very small errors can cause failures further along the process
  - Dropped or stuck parts
  - Protective stops

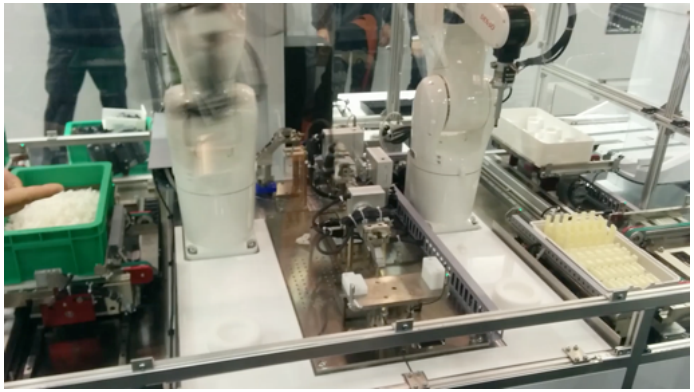
- Which can be compensated?
- Which need to be actively dealt with?

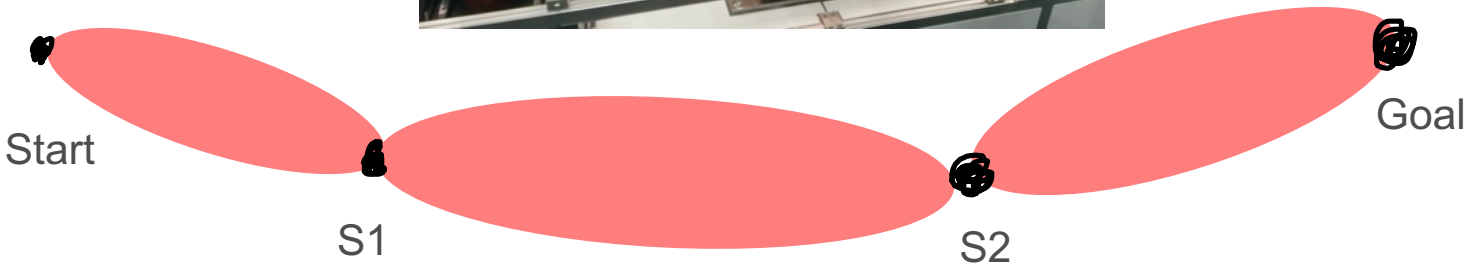




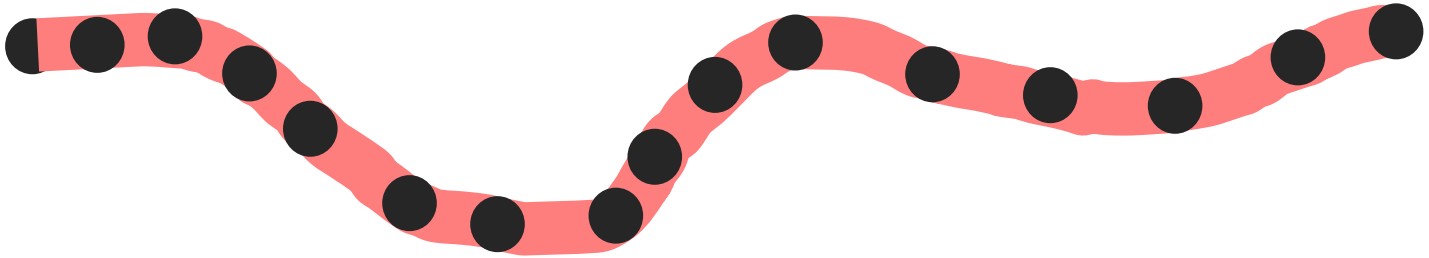


Uncertainty & Planning





From binary engineered checkpoints to continuous feasibility monitoring

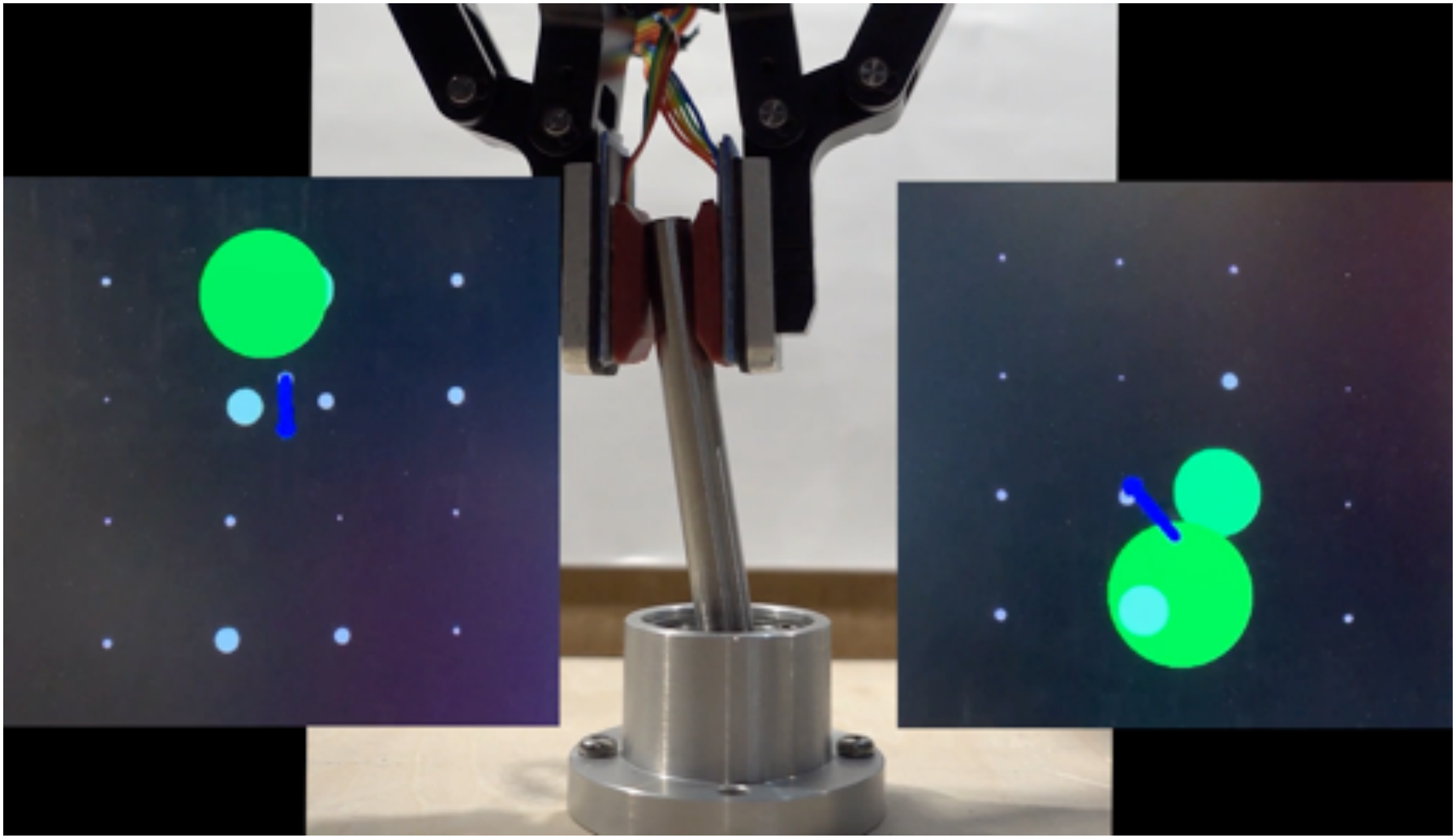


Reducing uncertainty

In-hand pose estimation

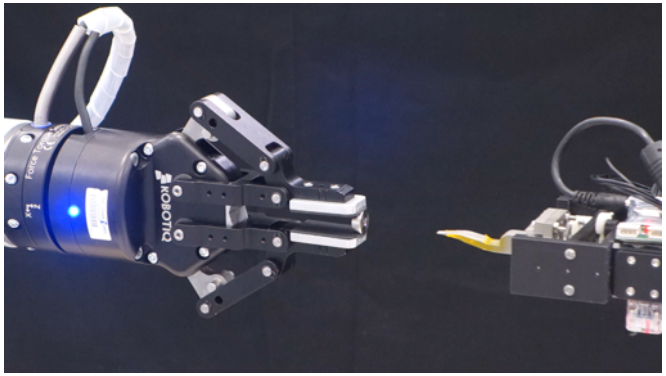
Limits of vision sensing

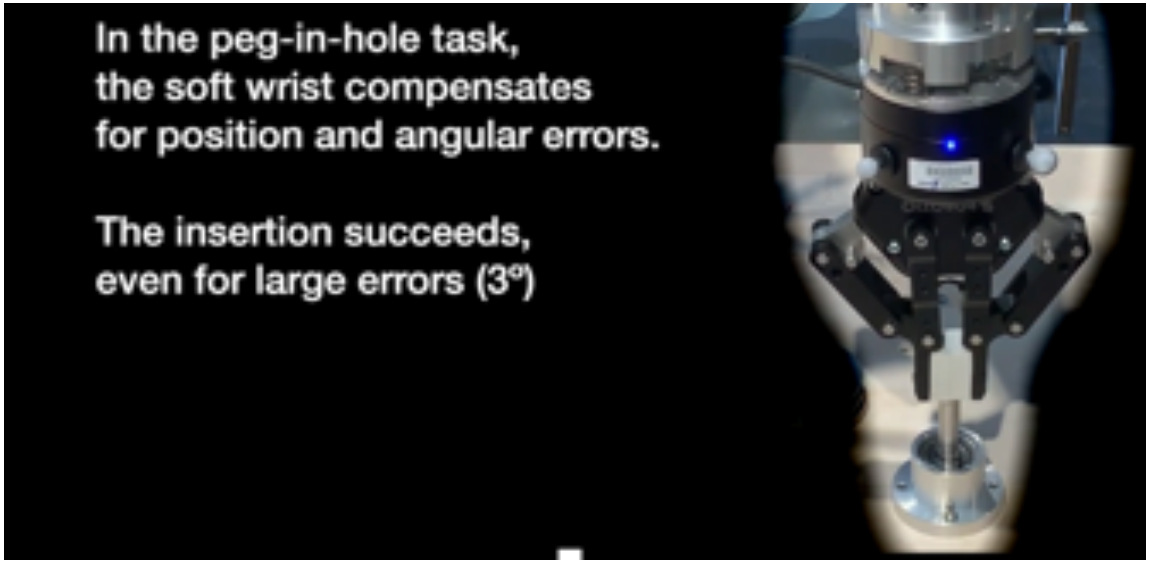
Tactile sensing



Compliance

Compensation for positioning and perception errors





ICRA2020

Conclusion

- WRS2018 assembly task is still a state-of-the-art benchmark

Challenges:

1. Low-level vs high-level programming
   - Task planning
   - Automatic assembly code generation?
   - Error recovery
2. Closed-loop perception
   - Tactile feedback, object pose estimation…
3. Simulation
   - Contact-rich interaction
   - Continuous feasibility checks

- Is there a gap between industry and research that is not being bridged?
- Do we need more open-source code and collaboration?
  How do we make robotics projects survive and reproducible?

https://arxiv.org/abs/1911.05884

WRS scores