

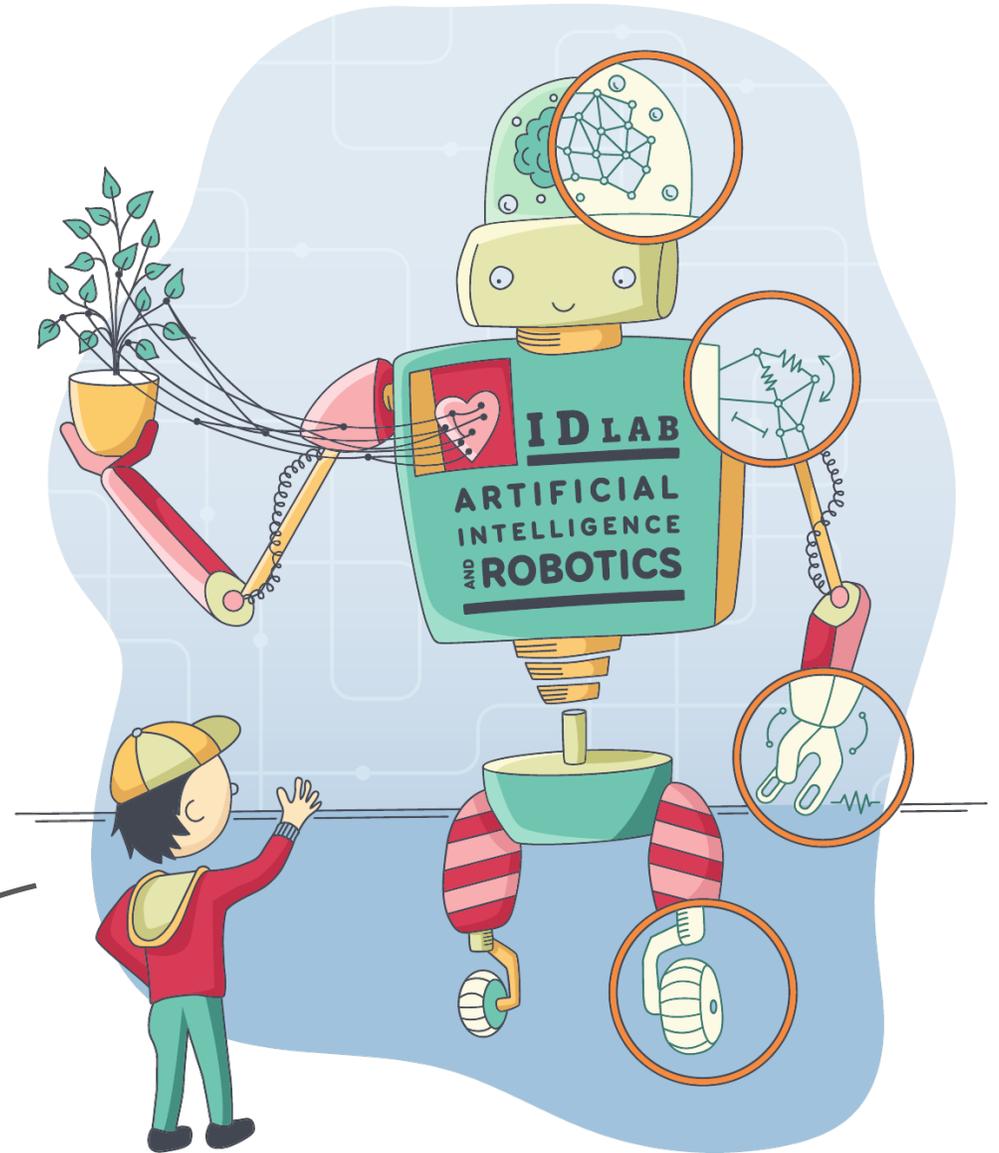


# ROMANDIC

## Beyond vision: sensing for fine manipulation of deformable objects

Francis wyffels

find us here





We hadn't this workshop if cloth was easy

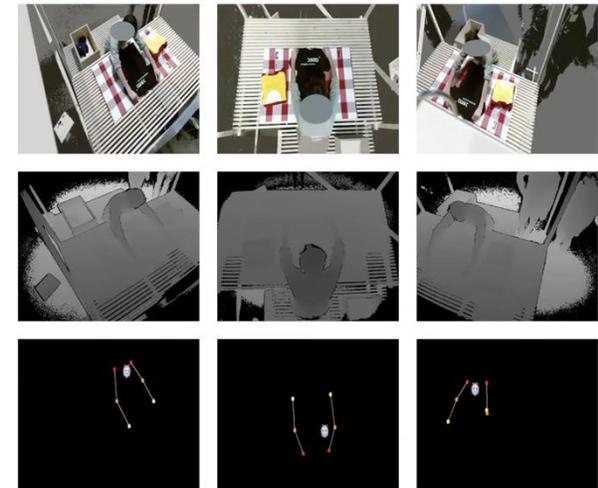


And folding cloth is difficult ... also for humans





# Let the public show the robot how we fold clothing!



Verleysen, A., Biondina, M., & wyffels, F. (2020). Video dataset of human demonstrations of folding clothing for robotic folding. INTERNATIONAL JOURNAL OF ROBOTICS RESEARCH, 39(9). <https://doi.org/10.1177/0278364920940408>

<https://airo.ugent.be/open-source/>



# Desired result: give a reward when nearing completion

Reward



100%



80%



60%



40%



20%

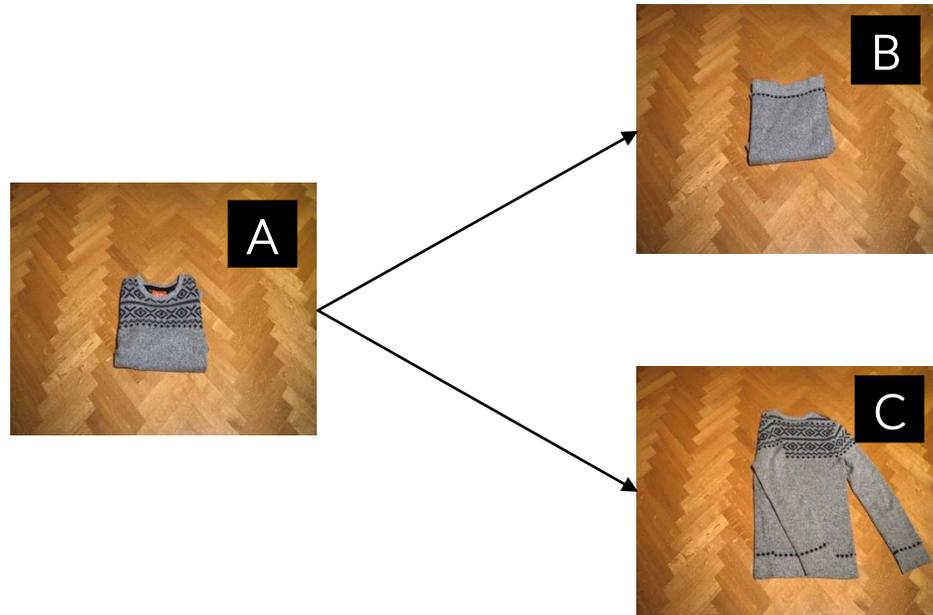
0%

Understand the task

Time



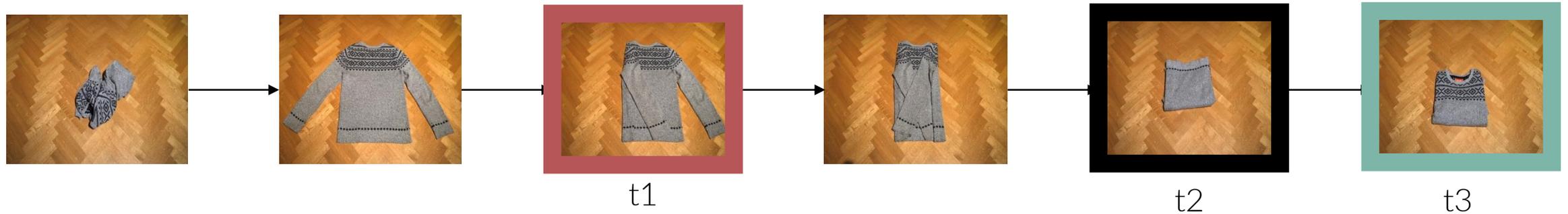
The robot can figure out the shirt descriptors by solving a fake task for which the data is easily generated



What is most similar to A?

# The robot can figure out the shirt descriptors by solving a fake task for which the data is easily generated

Chronological order



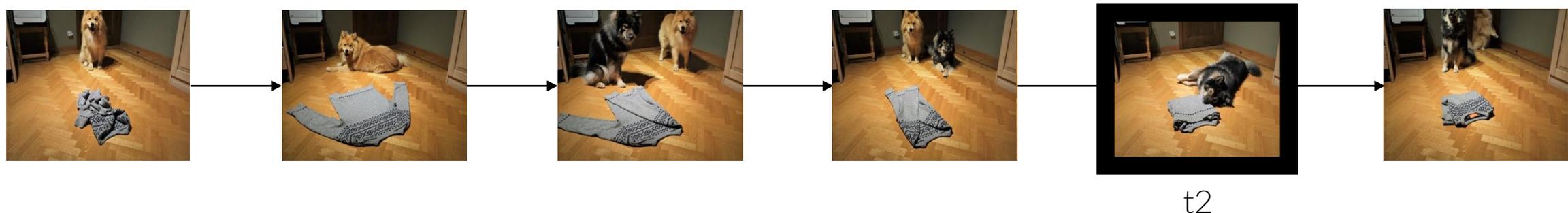
## Which image is most similar to image t3?

# The robot can figure out the shirt descriptors by solving a fake task for which the data is easily generated

Chronological from viewpoint 1:

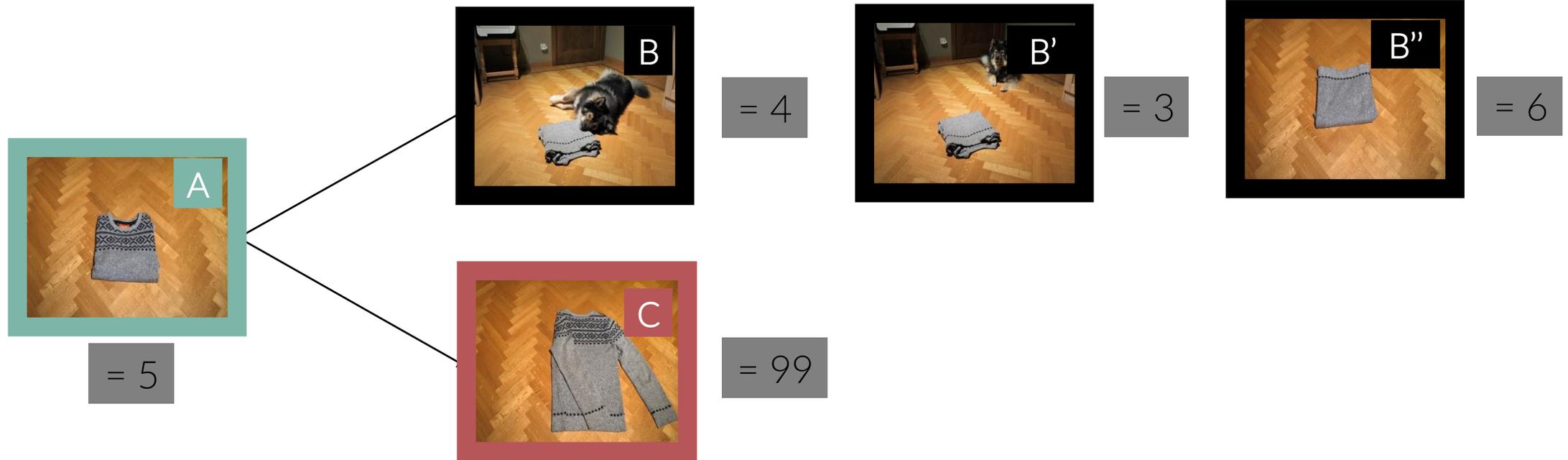


Chronological from viewpoint 2:

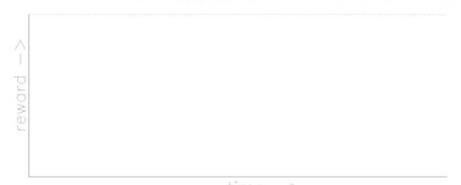
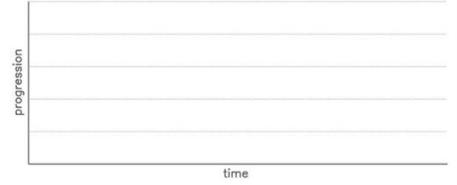
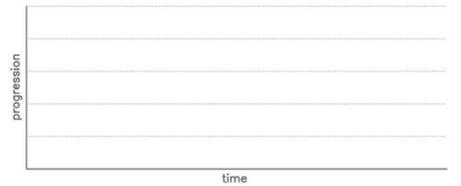
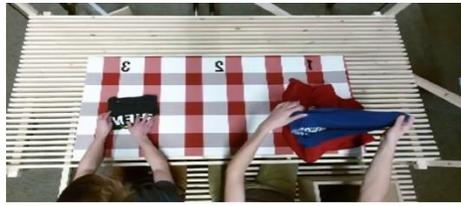
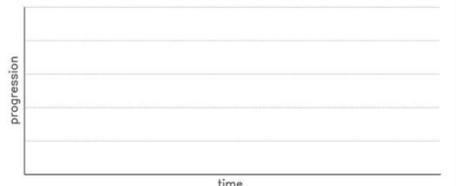
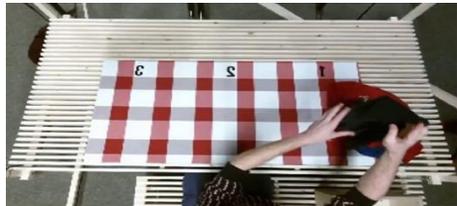
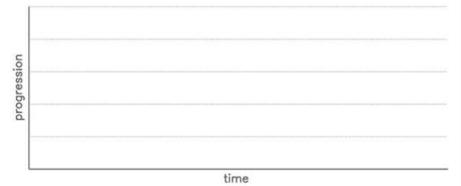
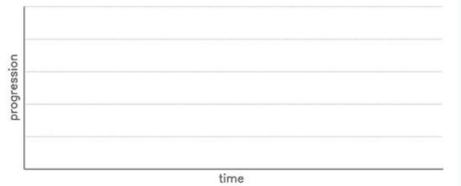
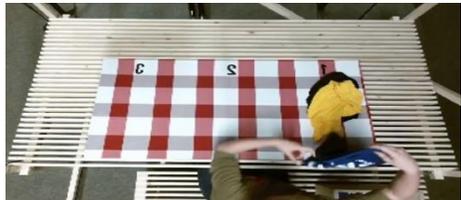
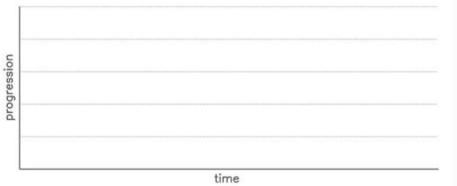


Which image is most similar to image t3?

# Similar images get a "similar" score







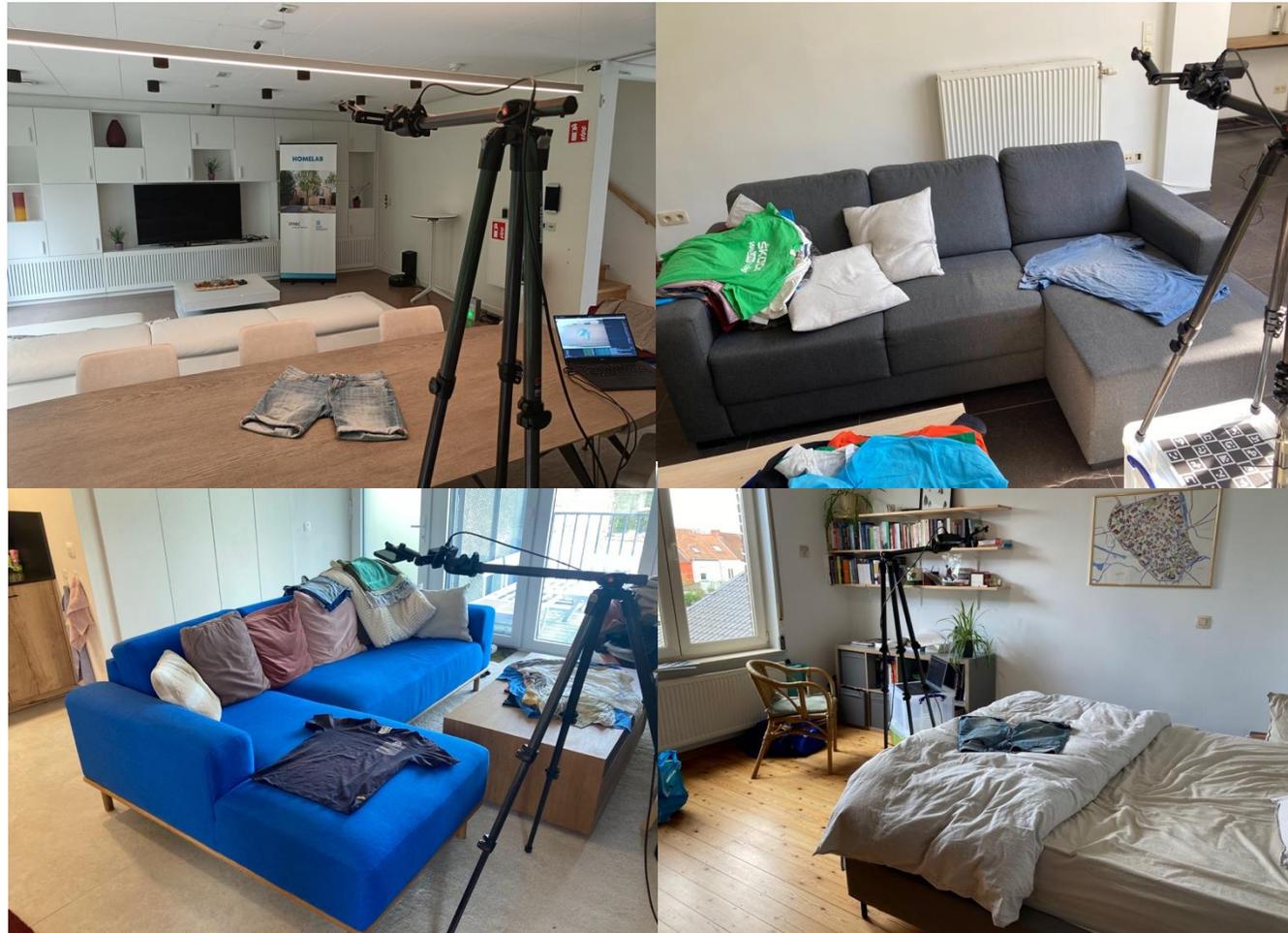
# Keypoint detection



# Synthetic Data Pipeline

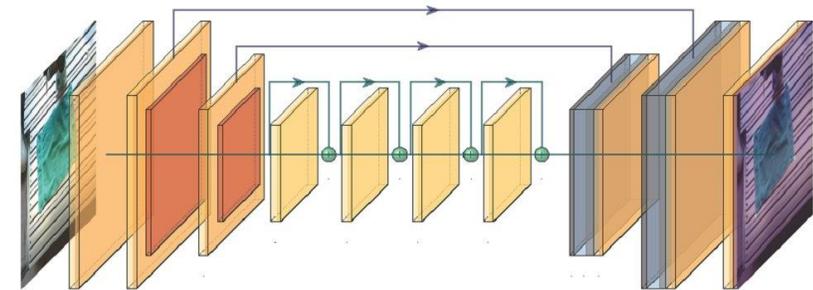
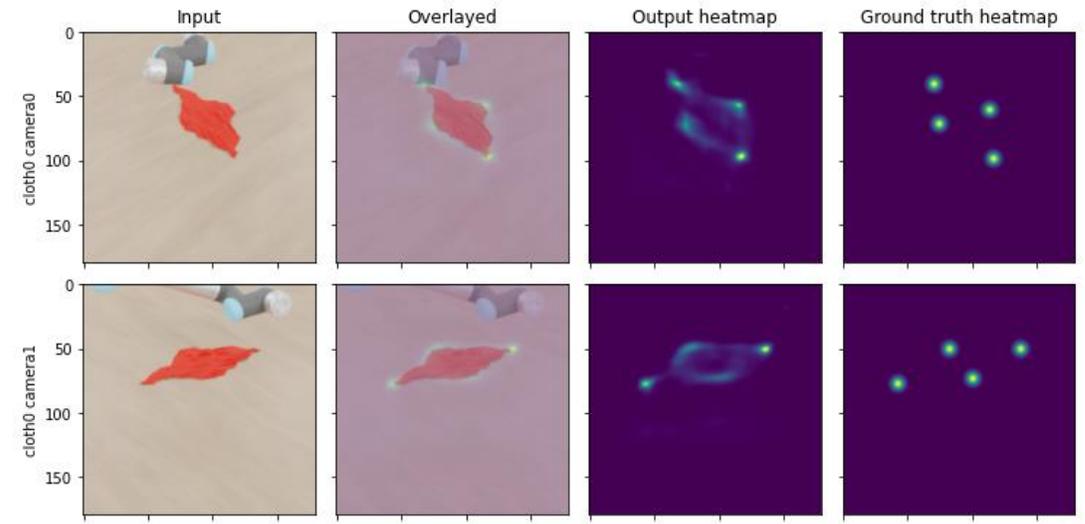


# Real Data

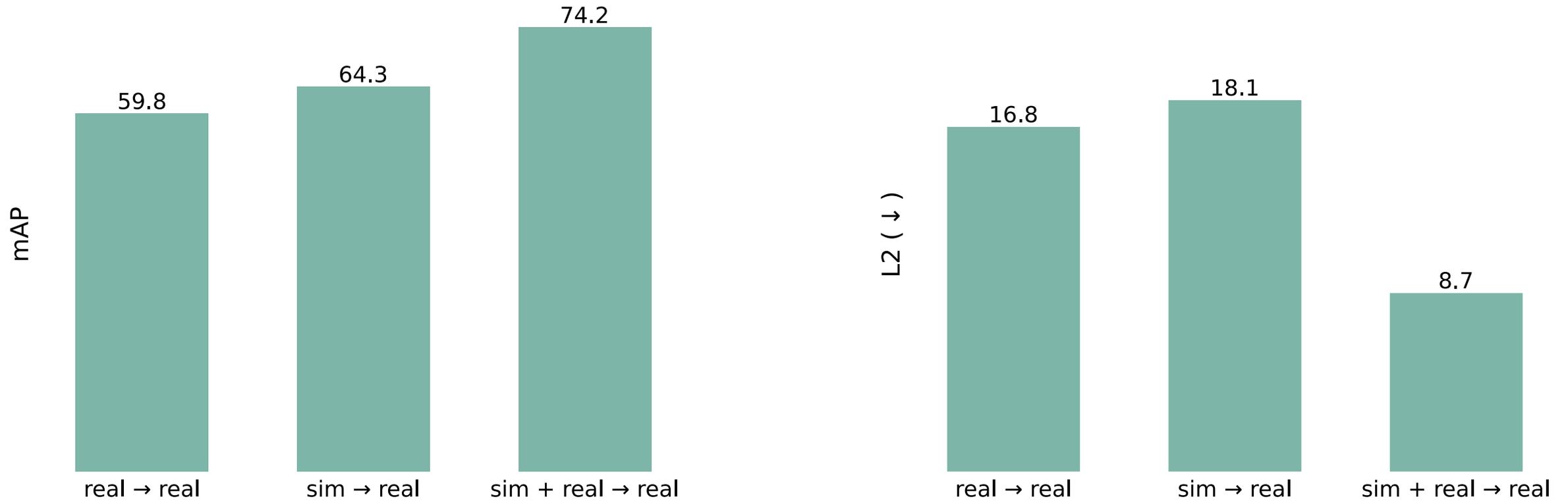


Lips, T., De Gusseme, V.-L., & wyffels, F. (2024). Learning keypoints for robotic cloth manipulation using synthetic data. *IEEE ROBOTICS AND AUTOMATION LETTERS*, 9(7), 6528–6535. <https://doi.org/10.1109/LRA.2024.3405335>

# Finding folding keypoints



# Results: $\text{sim} + \text{real} > \text{real}$

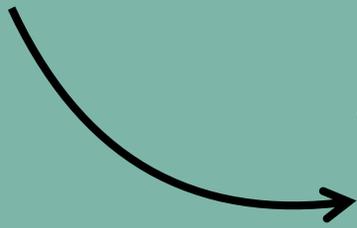




200 JAAR  
UNIVERSITEIT  
GENT

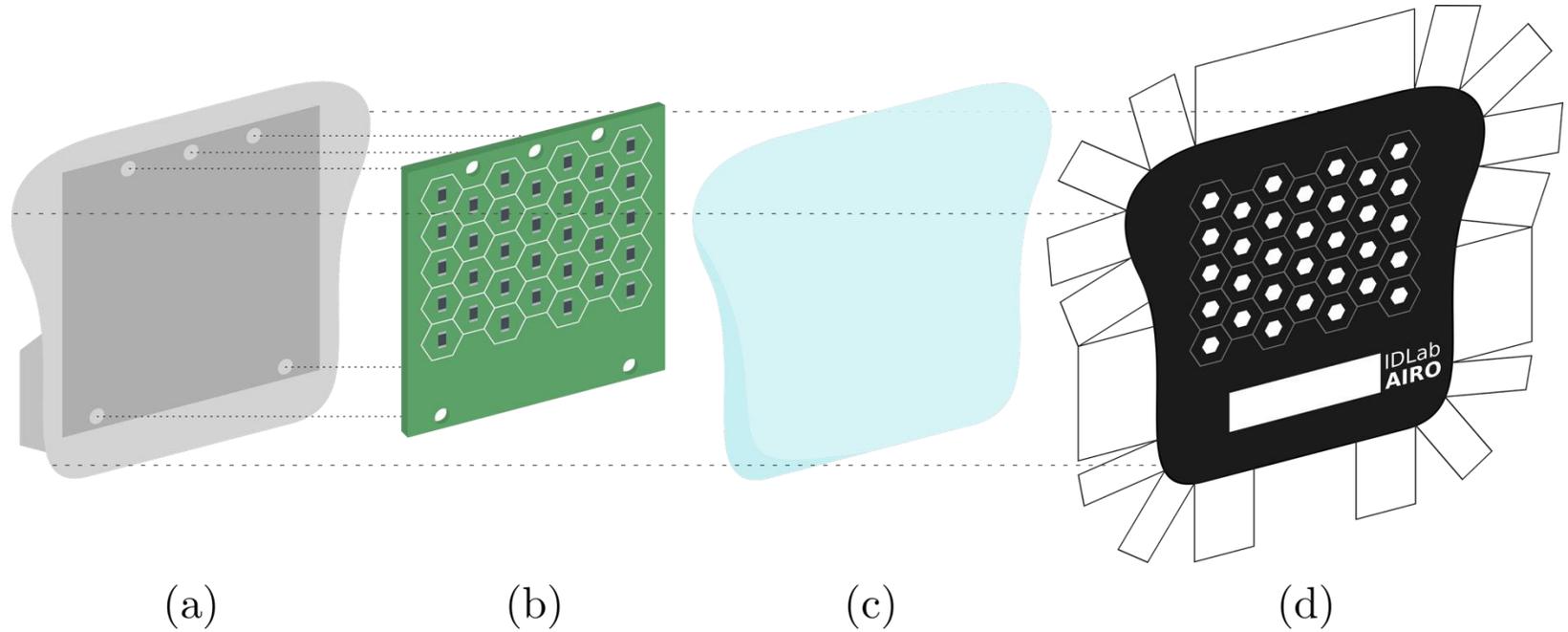
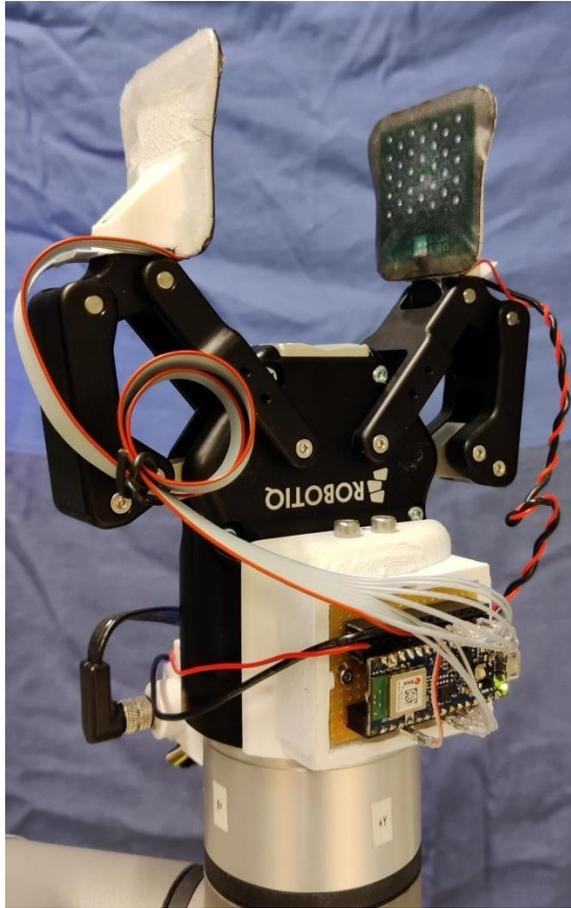
Playback speed x 20

# Beyond vision: instrumentation of grippers

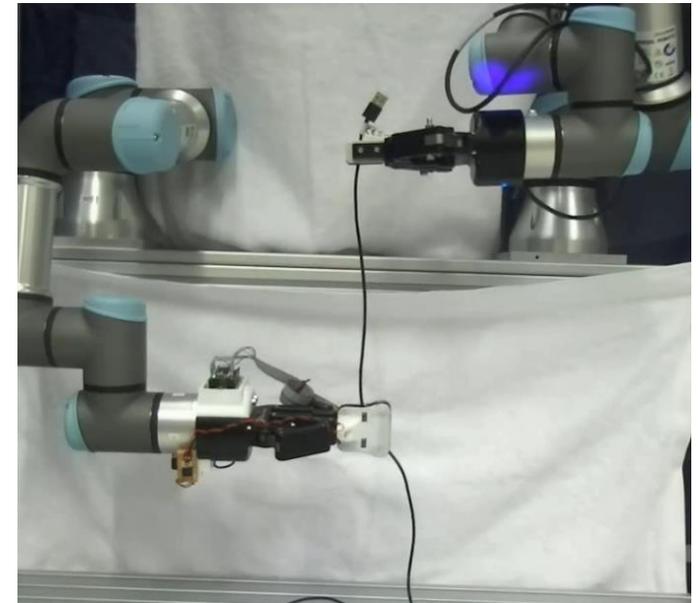
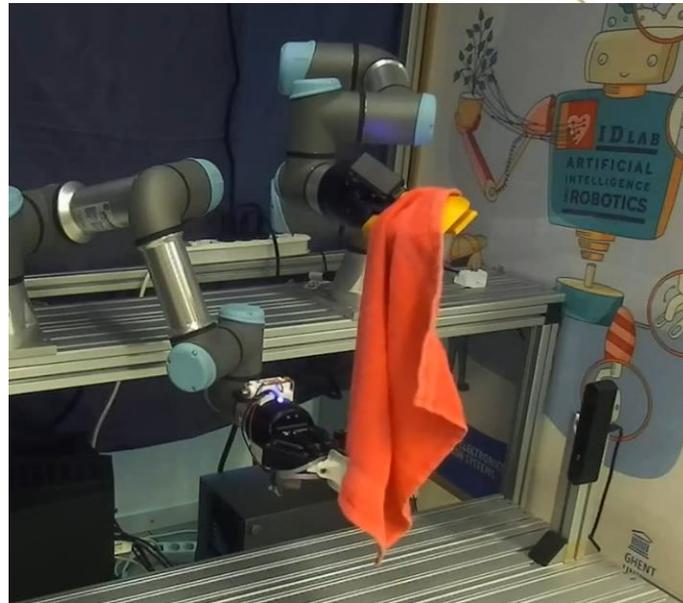
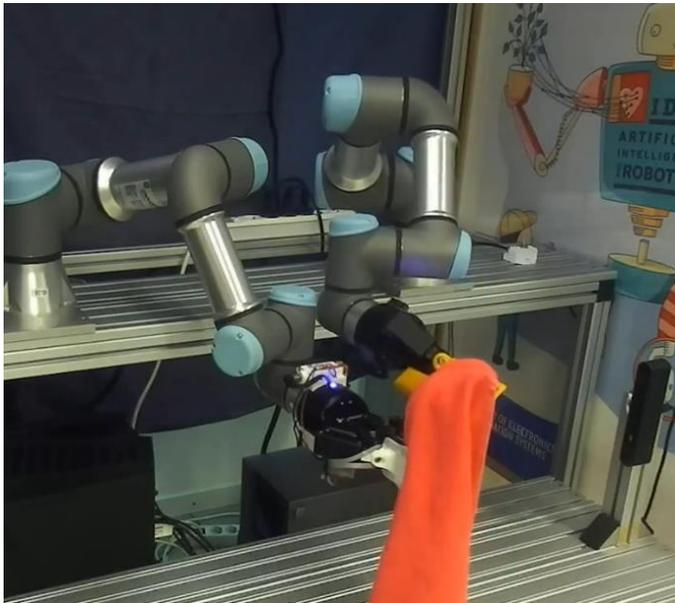
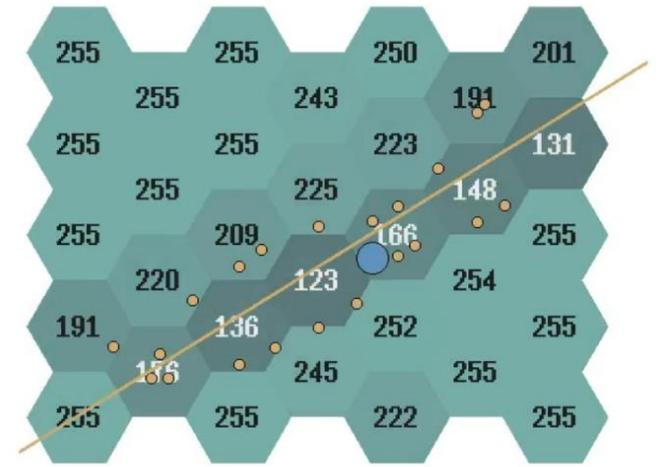
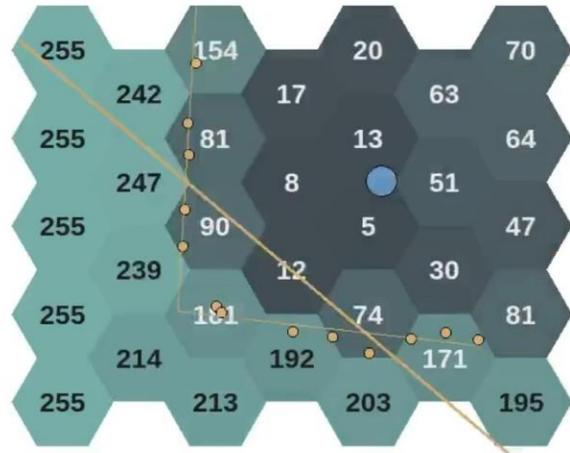
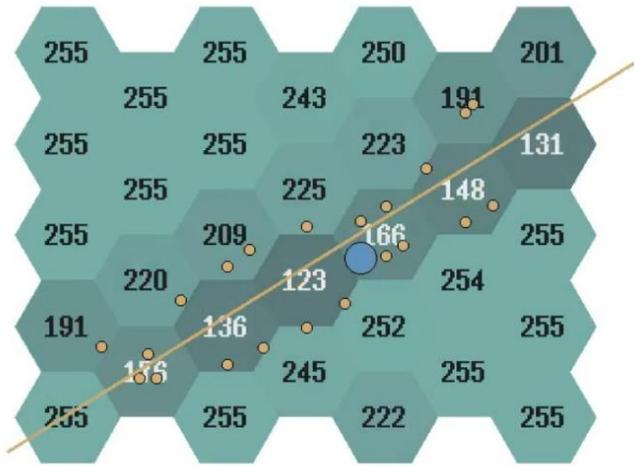


*Now I need a  
volunteer!*

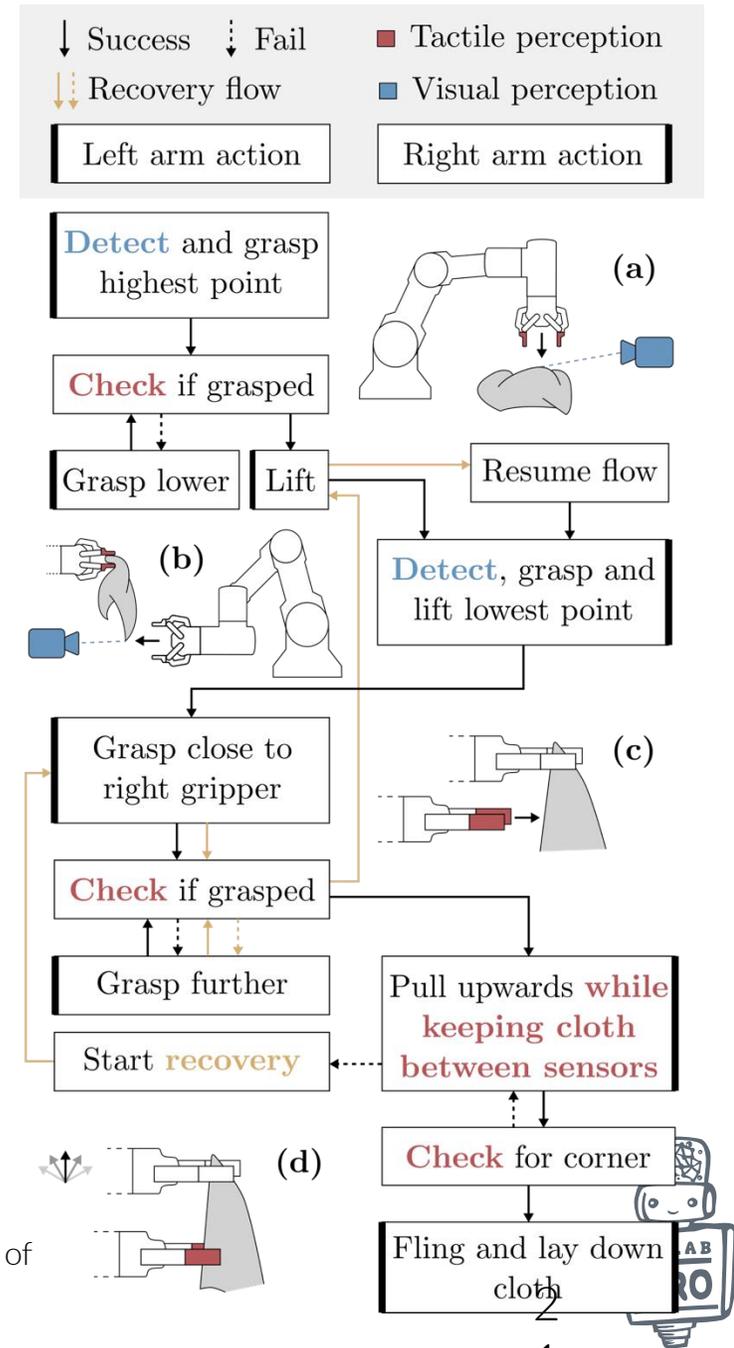
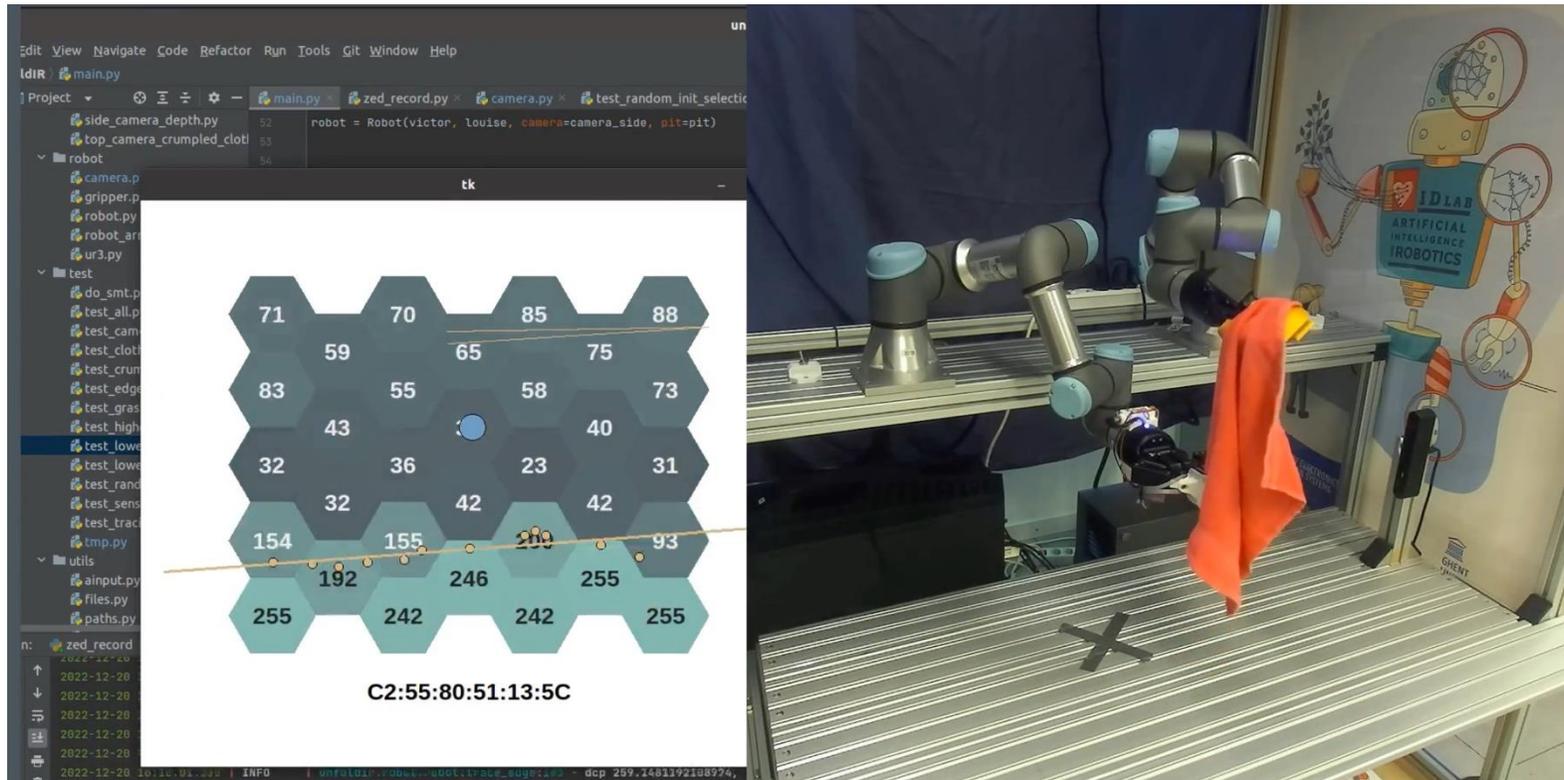
# The UnfoldIR Fingertip for Folding



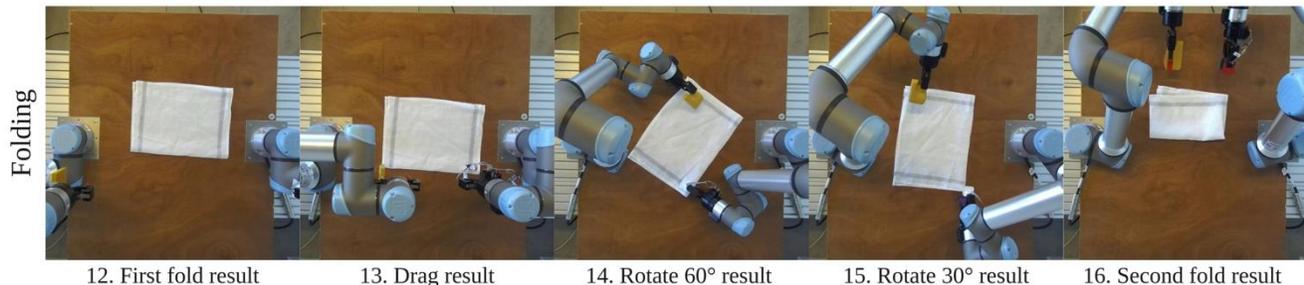
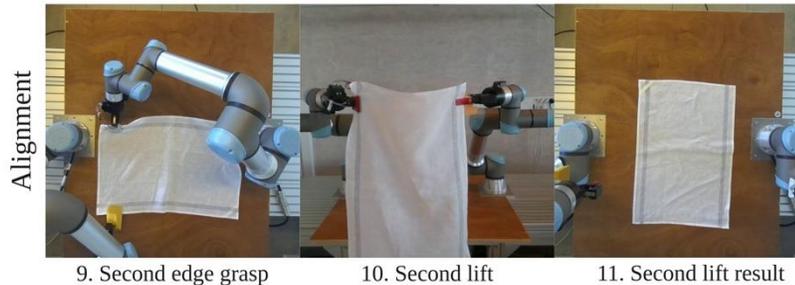
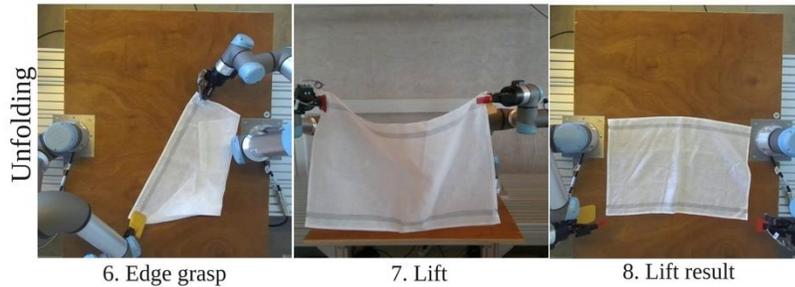
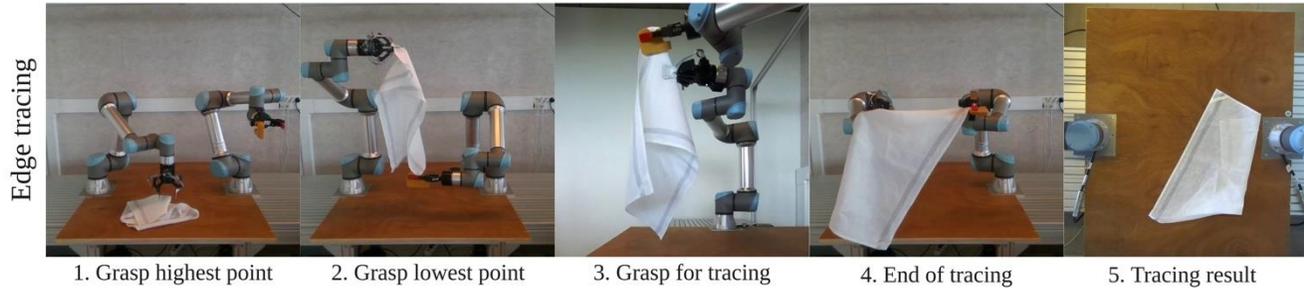
# The UnfoldIR Fingertip for Folding



# Unfolding with UnfoldIR

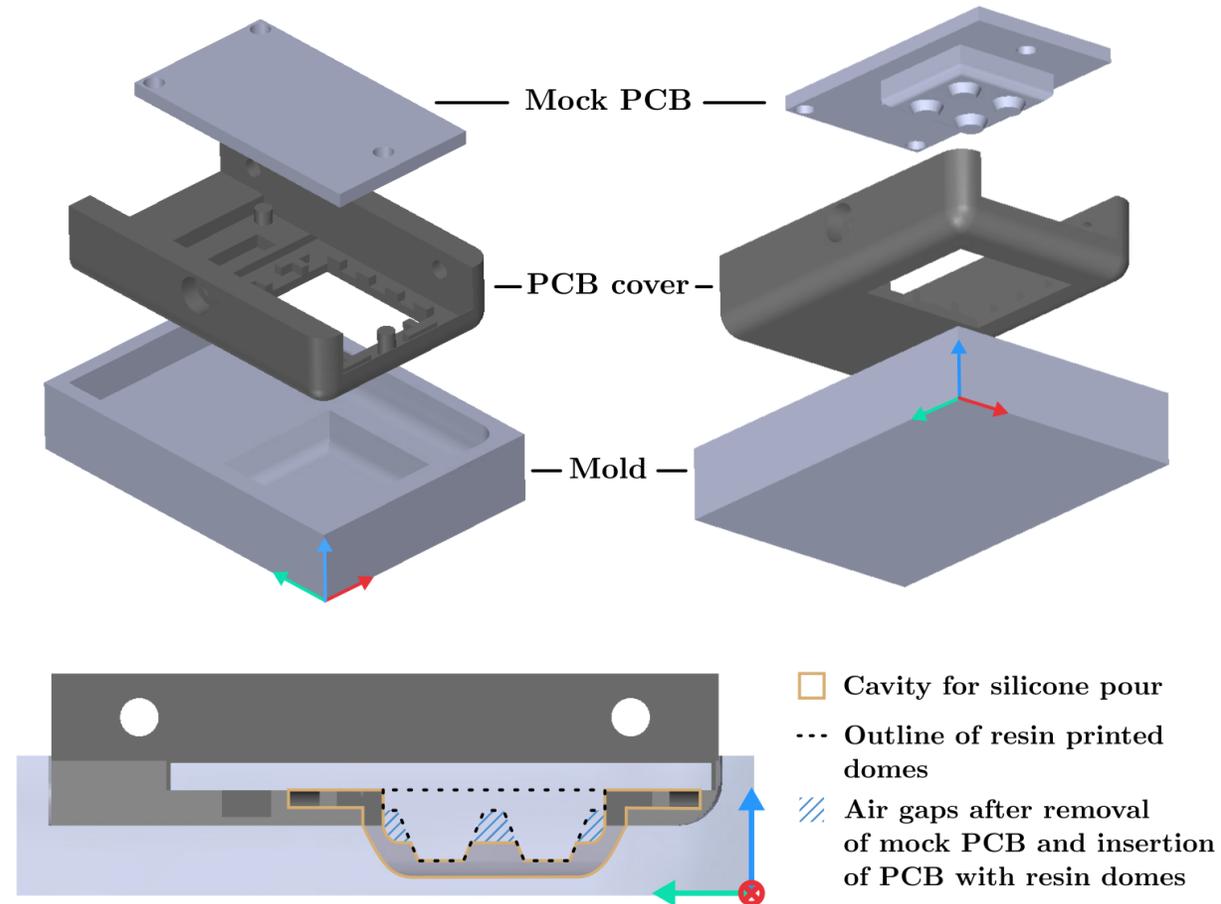
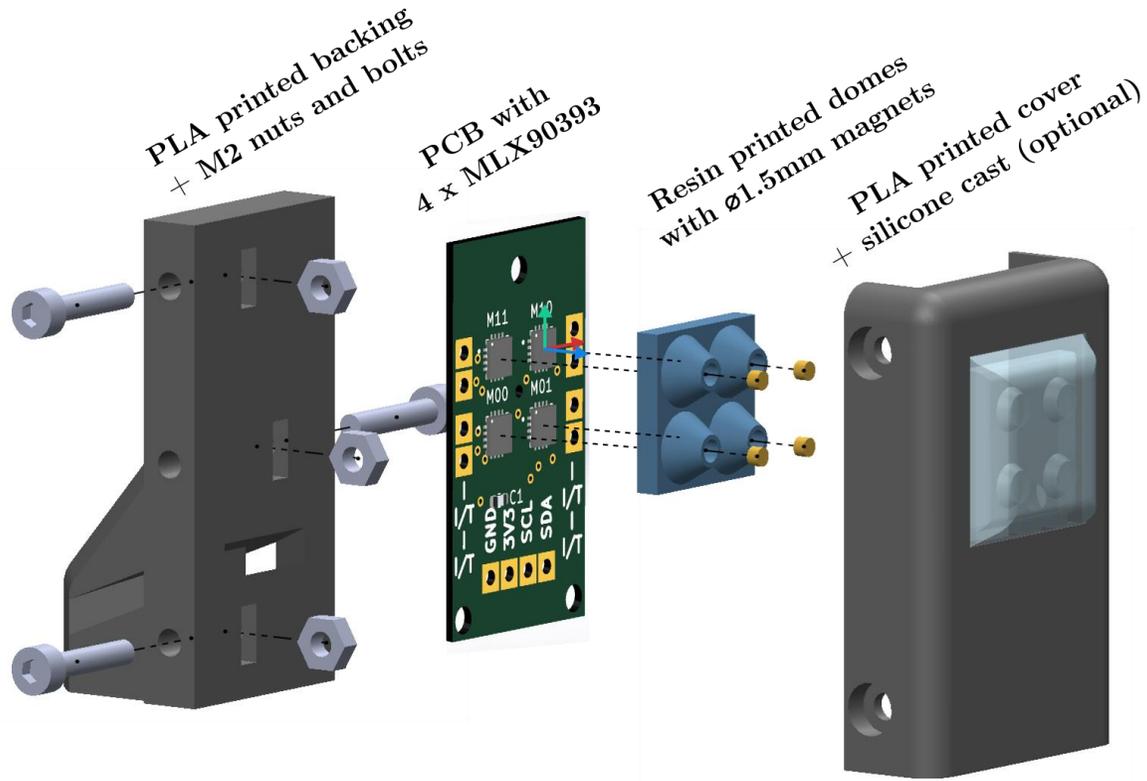


# The pipeline for IROS 2022 & ICRA 2023

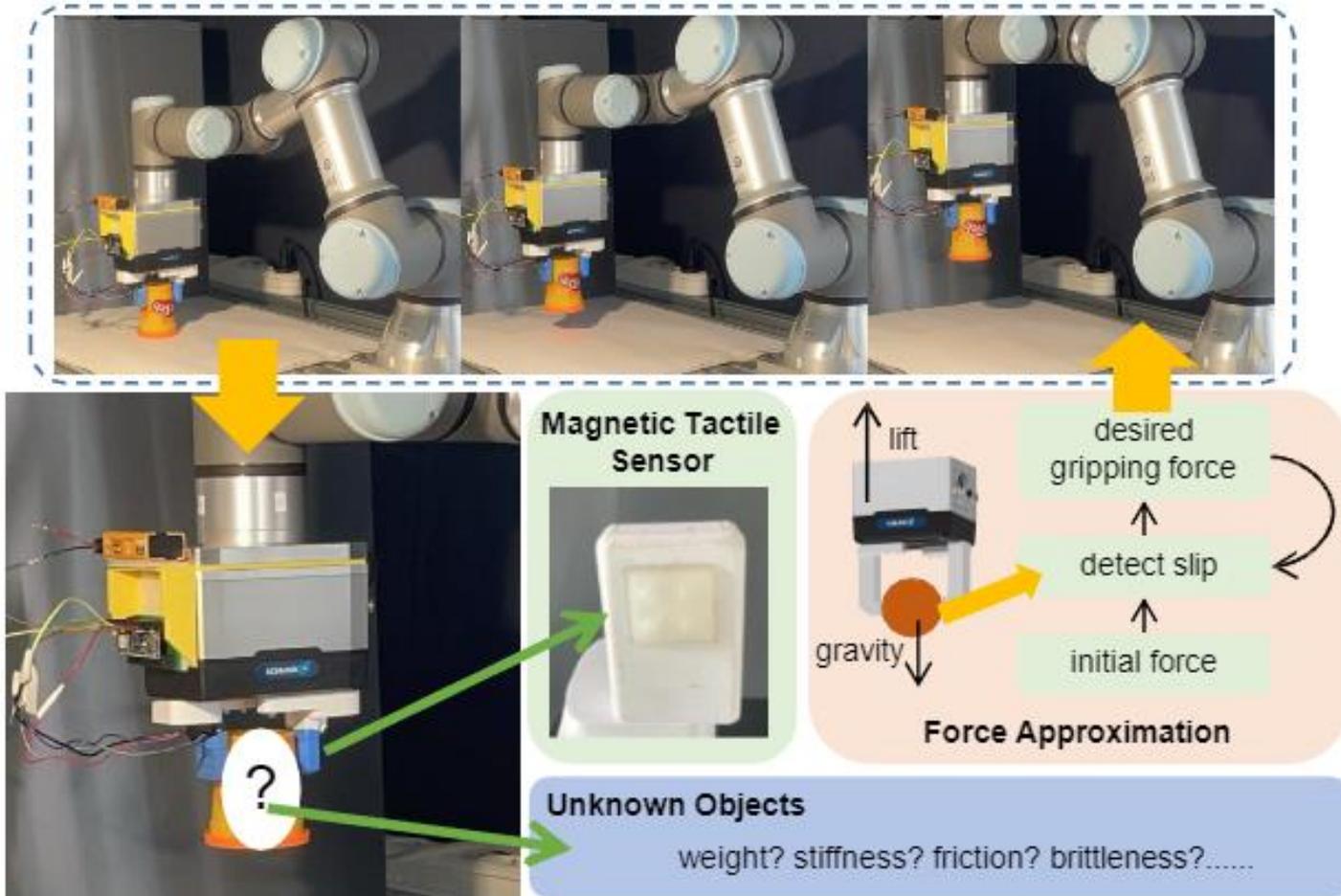


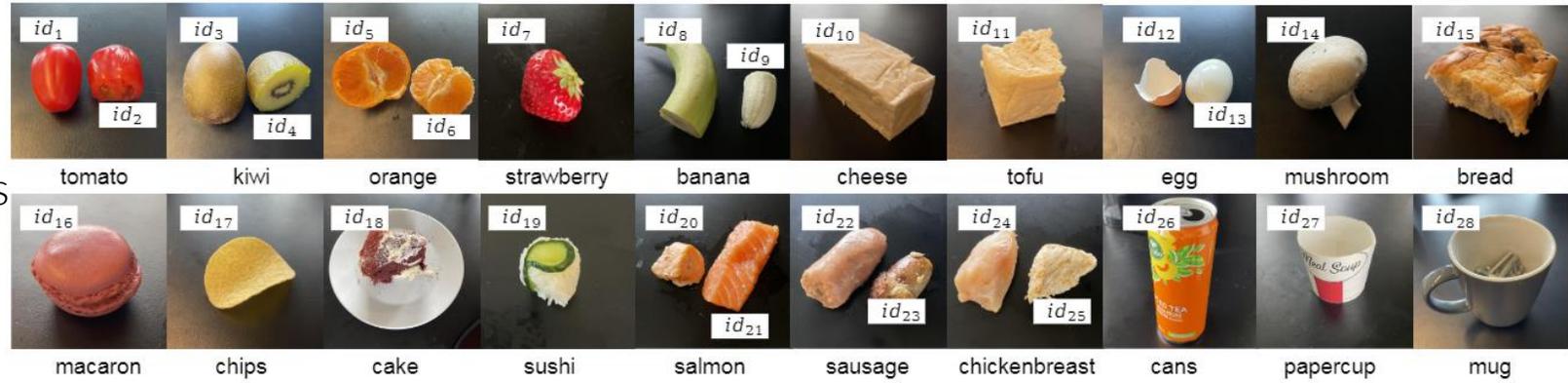
Step	Success rate
Edge tracing & unfolding (Figure 1.1–8)	23/60 (38%)
Edge tracing can start (Figure 1.3)	58/60 (97%)
Edge visible after tracing (Figure 1.4–5)	27/58 (47%)
Corner keypoints detected (Figure 1.5)	25/27 (93%)
Edge grasped for lift (Figure 1.6–8)	23/25 (92%)
Alignment (Figure 1.9–11)	18/23 (78%)
Folding (Figure 1.12–1.16)	17/18 (94%)
End-to-end	17/60 (28%)

# Tactile Sensing for Gentle Grasping



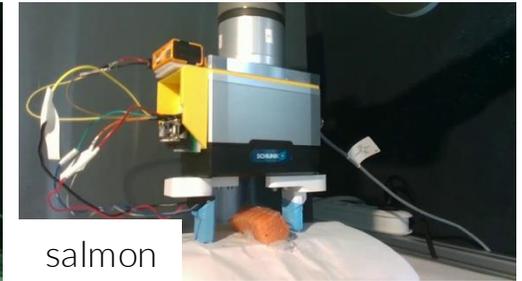
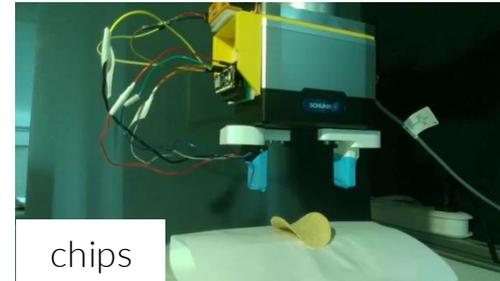
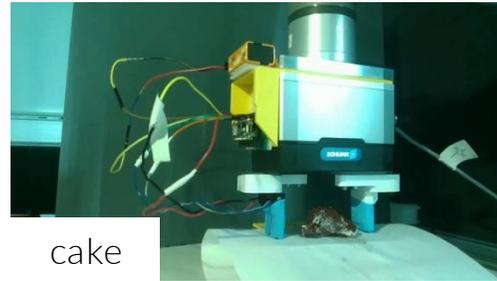
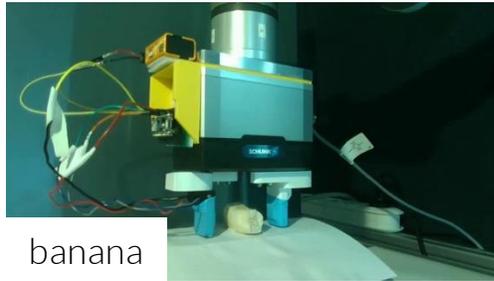
# Tactile Sensing for Gentle Grasping



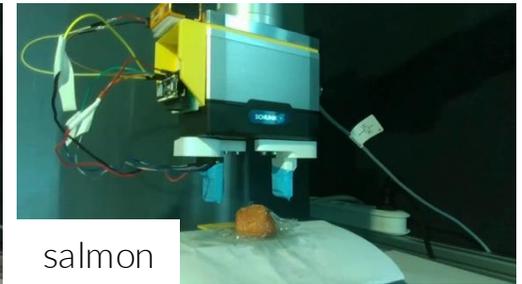
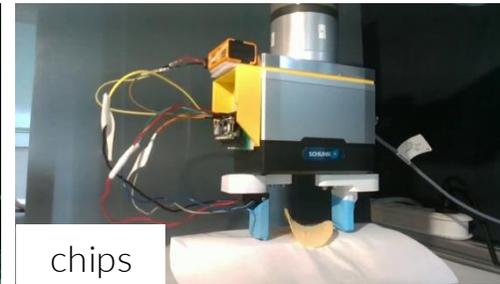
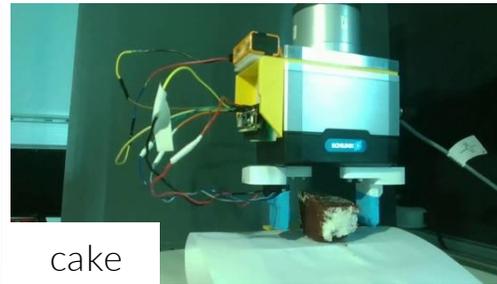
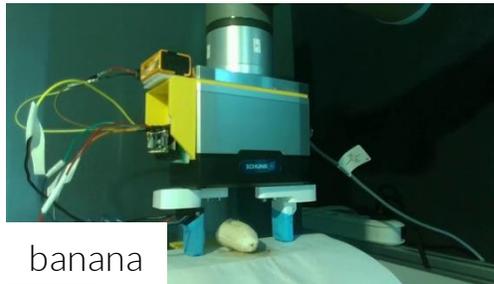


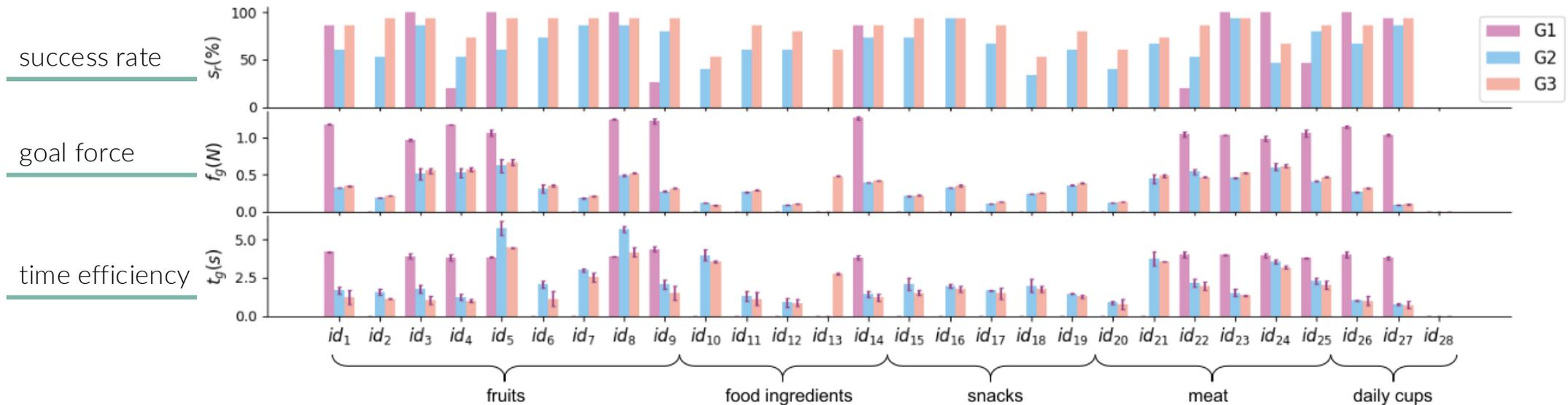
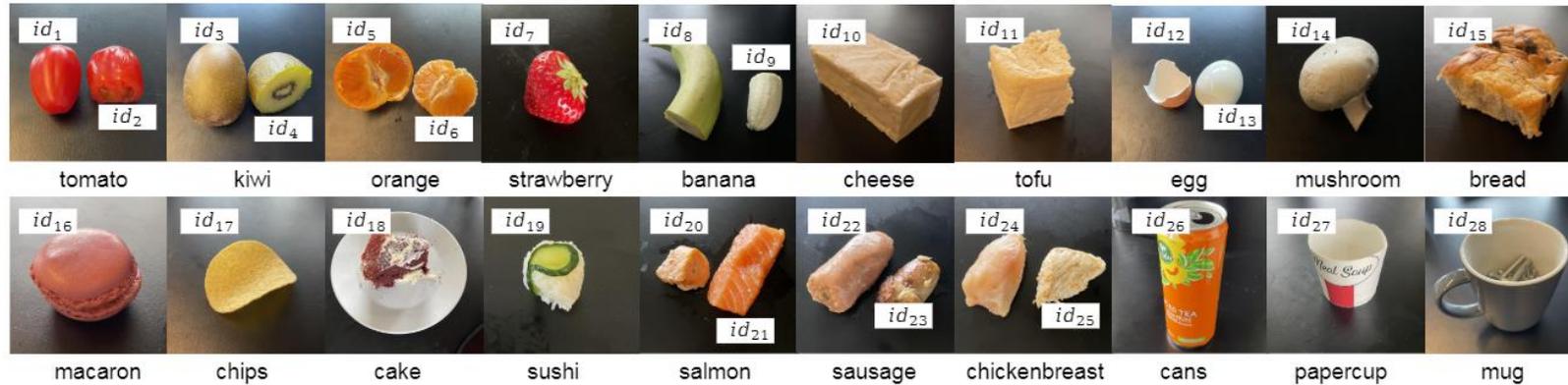
Tested daily objects

\*fixed initial force only



\*force approximation





\*G1: fixed force

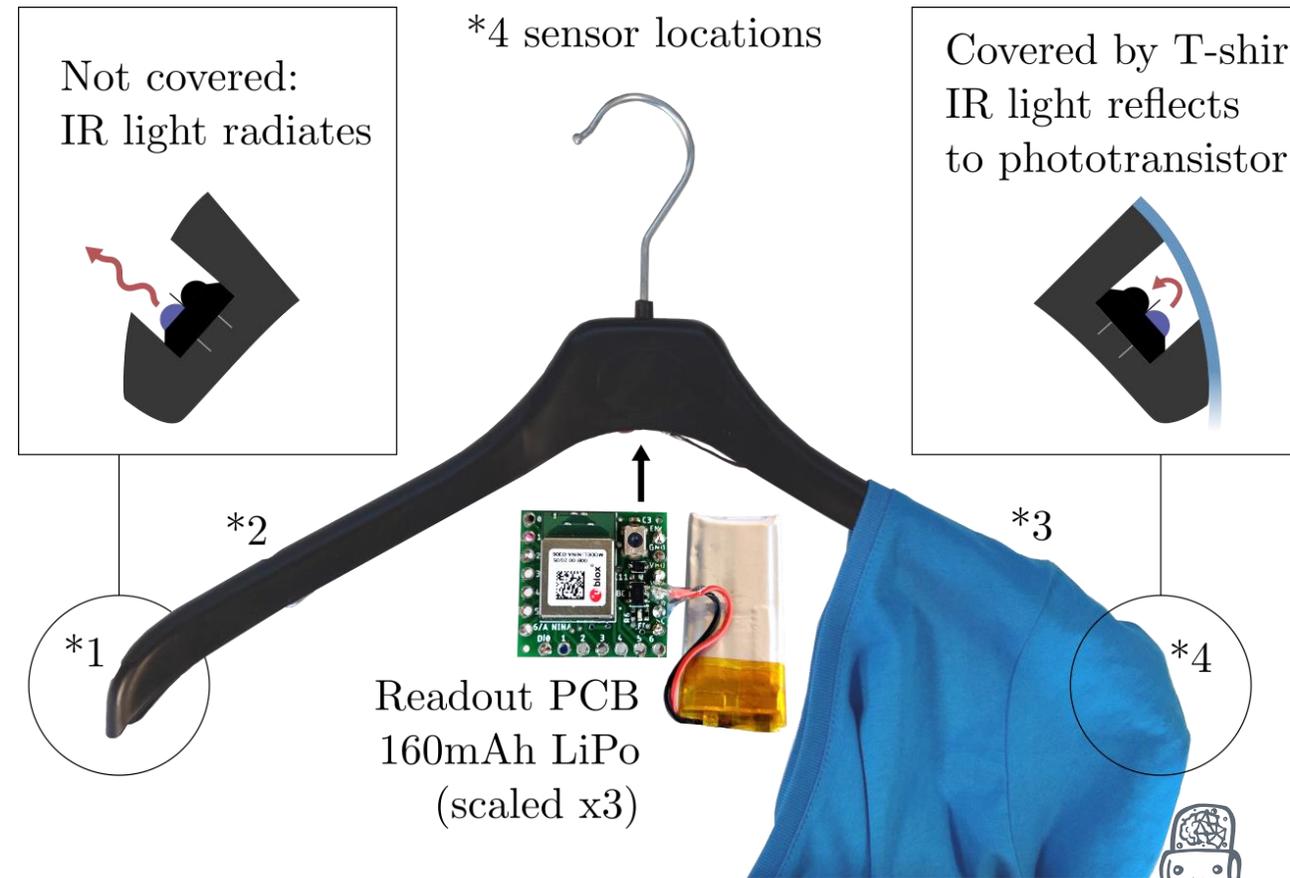
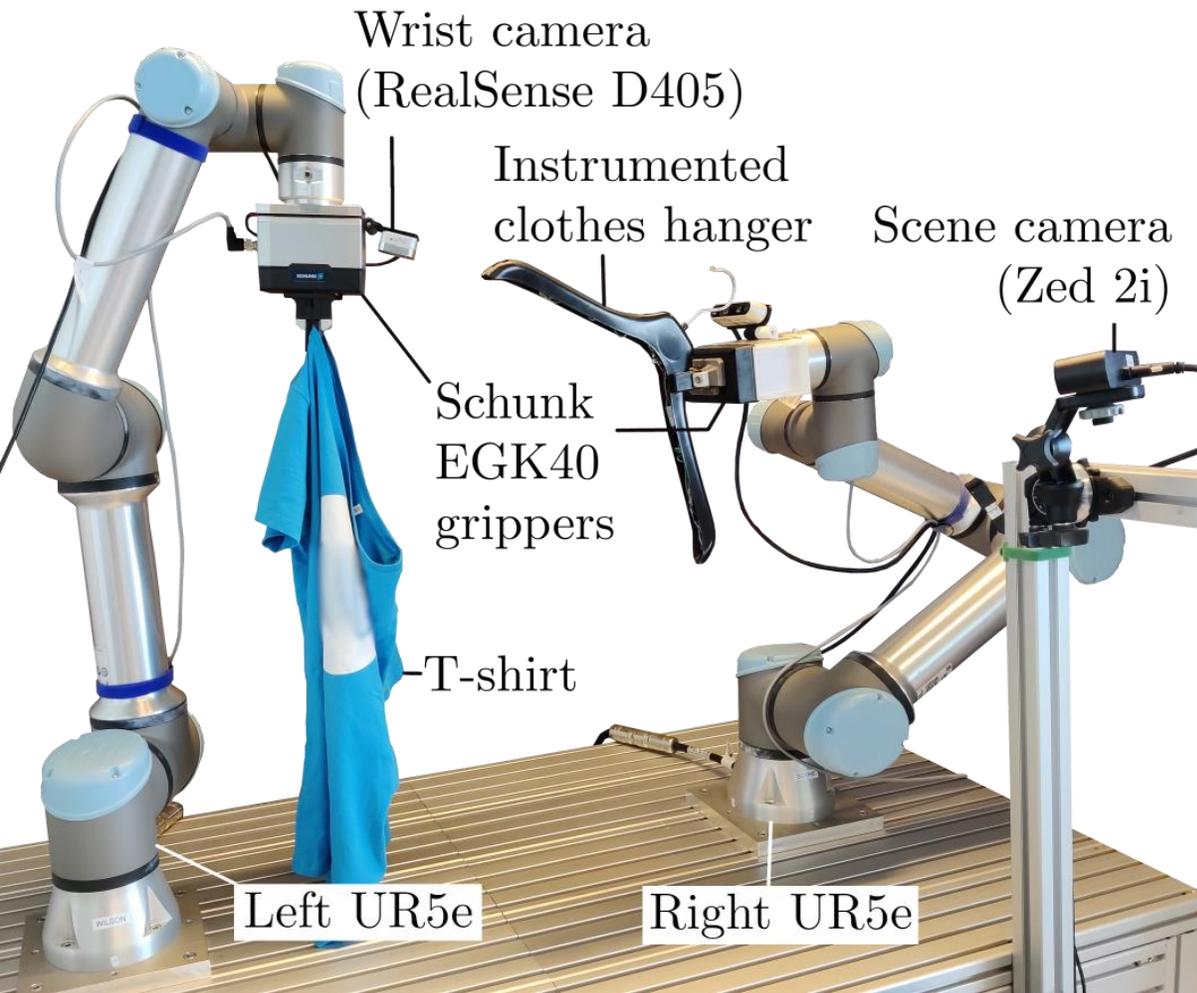
\*G2: fixed increment force

\*G3: adapted increment force

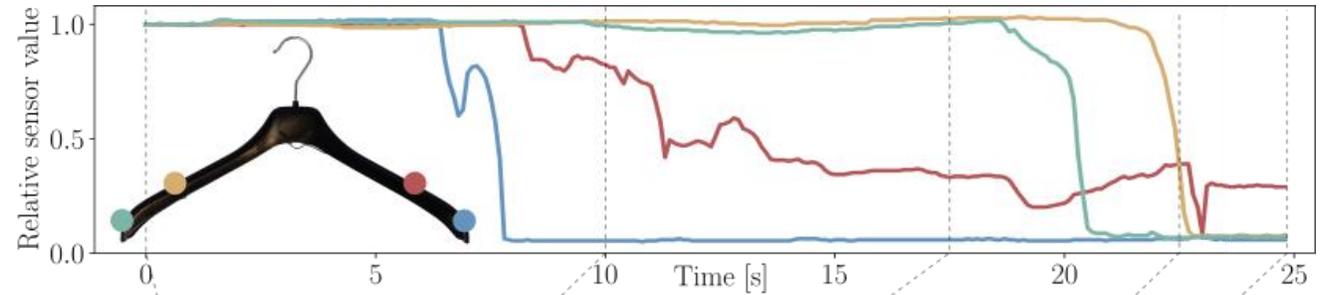


Beyond vision (bis):  
instrumentation of objects

# Instrumentation of objects to ease the learning process: cloth hanger case



# Instrumentation of objects to ease the learning process: cloth hanger case



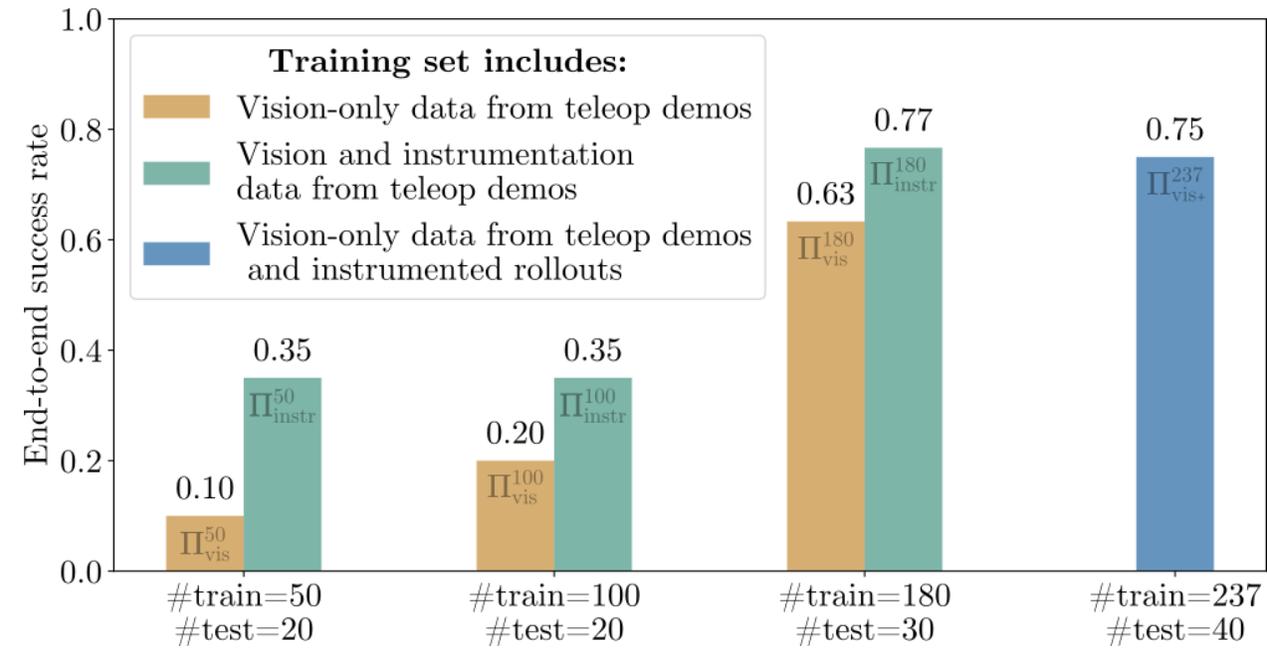
Initialisation      First insertion      Lift      Second insertion      Release & present



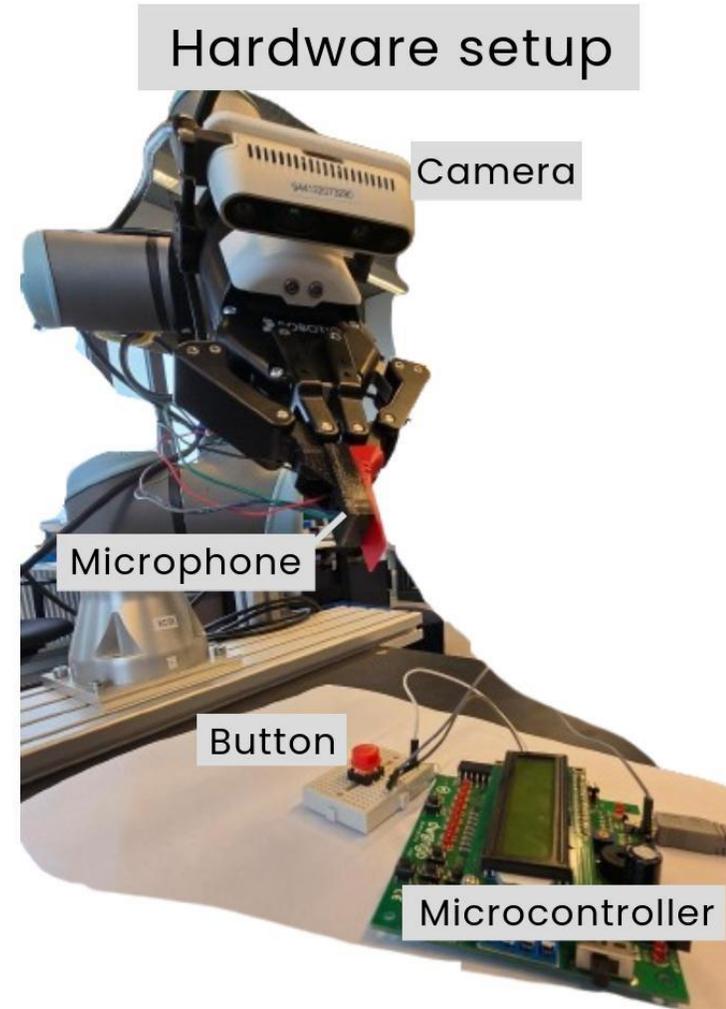
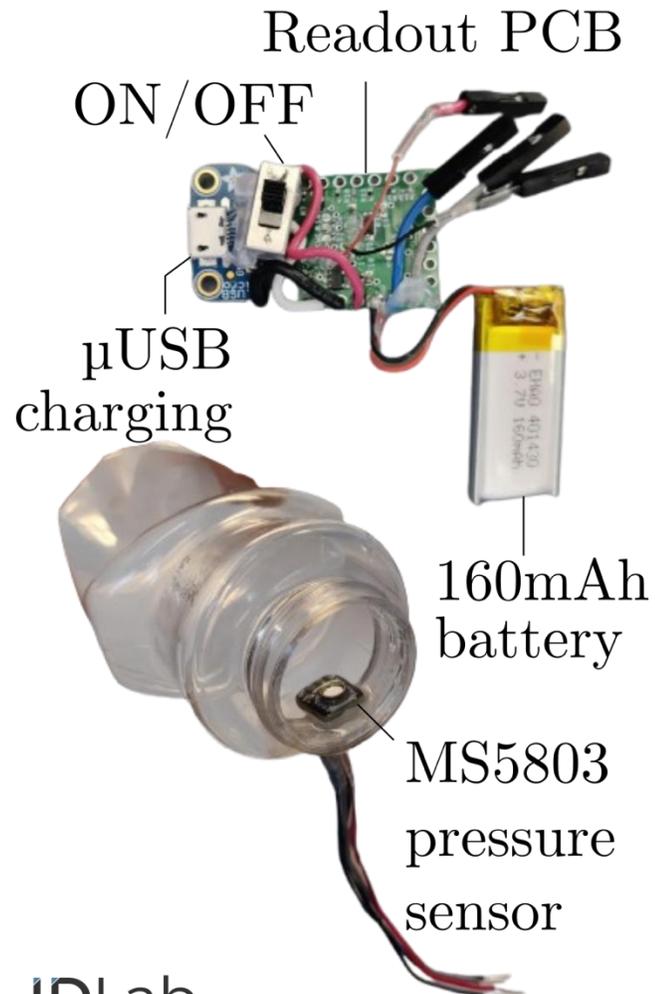
# Instrumentation of objects to ease the learning process: cloth hanger case

vision-only trained on a.o. instrumented rollouts

## Narrow collar opening 2

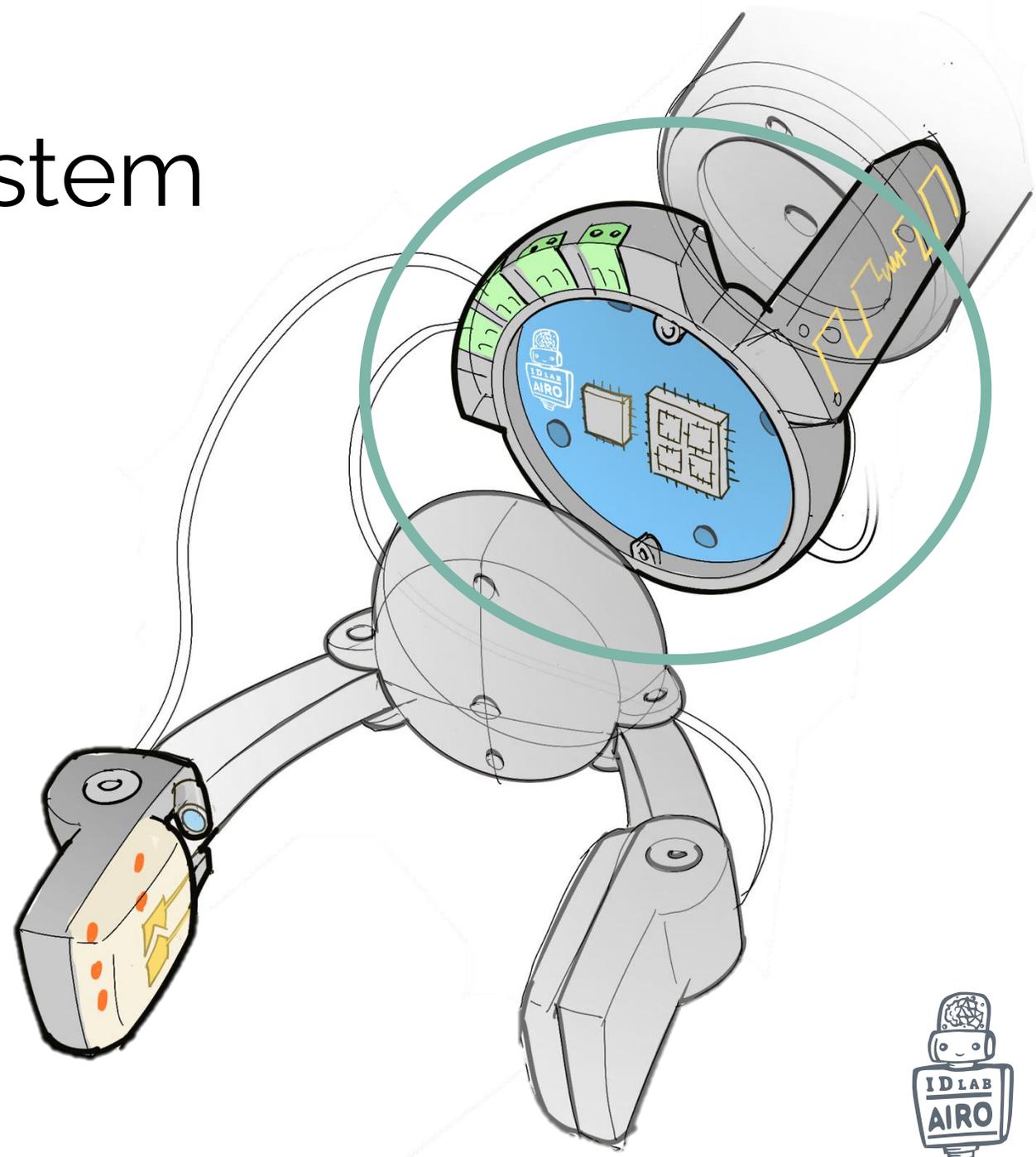
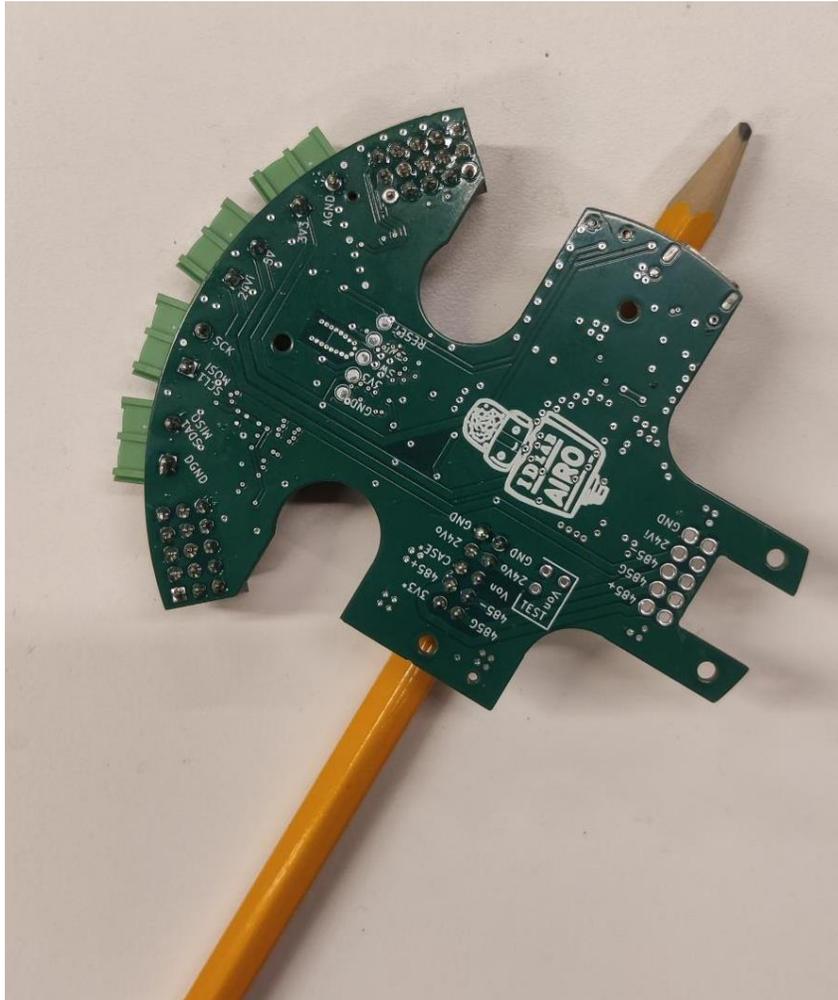


# Extending to other cases: bottles & buttons

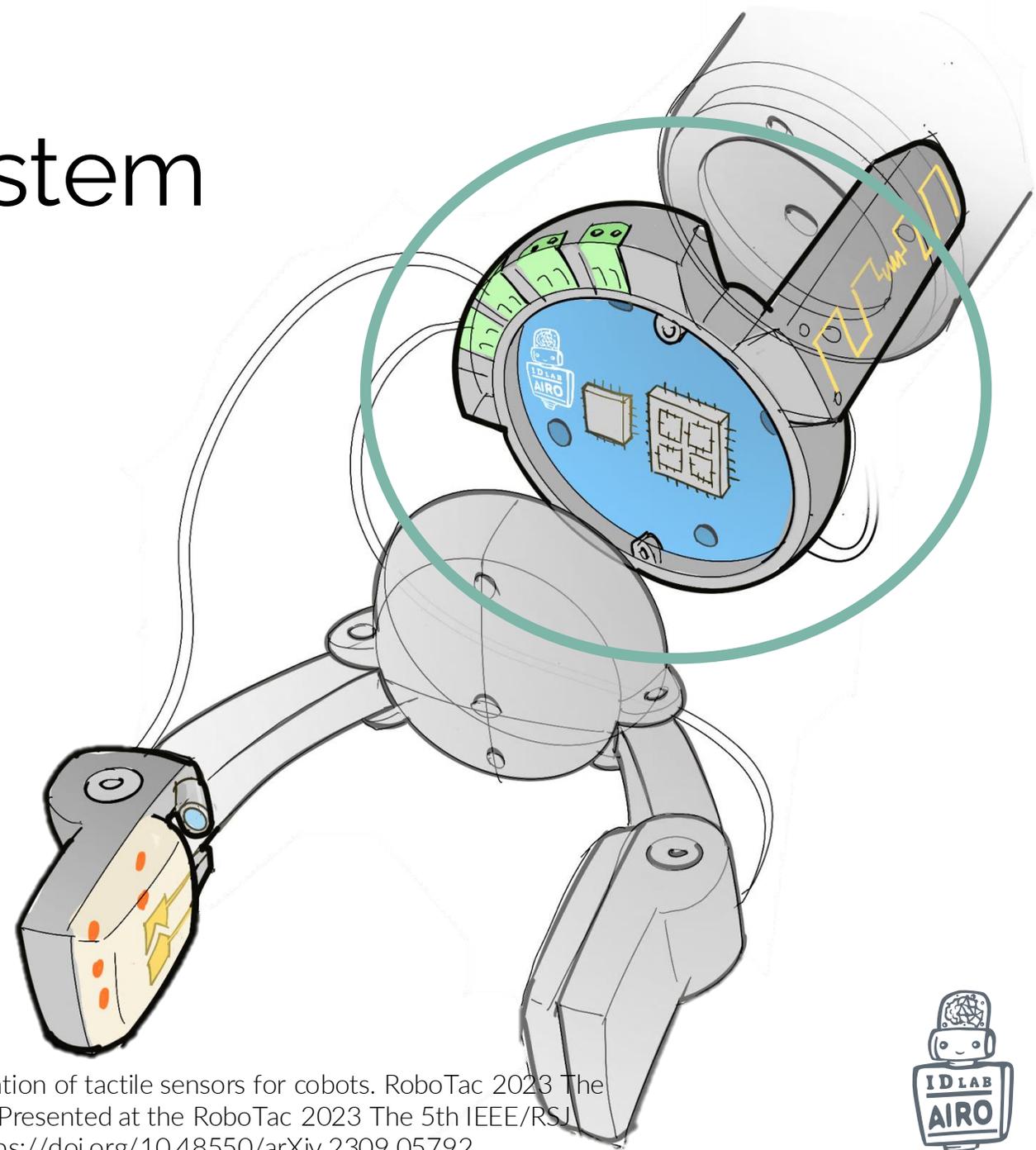
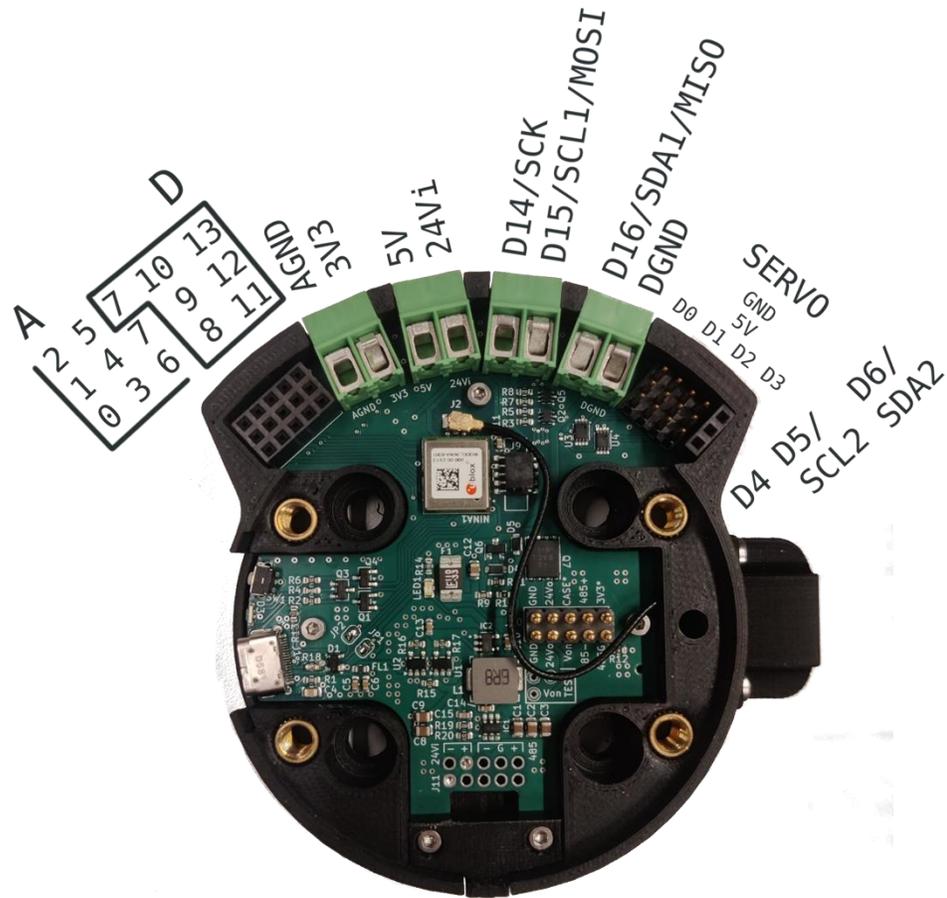


# The Halberd eco-system

# The Halberd Eco-system



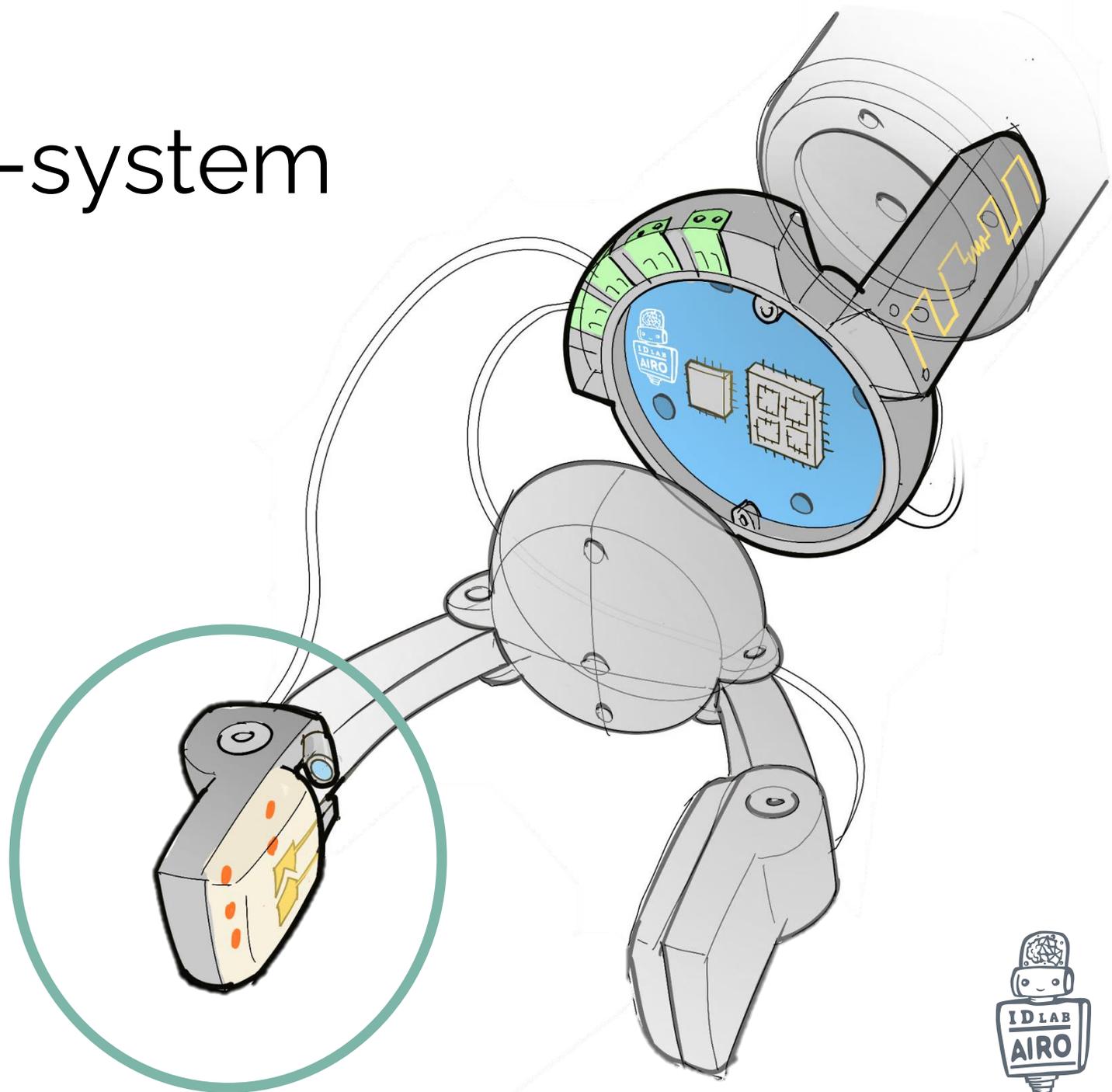
# The Halberd Eco-system



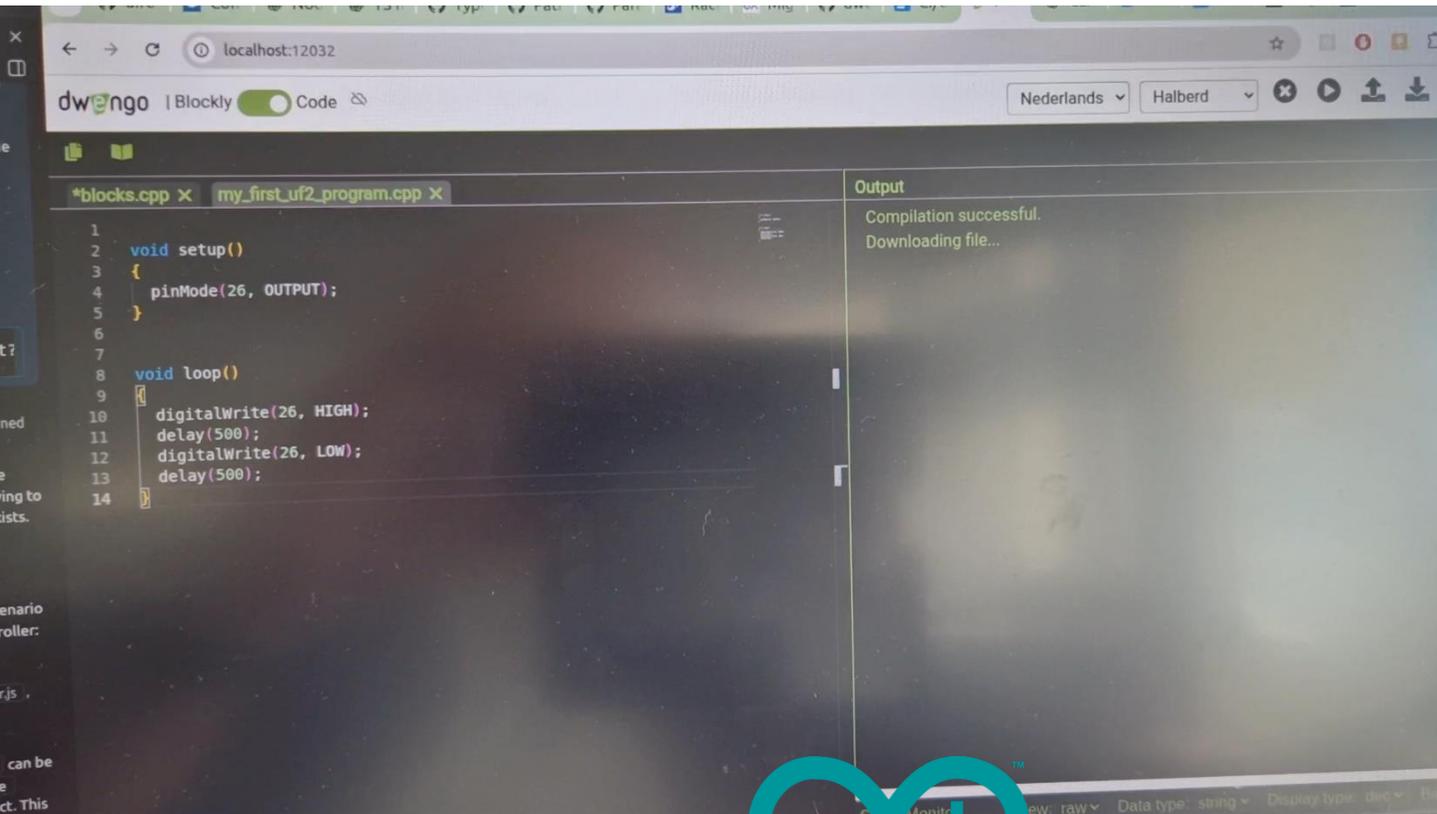
# The Halberd Eco-system

- Capacitive
- Piezoresistive
- Magnetic
- Laser interferometry
- Barometric
- Optical (IR)
- RGB camera
- Sound

<https://airo.ugent.be/open-source/>

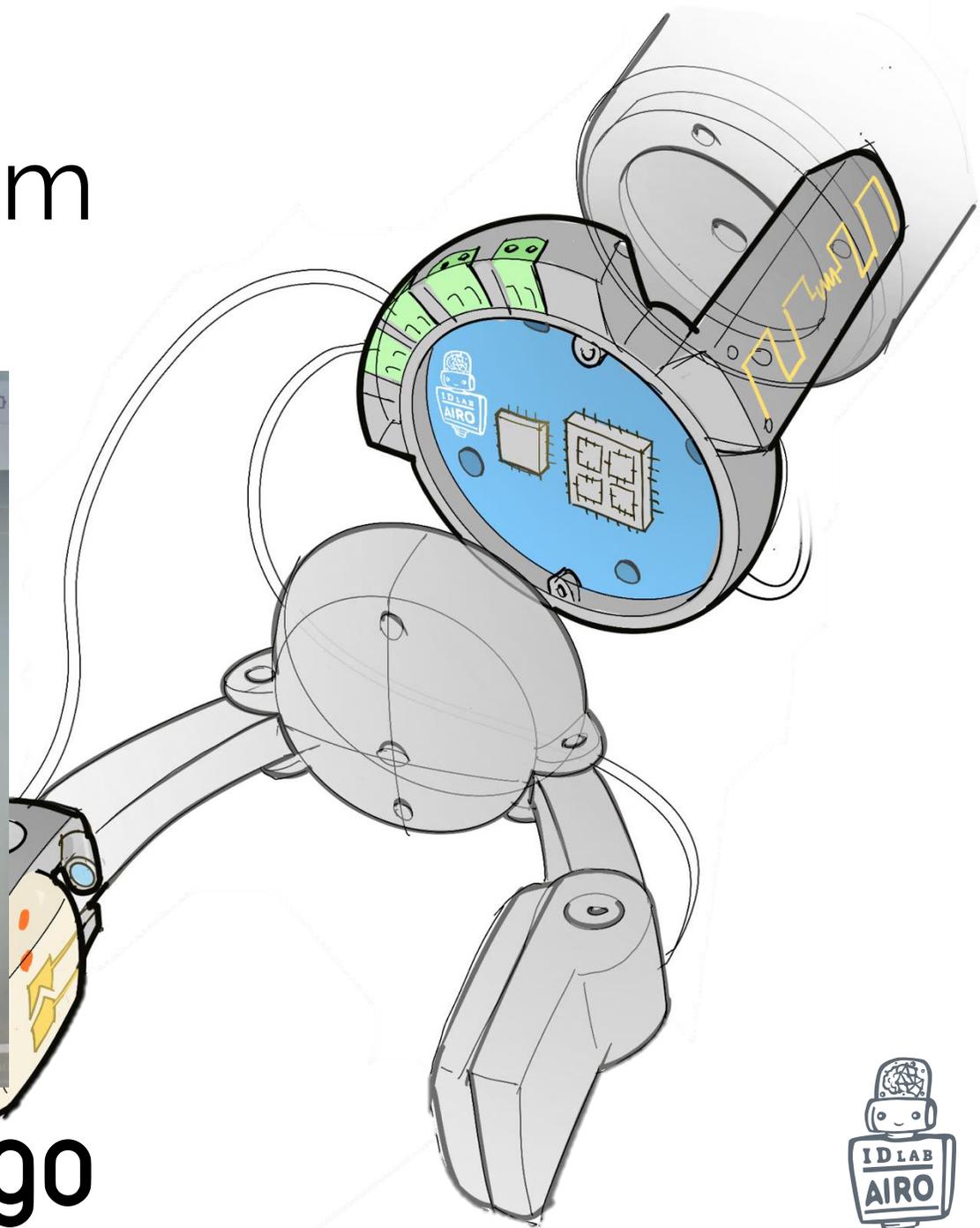


# The Halberd Eco-system



```
1 void setup()
2 {
3   pinMode(26, OUTPUT);
4 }
5
6
7
8 void loop()
9 {
10  digitalWrite(26, HIGH);
11  delay(500);
12  digitalWrite(26, LOW);
13  delay(500);
14 }
```

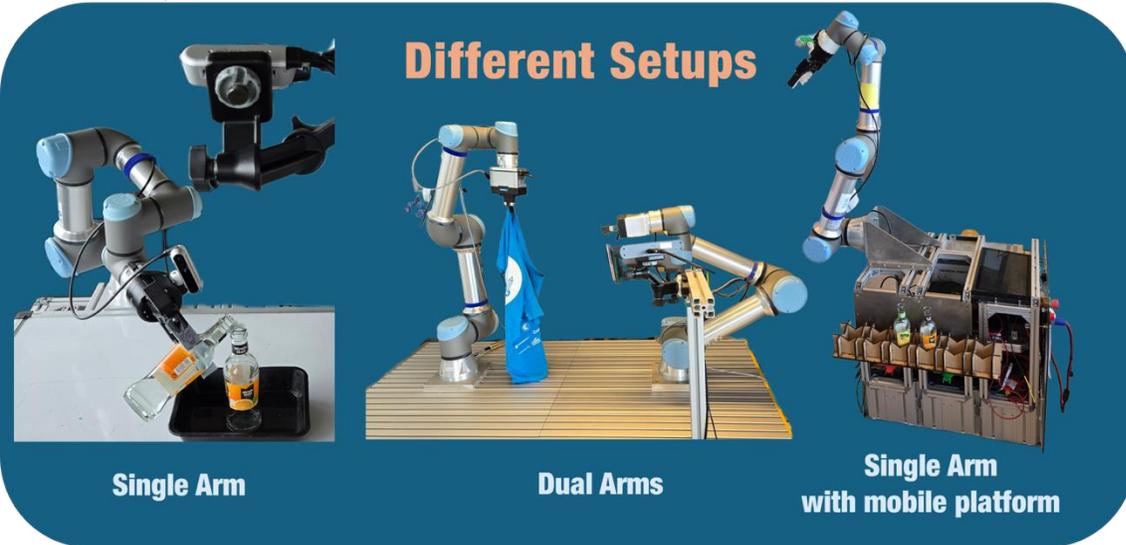
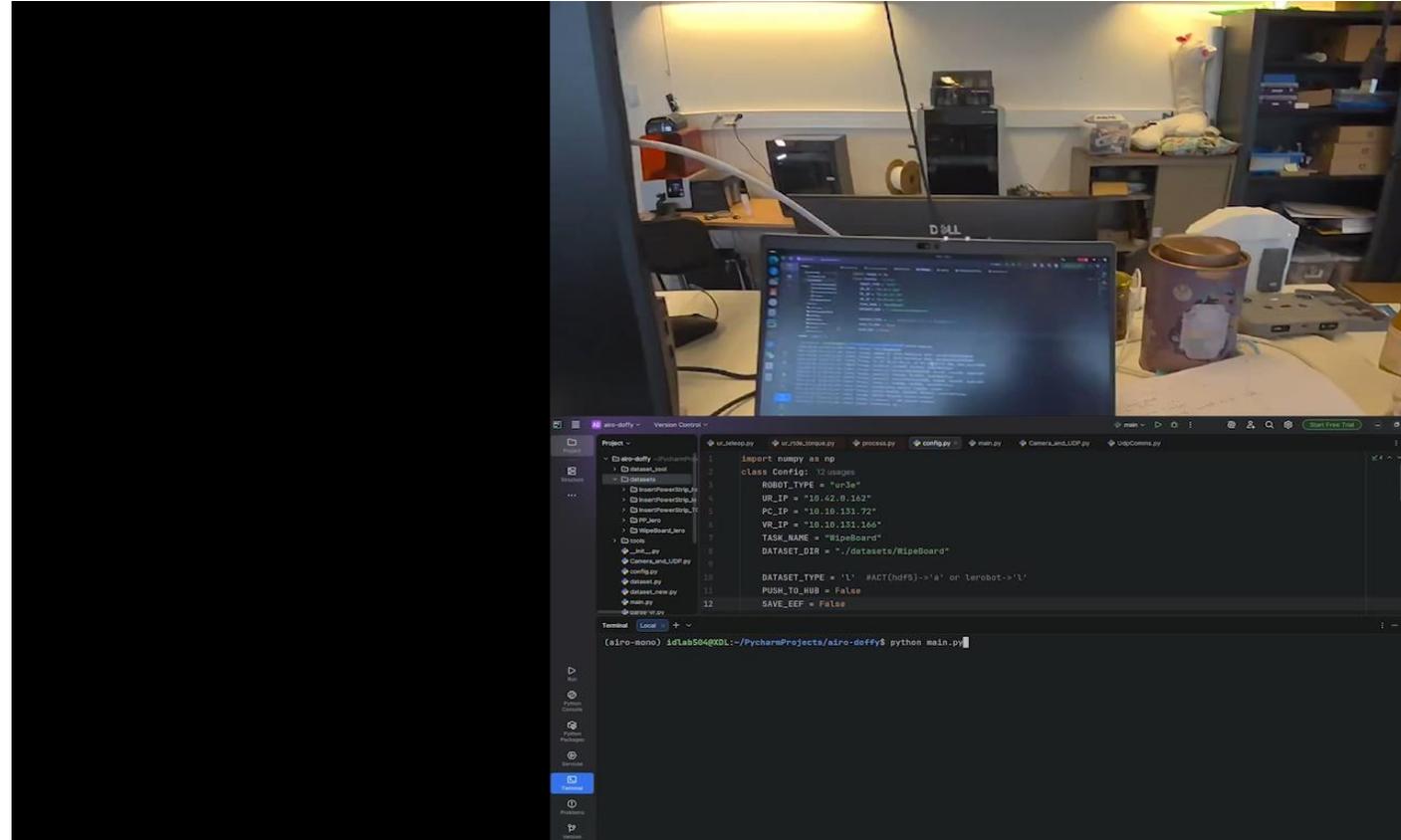
Output  
Compilation successful.  
Downloading file...



# The Halberd Eco-system



Immersive VR Interface



Demo

# We are always open to collaborations!

