



Robotic assembly and manipulation – a reality

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2019/11/4 @ IROS 2019, Macau

OMRON

Profile

OMRON

- 40000 employees worldwide
- Top 100 Global Innovators

2016: OMRON Adept Technologies

2018: New research centers

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



Blood pressure at home



Automated ticket machines



Factory automation

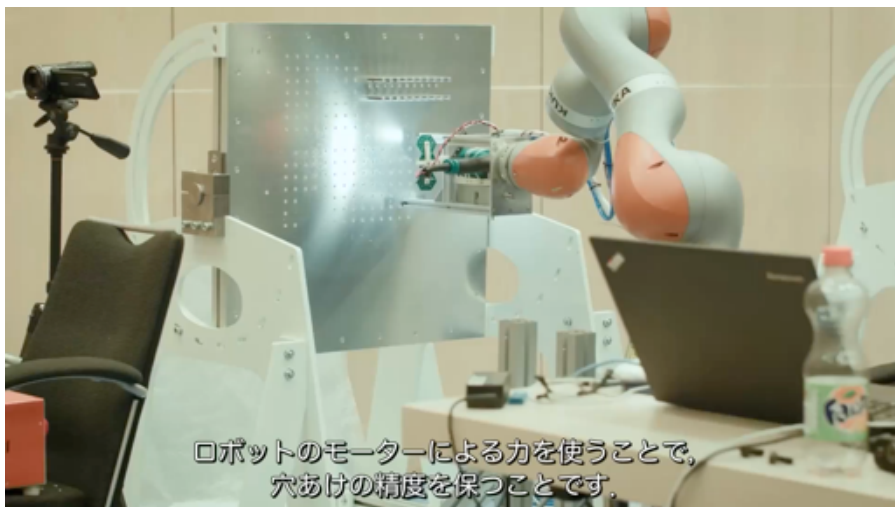


Table tennis robot Image:Engadget

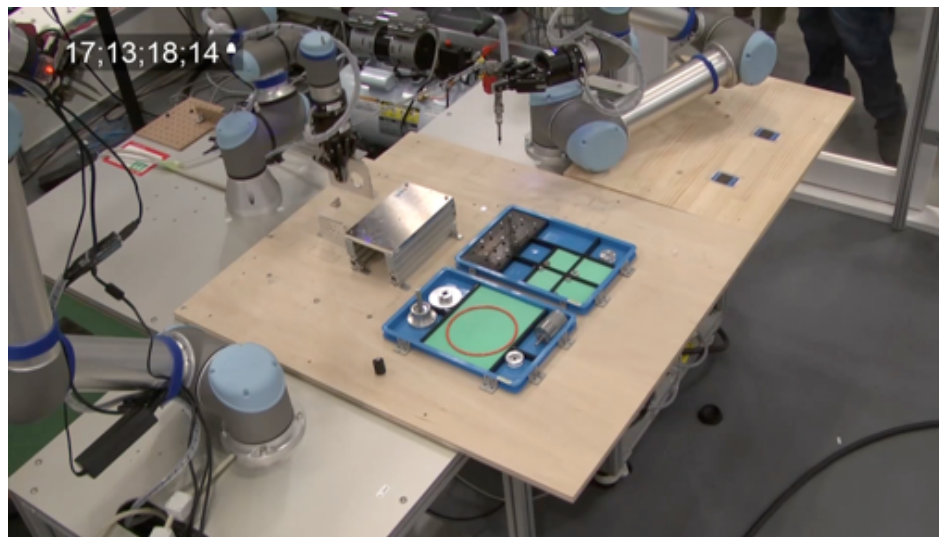
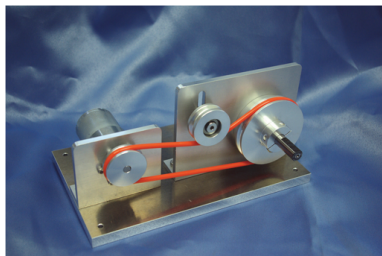
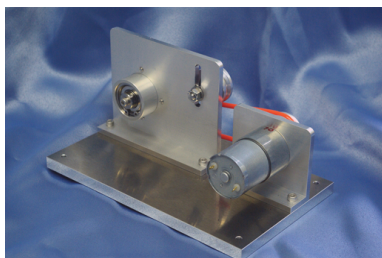


Self-introduction

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

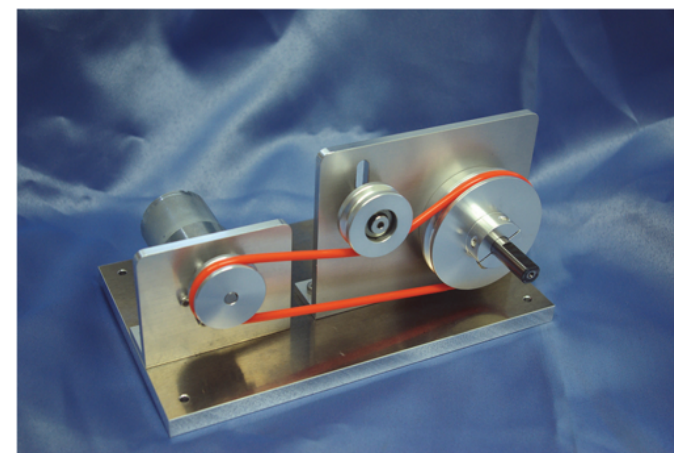
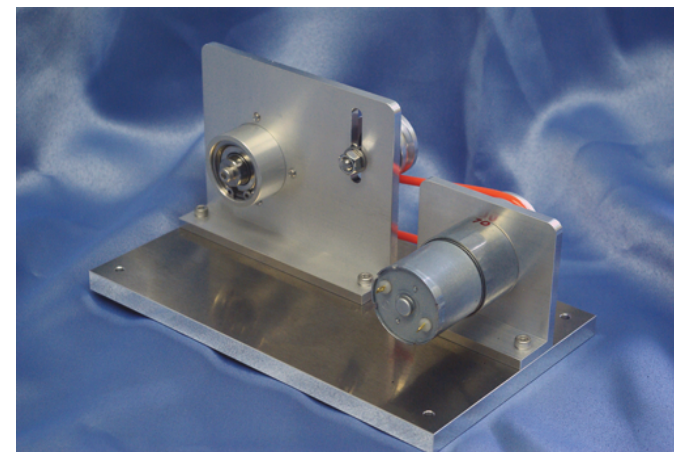
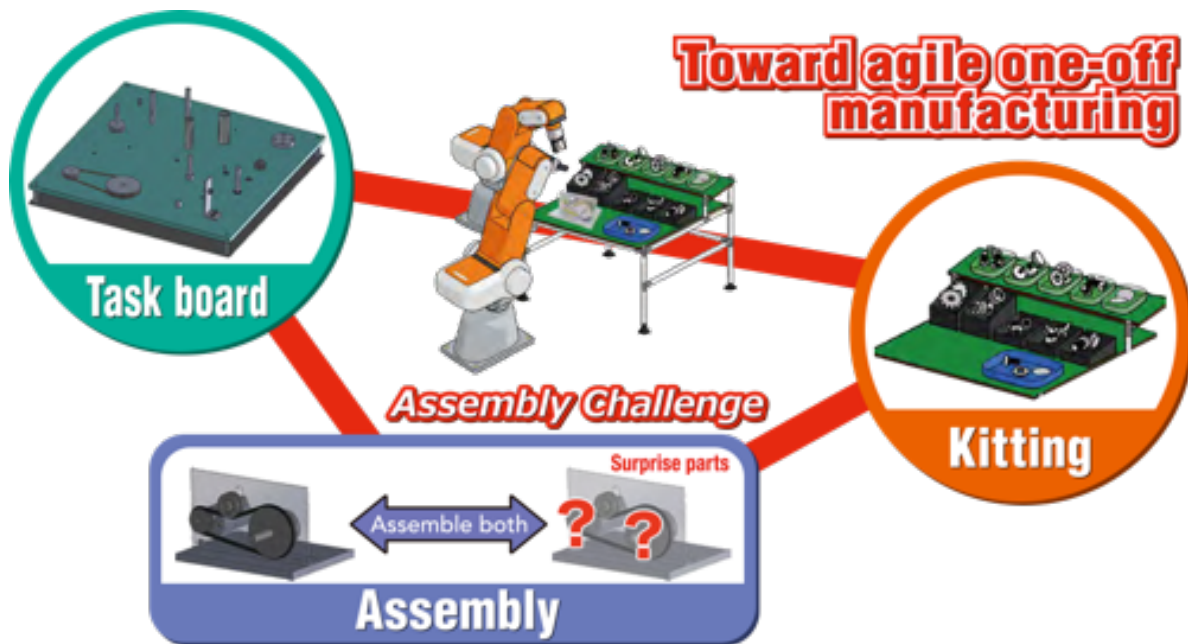
3. Conclusion

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*

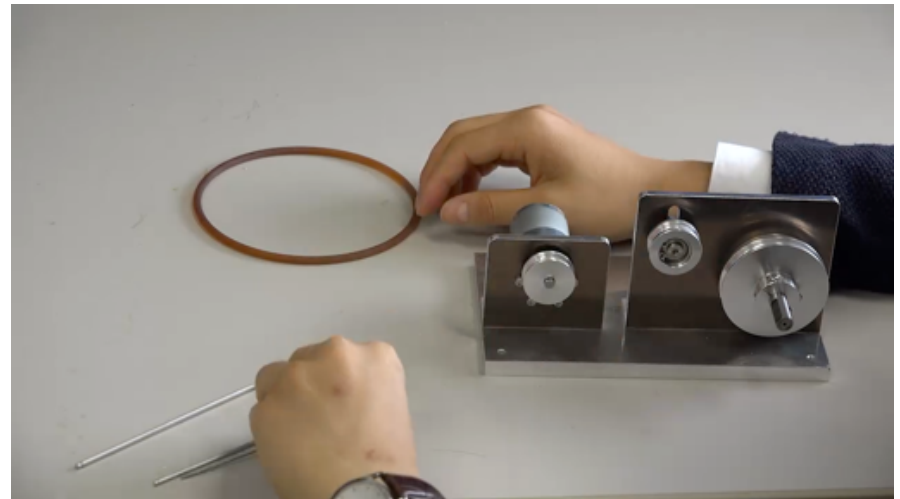
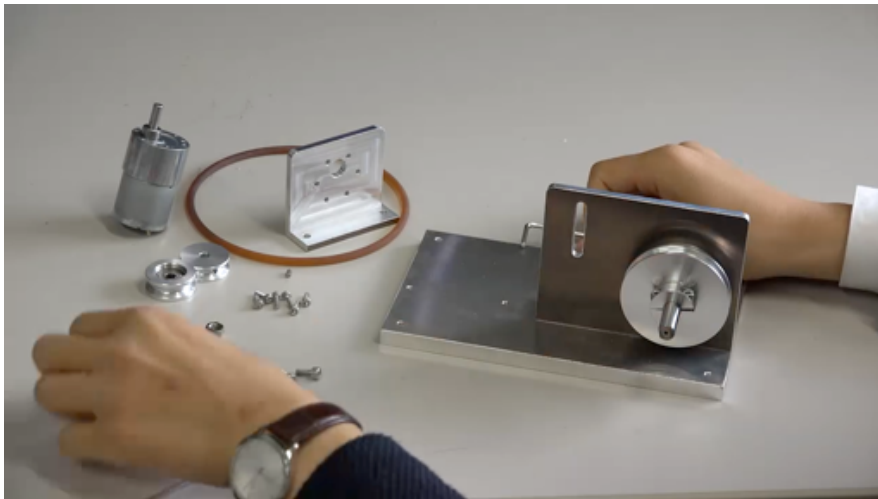
→ <https://arxiv.org/abs/1911.05884>

World Robot Summit Assembly Challenge



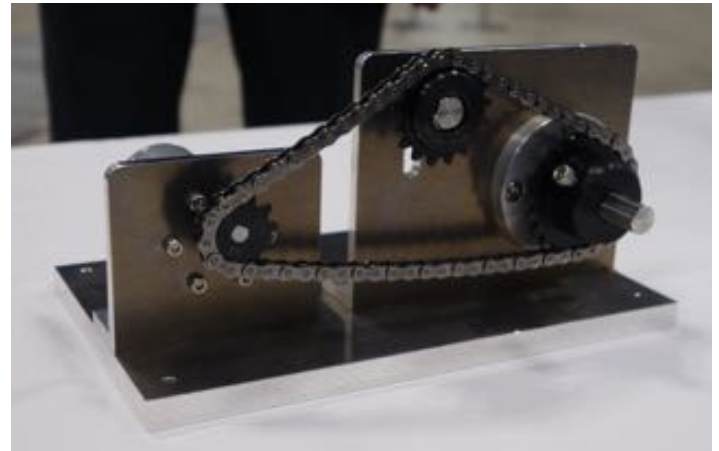
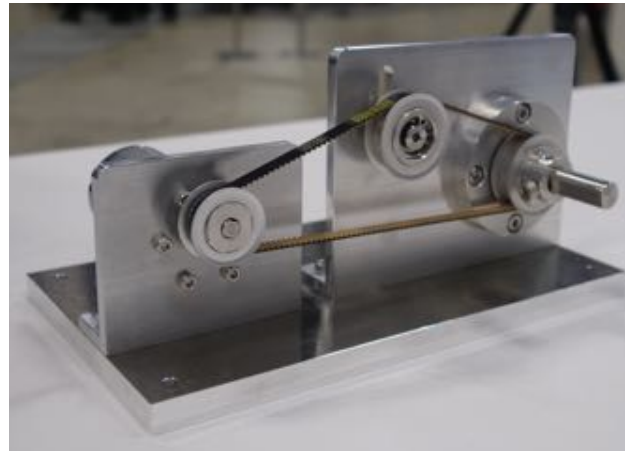
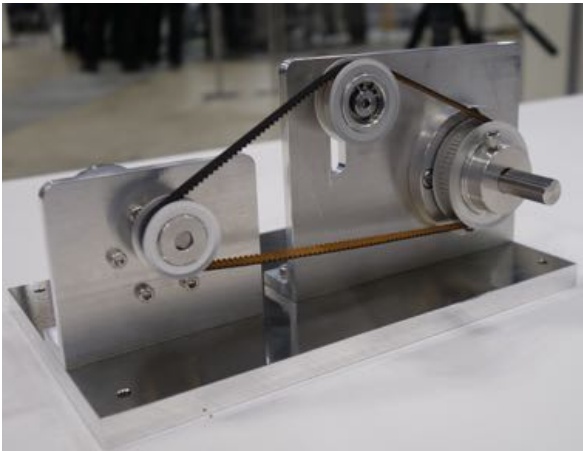
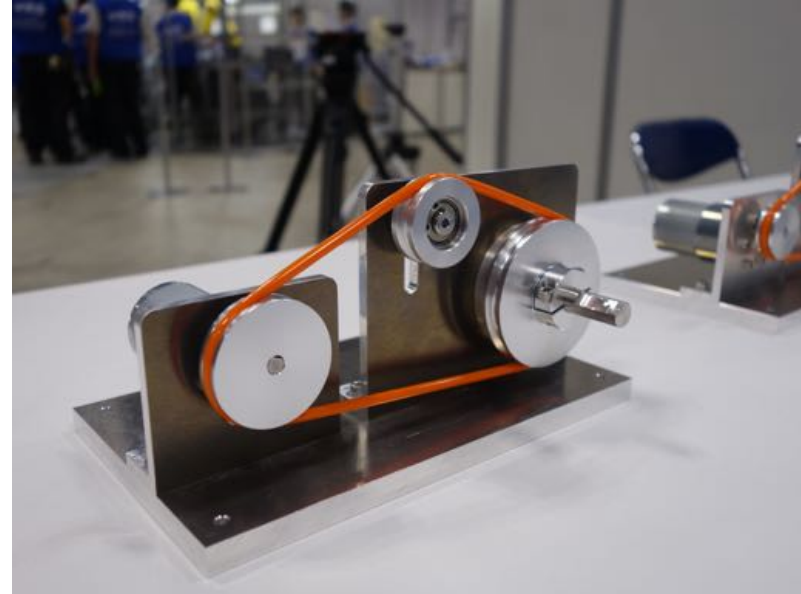
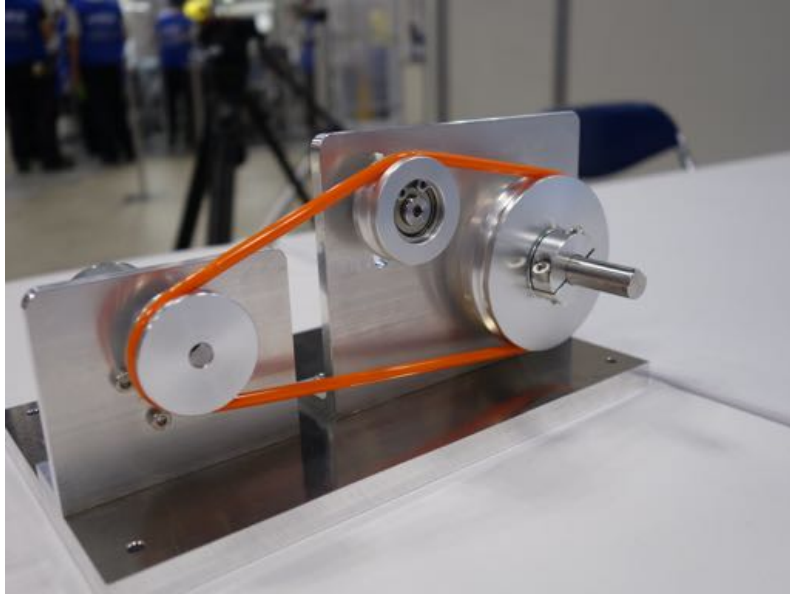
World Robot Summit Assembly Challenge

Human demonstration



Surprise parts

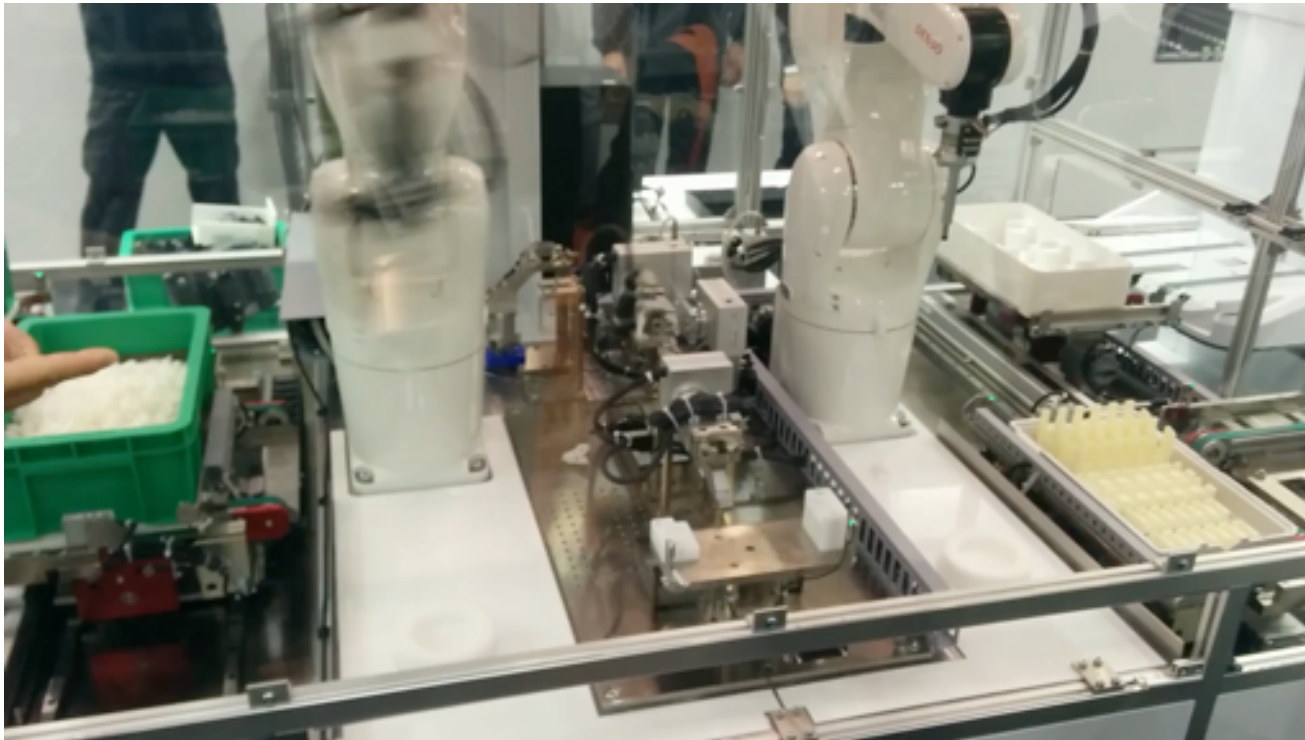
Announced 1 day in advance



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

TEAM

industrial robotics category

OZAS

OSAKA UNIV

OMRON

AIST

SENSETIME JAPAN

Kensuke HARADA

Felix VON DRIGALSKI

Yukiyasu DOMAE

Taku YOSHIOKA

Weiwei WAN

Ixchel RAMIREZ-ALPIZAR

Damien GERARD PETIT

Joshua TRIYONOPUTRO

Kaidi NIE

Xinyi ZHANG

Chisato NAKASHIMA

Yoshiya SHIBATA

Yoshinori KONISHI

Yoshihisa IJIRI

Yasushi KOWA

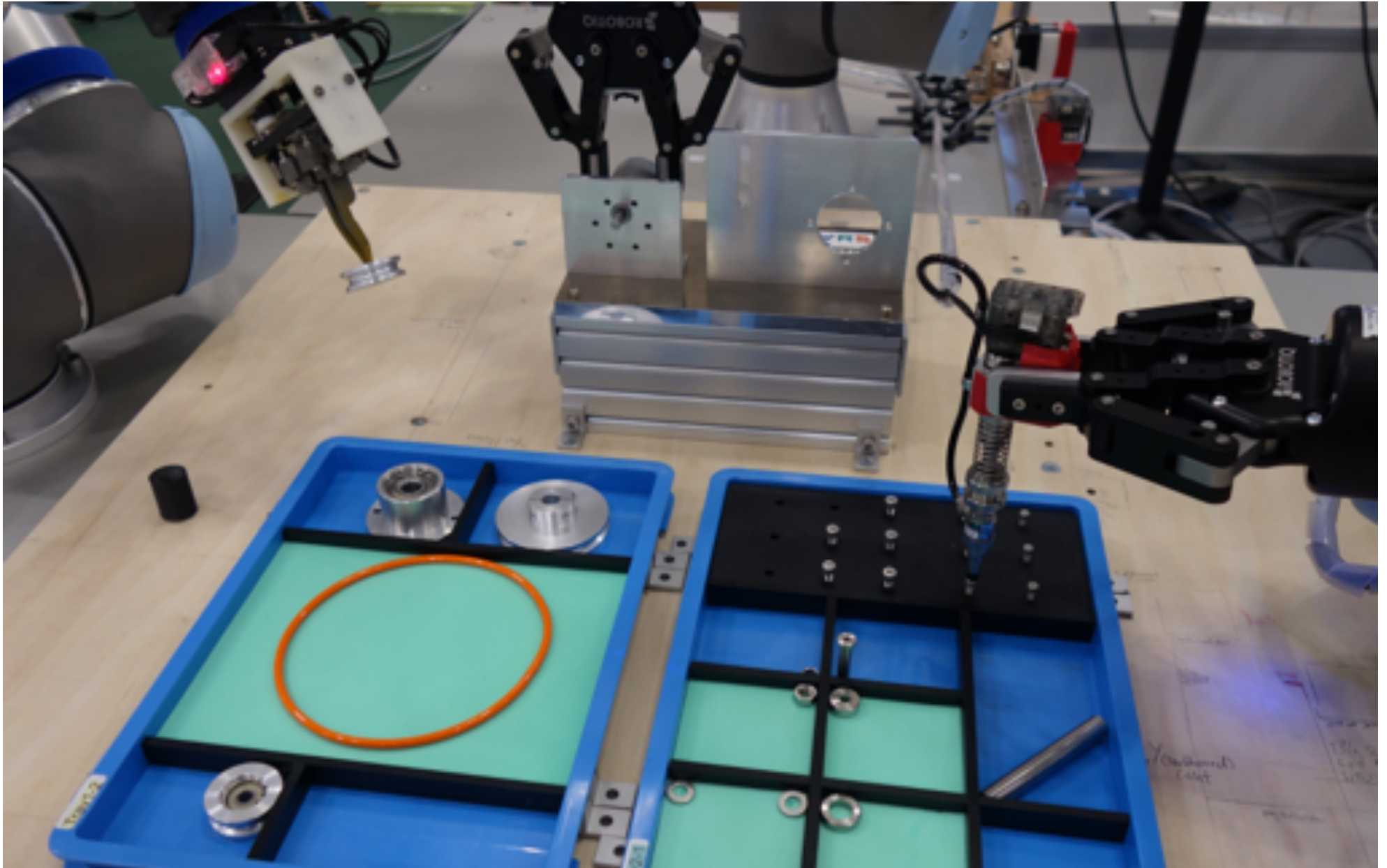
Michiaki HIRAYAMA

Toshio UESHIBA

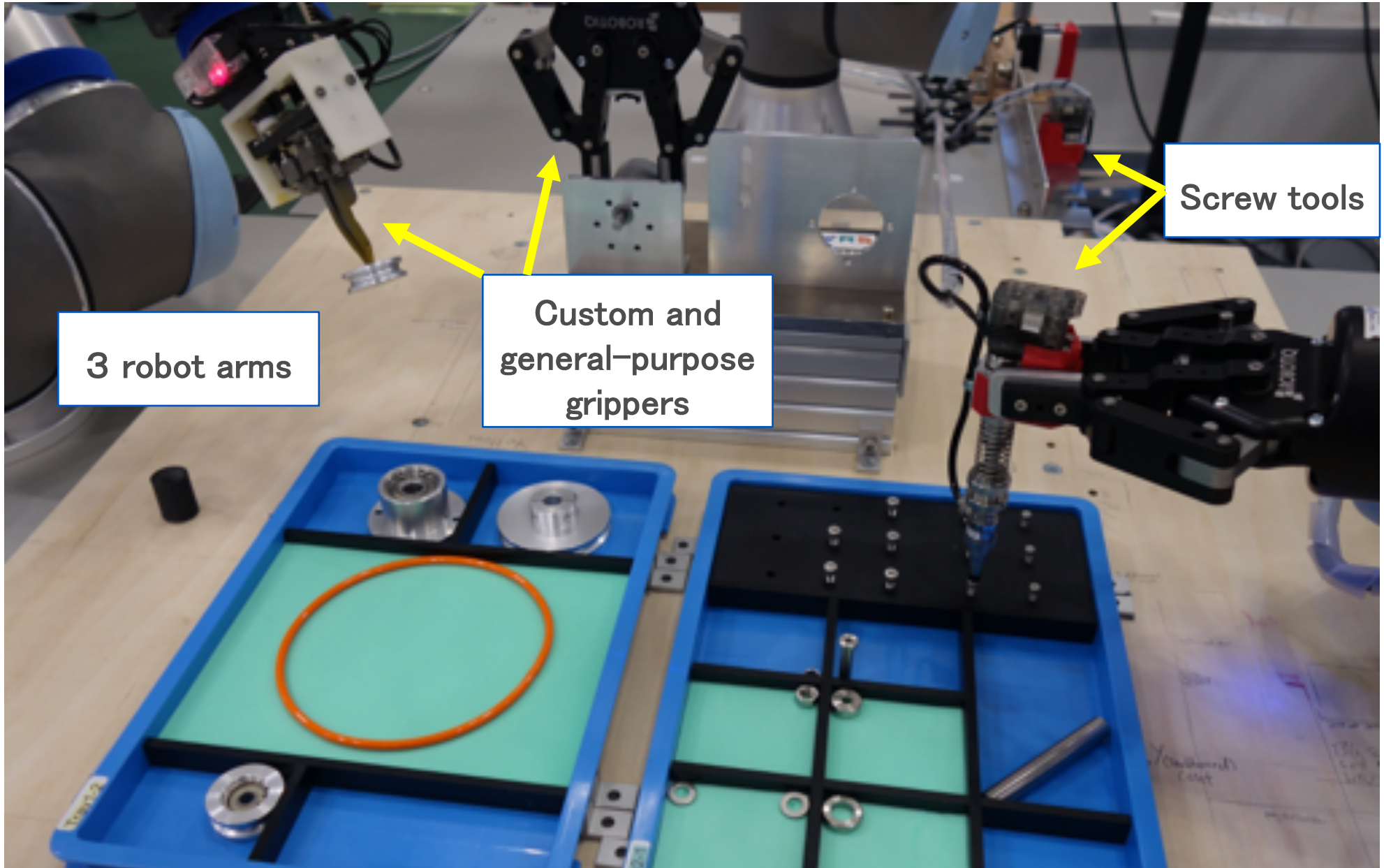
Ryuichi TAKASE

Yuma HIJIOKA

System



System



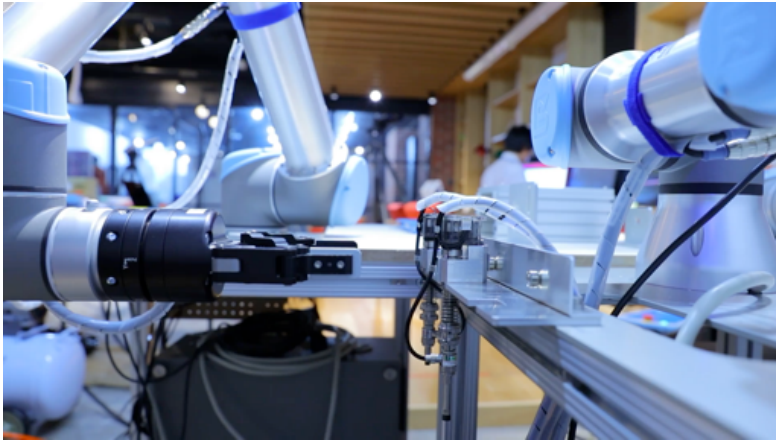
3 robot arms

Custom and
general-purpose
grippers

Screw tools

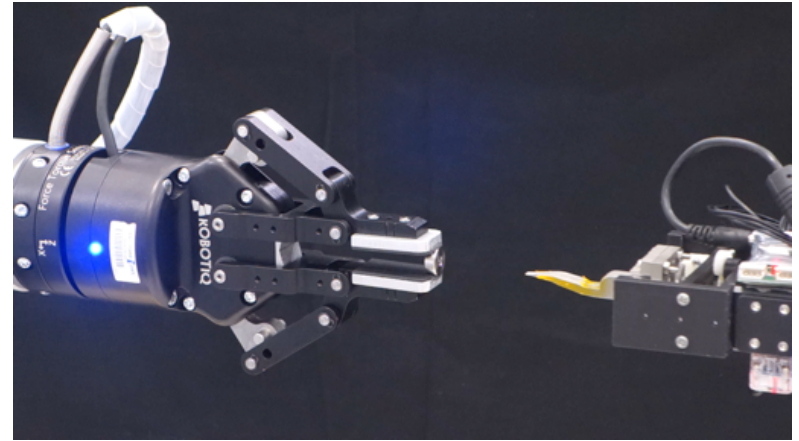
System

**Flexible tool use
without tool changers
(SICE Award)**



Compliance

Jigless part centering

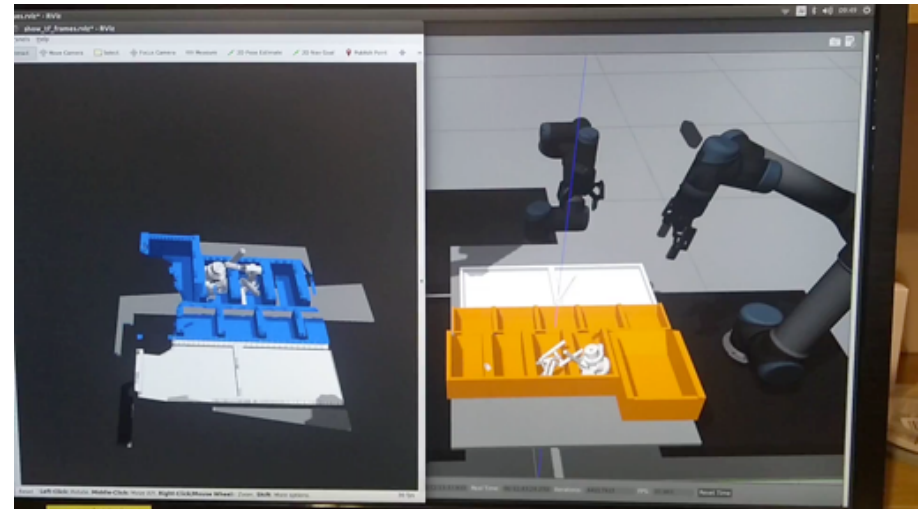
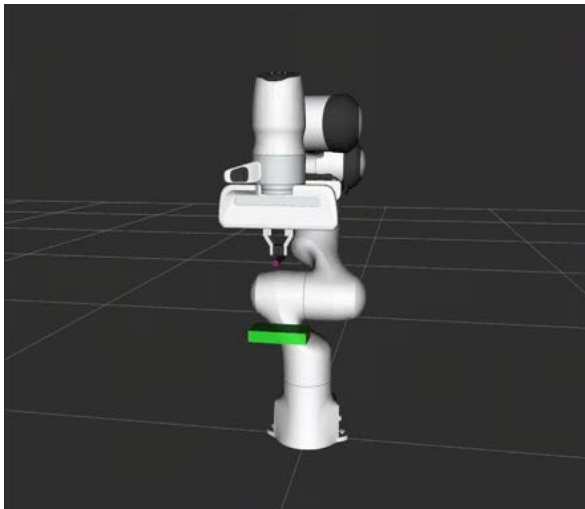
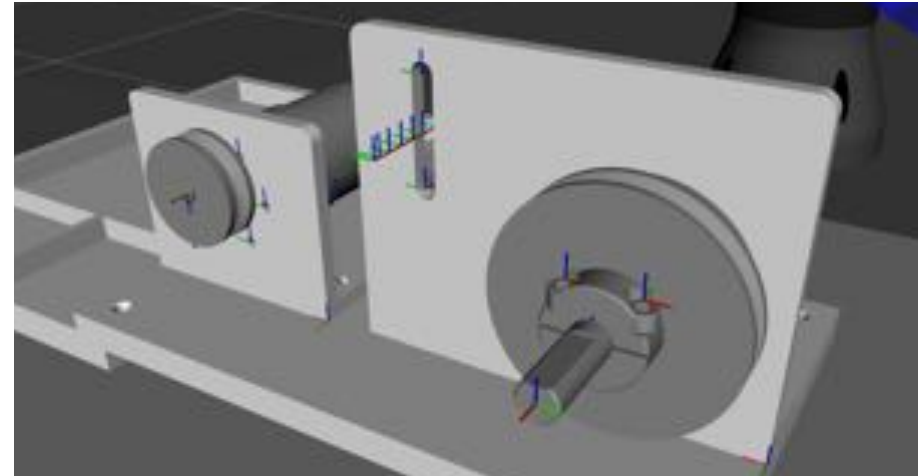


Public ROS code

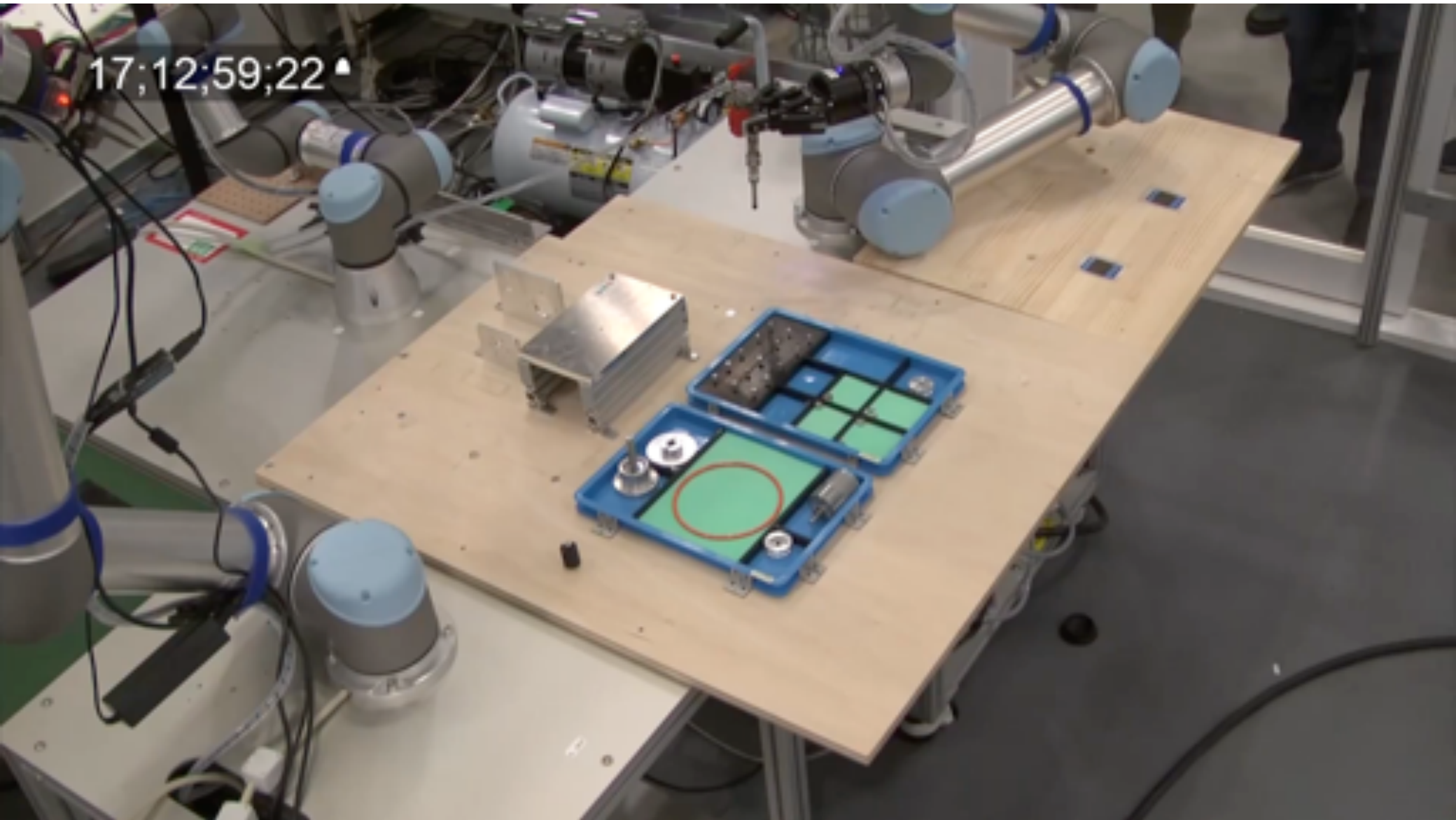
1. Assembly generator
2. Multi-robot configuration
3. Task instructions

All code public:

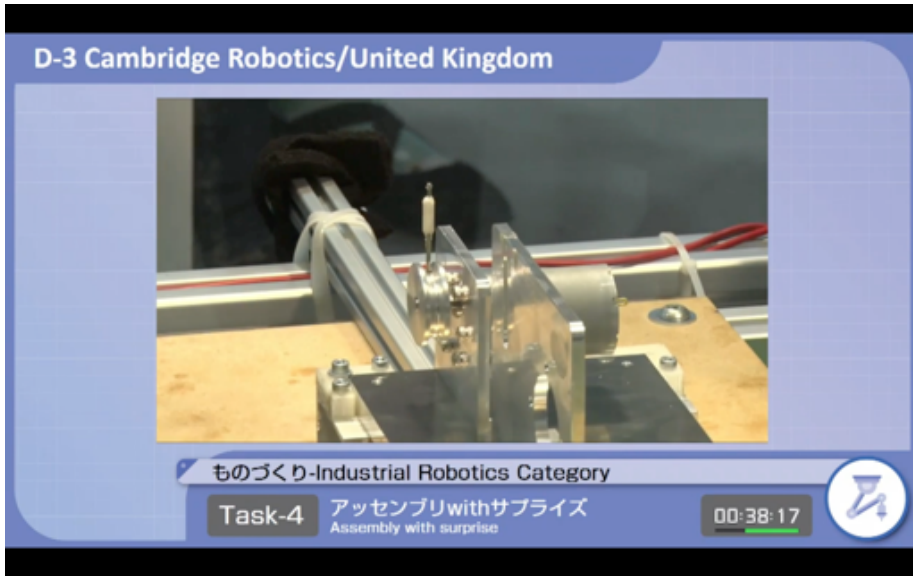
github.com/o2as/ur-o2as



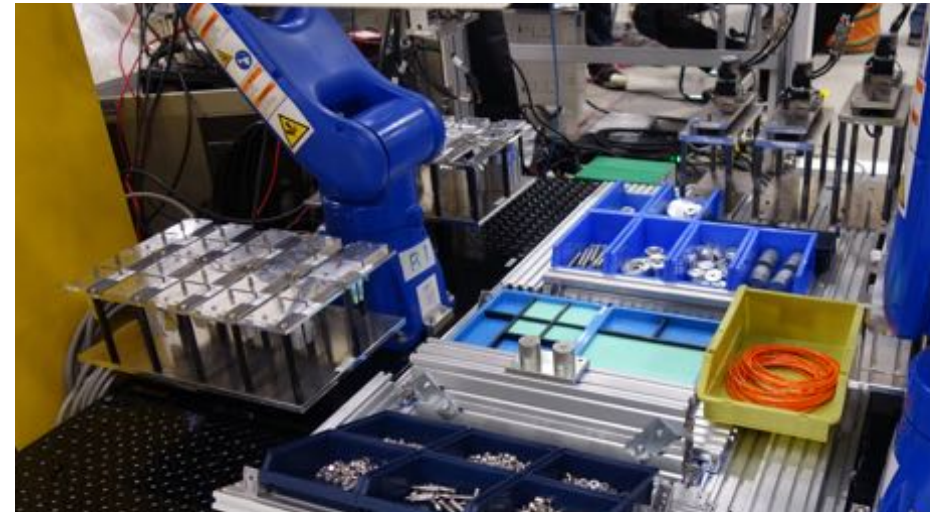
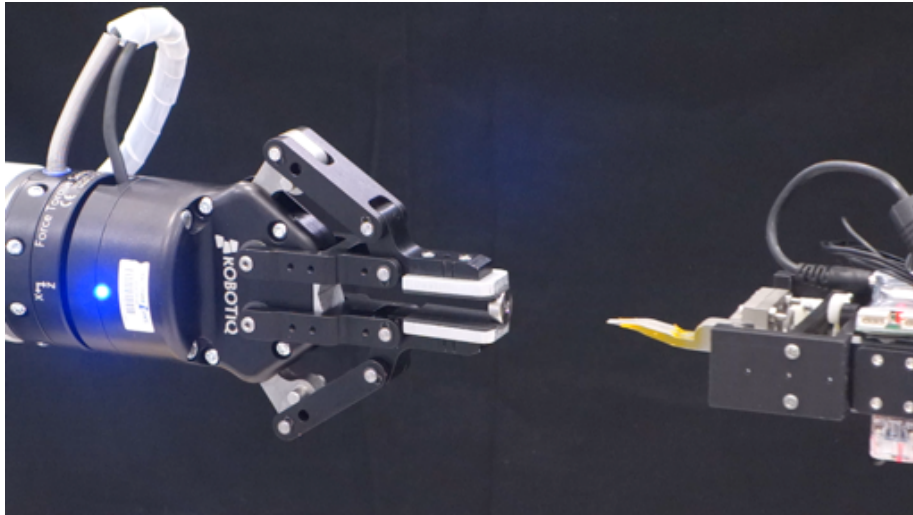
Result



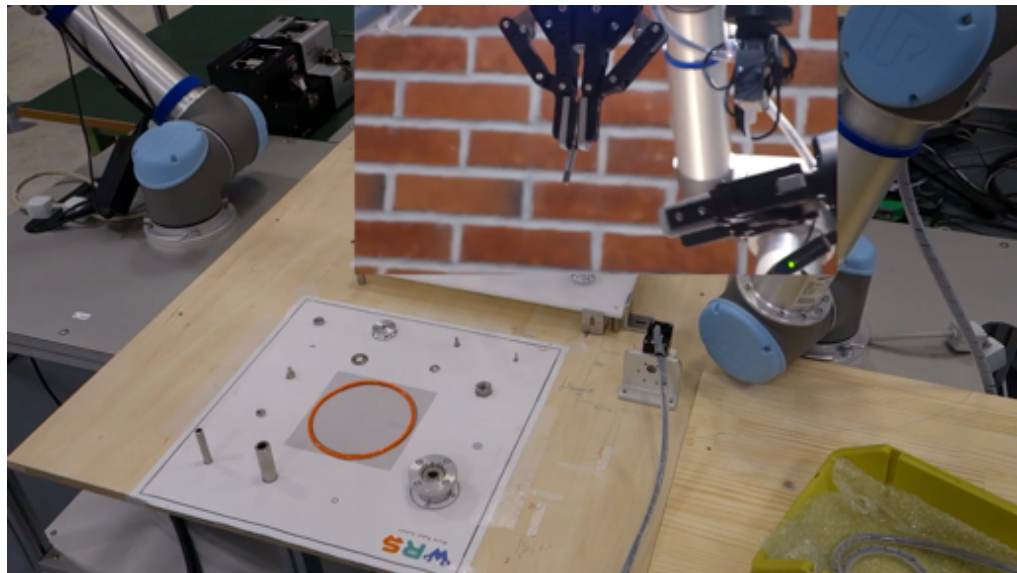
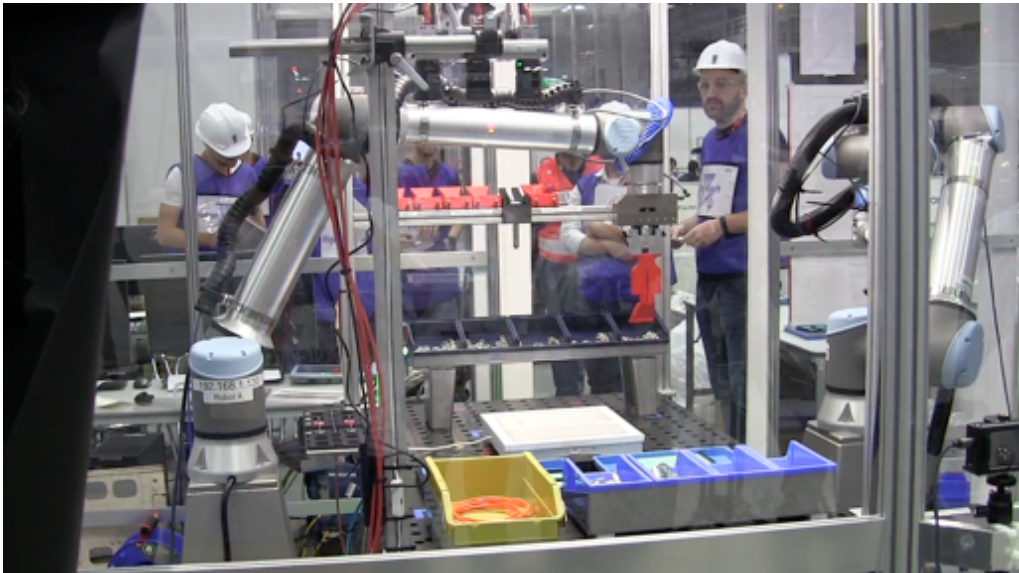
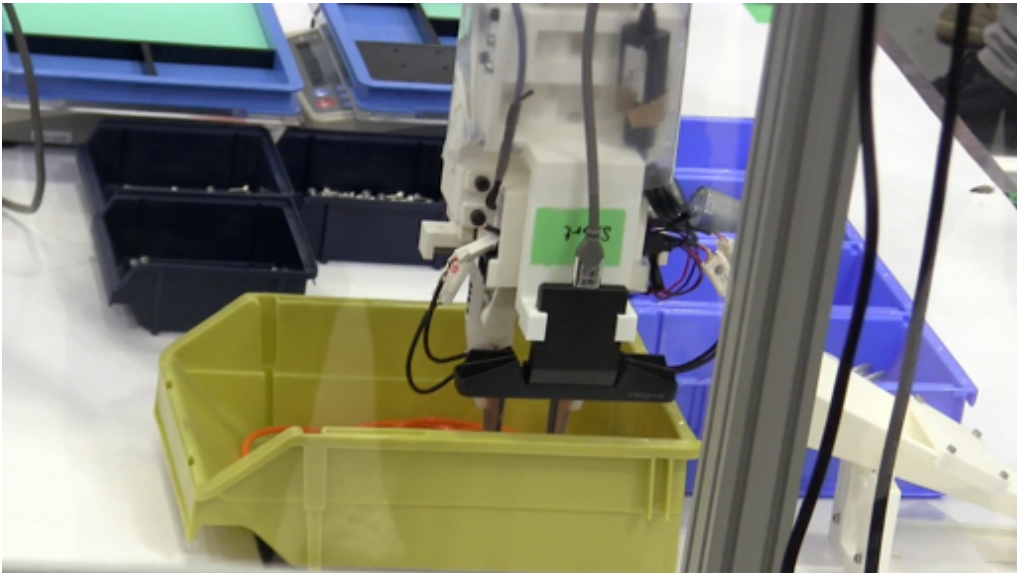
Strategy differences




VS



Flexibility vs Specialization




B-4 SDU Robotics/Denmark



ものづくり-Industrial Robotics Category

Task-4 アッセンブリwithサプライズ
Assembly with surprise

00:41:32



2. Difficulties

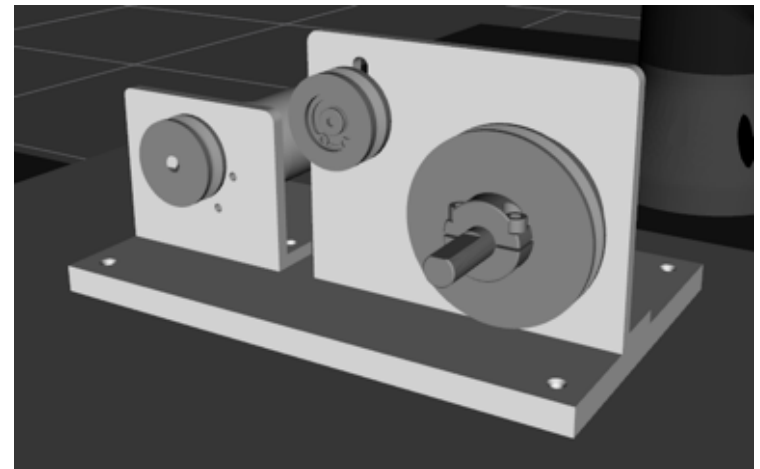
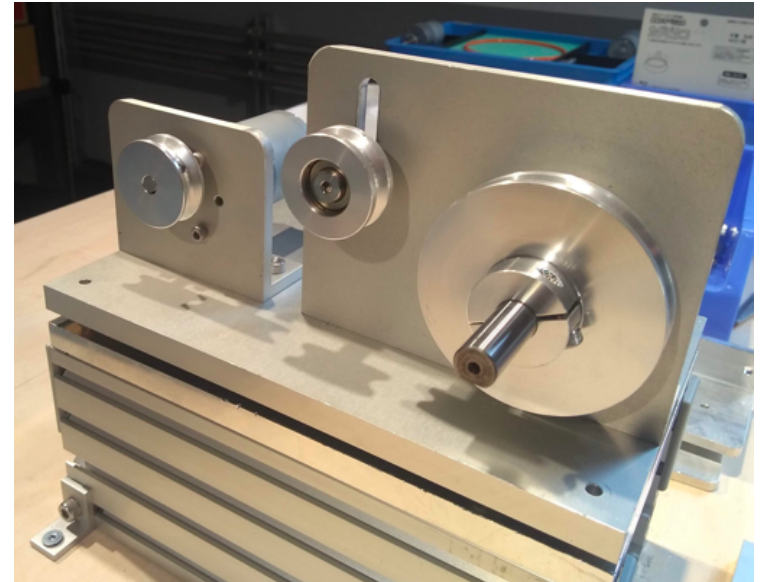
1. **Assembly code construction very labor-intensive**
 - No “sensible” way to instruct robots
2. **Hard to deal with uncertainty**
 - Success checks
 - Error recovery
3. **Calibration**
 - Sub-mm accuracy required

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?

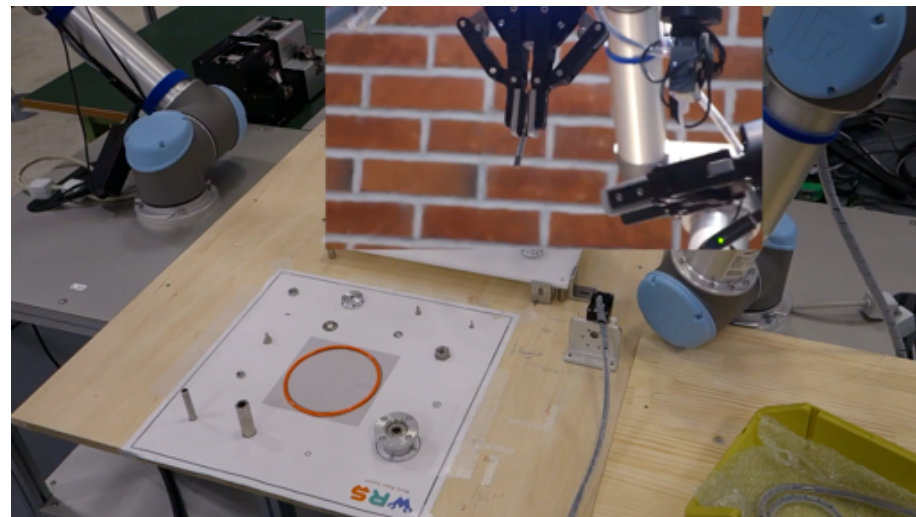
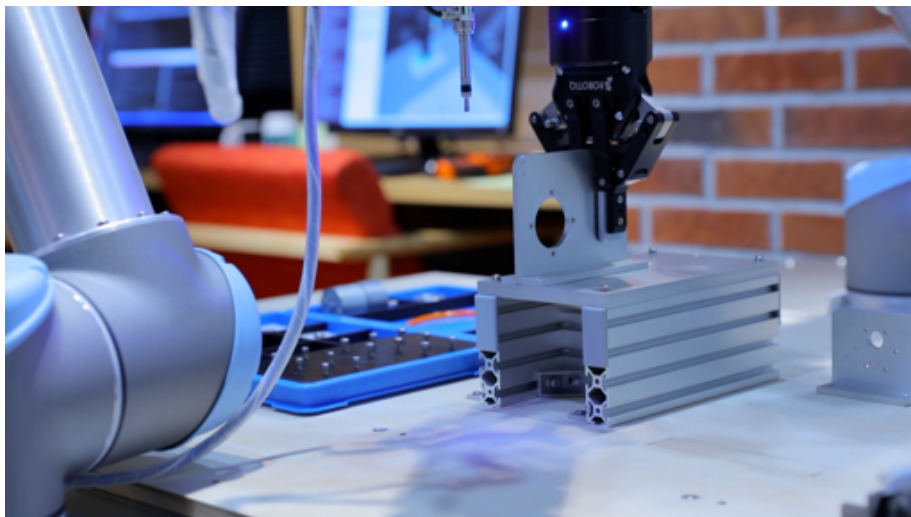
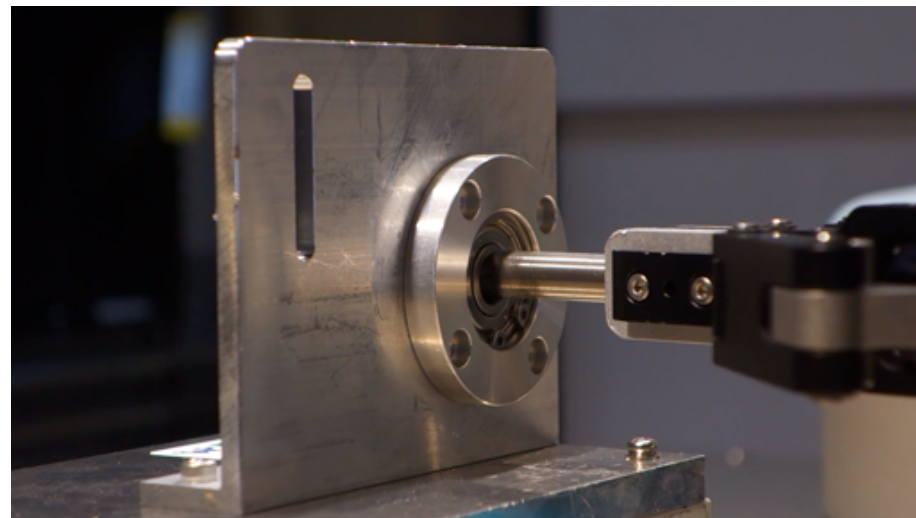
What was desirable:

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

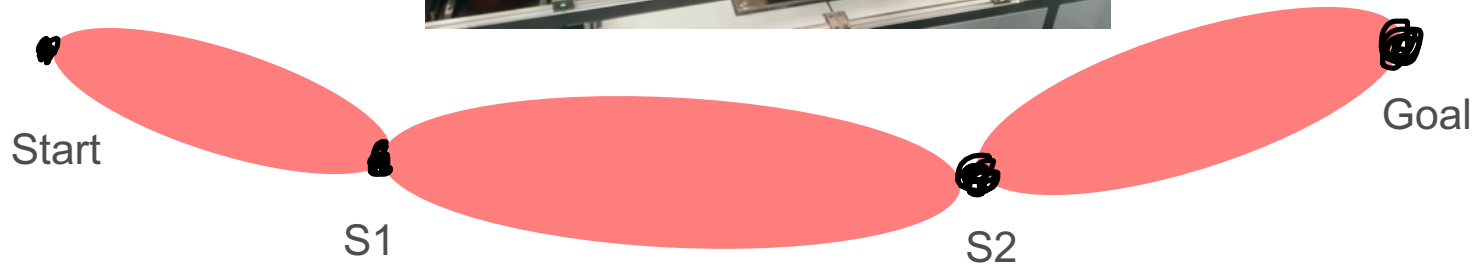
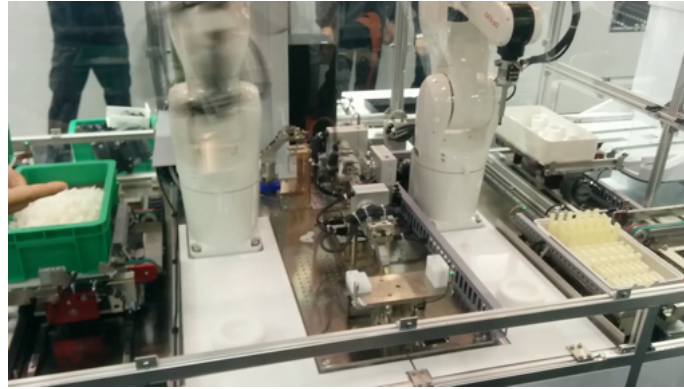


Effects of small uncertainties

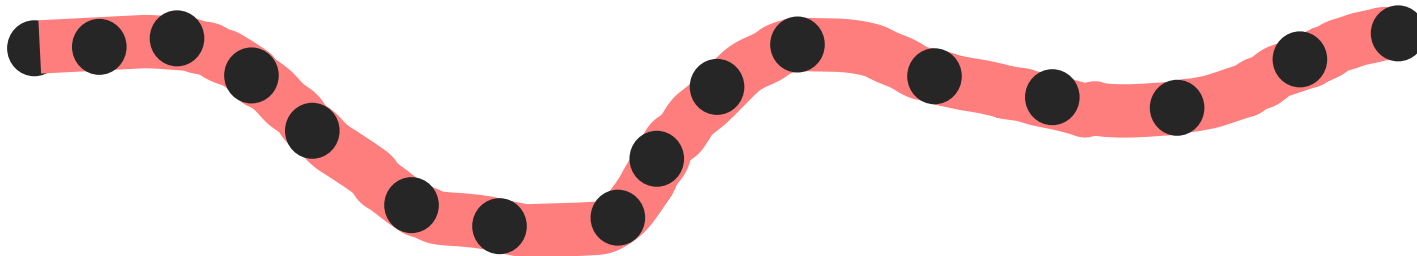
- Very small errors can cause failures further along the process
 - Dropped or stuck parts
 - Protective stops
- Which can be compensated?
- Which need to be actively dealt with?



Uncertainty & Planning



From binary engineered checkpoints to continuous feasibility monitoring



Reducing uncertainty

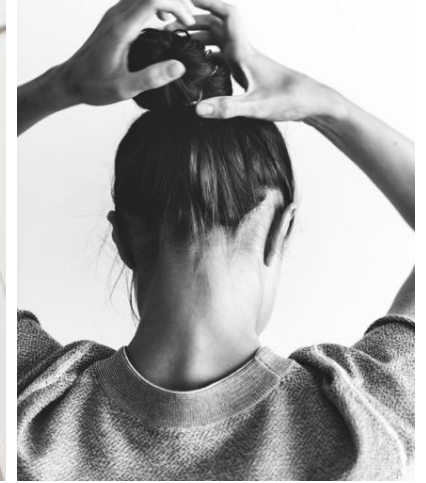
In-hand pose estimation



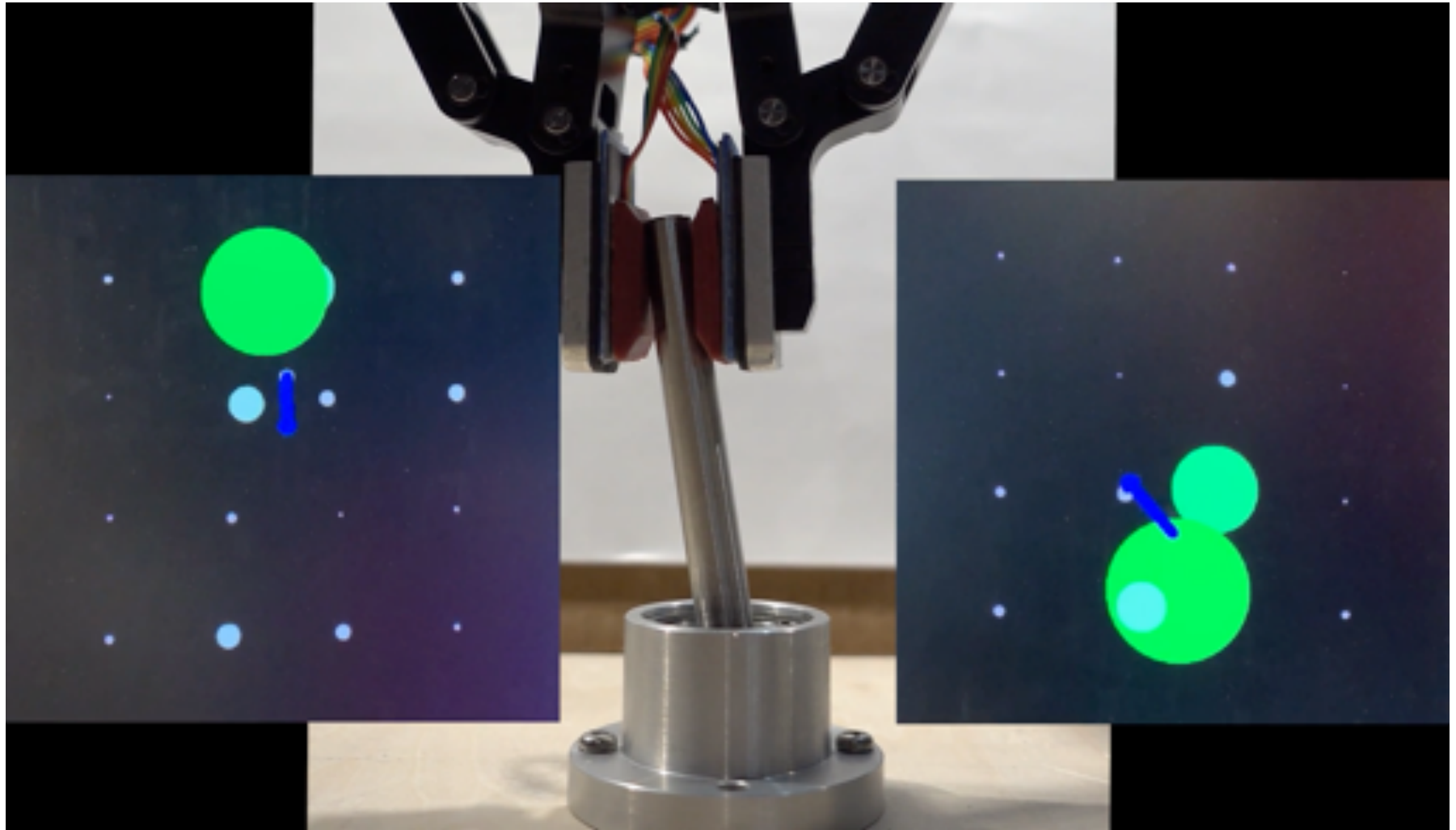
We propose a method that uses contacts with the environment to estimate the object's in-hand pose.

Each contact improves the pose estimate by extracting new information.

Limits of vision sensing

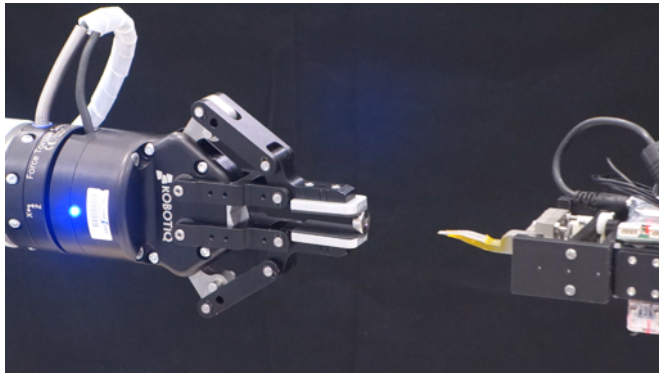


Tactile sensing



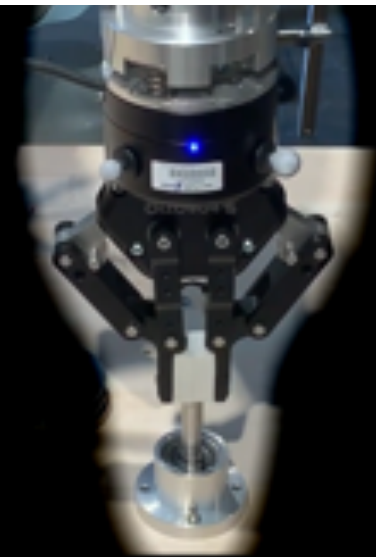
Compliance

Compensation for positioning and perception errors



In the peg-in-hole task,
the soft wrist compensates
for position and angular errors.

The insertion succeeds,
even for large errors (3°)



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

WRS 2018 final scores

