Team NAIST-Panasonic

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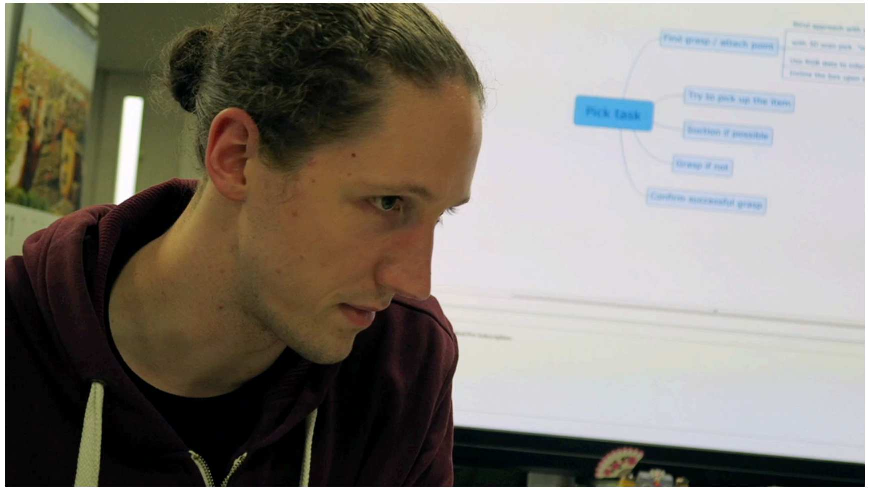


Team **NAIST-Panasonic** = 20 Members

Outline

- Lessons from the past
- New challenges
- Suction force analysis
- Storage system
- Conclusion

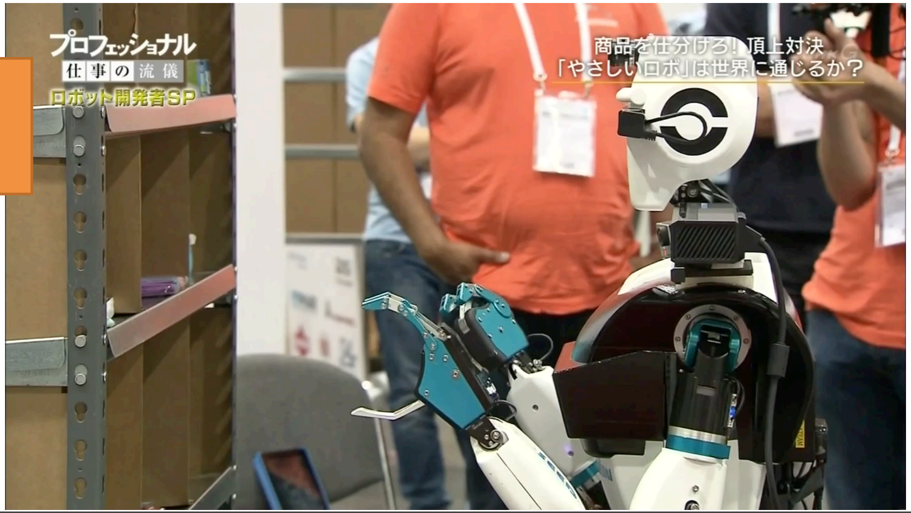
Lessons from the past

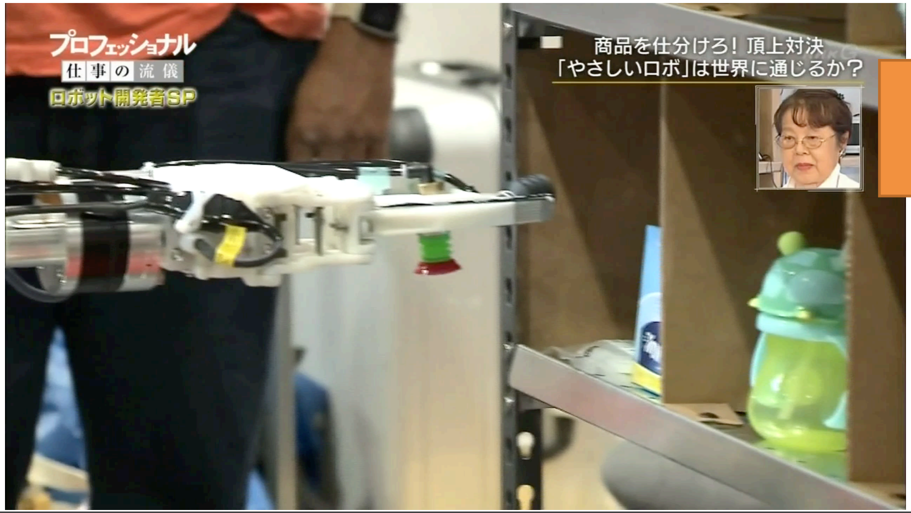
Failures examples

Recognition failure

Grasping approach

Unexpected collision





Item loss

Failures and potential impact

Failure	Potential impact
Collision with storage system	Round loss
Planning failure	Round loss
Items left on recognition space	Object recognition capability loss
Losing suction contact	Point loss due to dropped item
Two-item grasping	Point loss due to lost item
Object recognition errors	Point loss due to misplaced item
Grasping failures	Time loss
Slow path-planning	Time loss

Lessons from the past

Hardware

- One 7-DOF manipulator can suffice
- 7-DOF can be faster than 6-DOF manipulator (shorter joint space distance)
- Suction tool worked for 80% of the items
- Professional suction system needed for reliability
- Sensor stability issues possible

Software

- Learning-based object recognition has high success rate
- Depth information may not improve object recognition
- Illumination significantly affects object recognition (RSJ review)
- Datasets can be used (Team C^2M, Team R U Pracsys, Team MIT-Princeton)
- MoveIt planning speed can be prohibitive

Strategy & Workflow

- Failures are unavoidable
  → Error recovery is essential
- State machines effective for task planning (Team Delft)
- Do not modify the code in the last minute (!)

New challenges

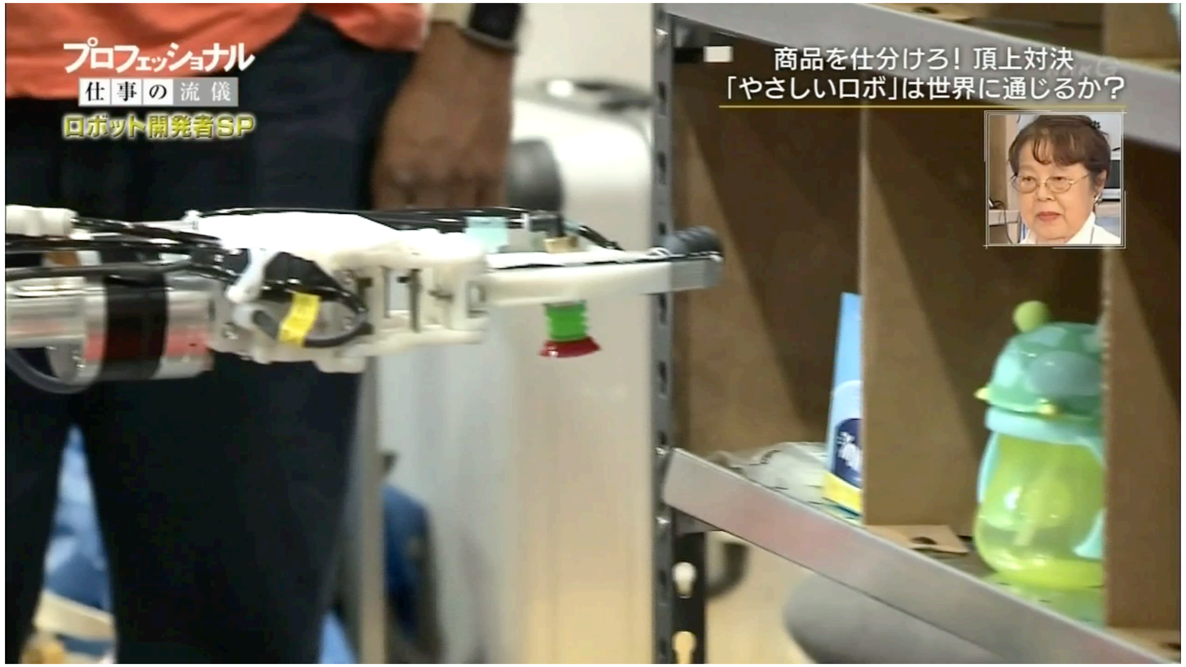
New Challenges in ARC 2017

- Half of items unknown until 30 min. before round
  - Too short to gather data and train
- New design dimension: Storage system
  - Storage system can be adapted to robot
- Storage system volume significantly reduced
  - 30% (!) of previous years'
  - Increased occlusions and stacked items

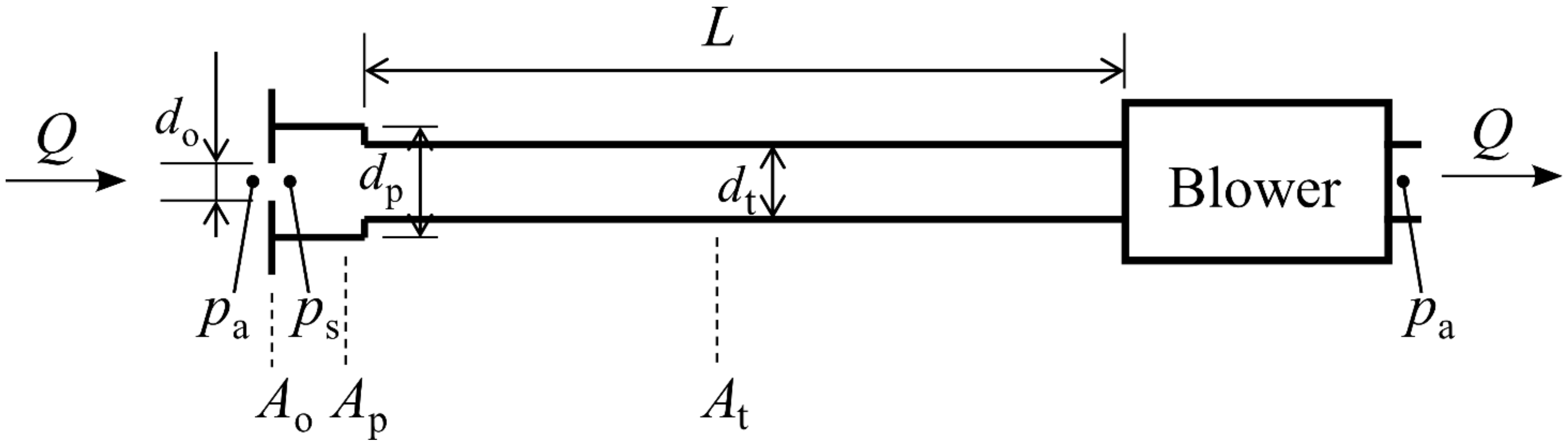
Our requirements:

- Object recognition using pictures and models supplied by Amazon (not only learning-based methods)
- Maximize surface of storage system to minimize clutter
- Catch and fix errors during the round to compensate for uncertainty

Suction force analysis



Suction tool model

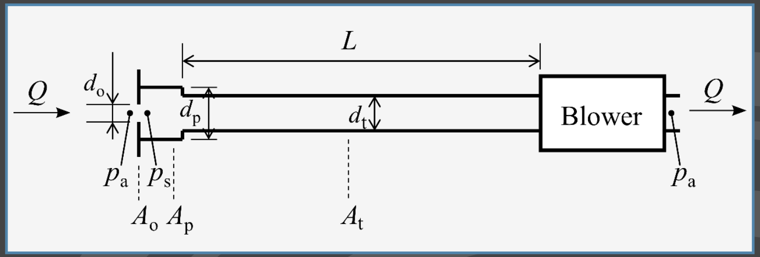


$F = \Delta p^*(A_p\text{-}A_o)$

Perfect contact: $A_o = 0$
No contact: $A_o = A_p$

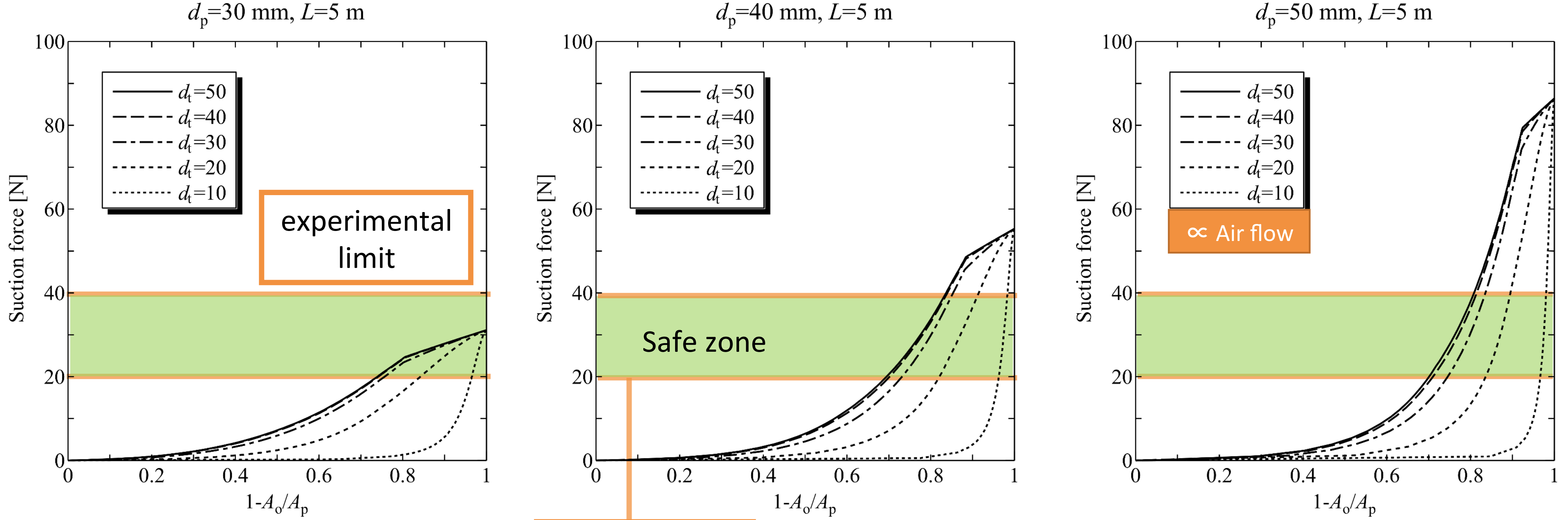
Q: flow rate
p_a: atmospheric pressure
p_s: internal static pressure
L: tube length

A_t, d_t: tube cross section area / diameter
A_p, d_p : suction cup cross section area / diameter
A_o, d_o : opening cross section area / diameter



Suction force

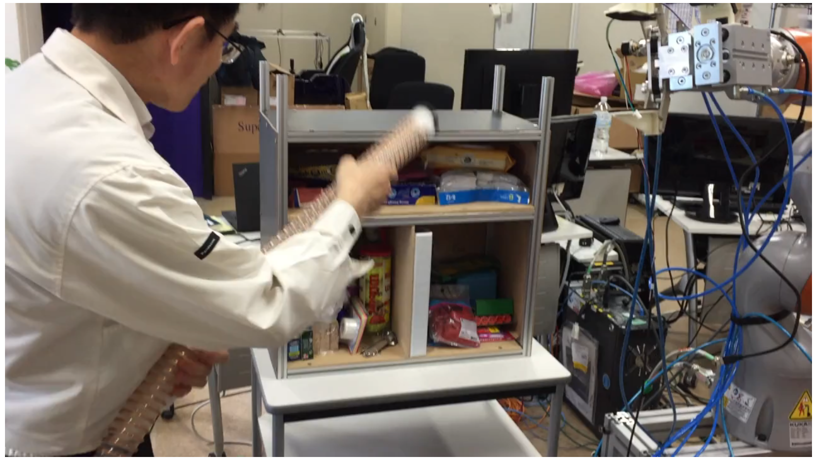
∝ Max force



20 N ≈ 2 kg static weight

∝ Contact

Suction tests



With d_p = 40 mm and d_t = 30 mm:

- 36 items can be suctioned (90%)
- 9 items can be potentially damaged (22.5%)

Successfully suctionable items include:

- Marbles
- Measuring spoons
- Bath sponge
- Dumbbell (with a lot of luck)

Unsuccessful:

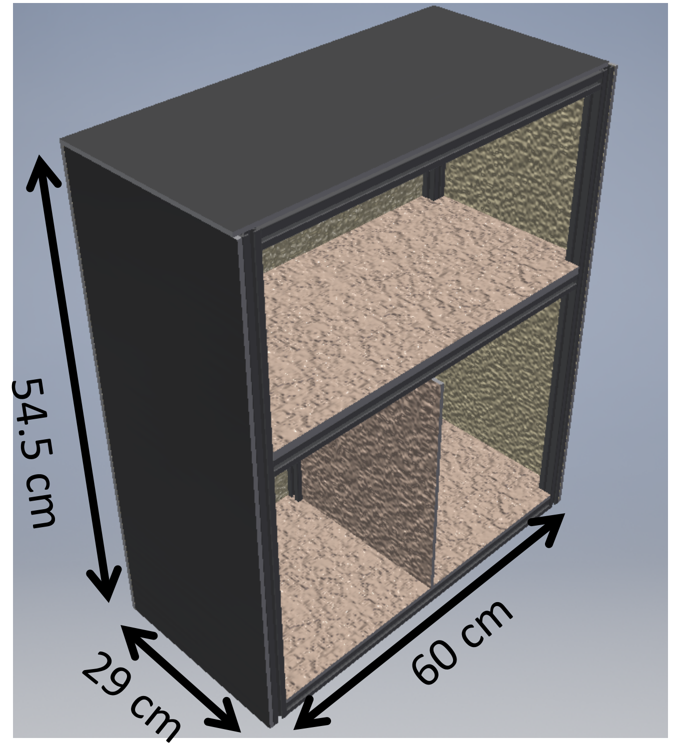
- Mesh cup
- Brush
- Scissors

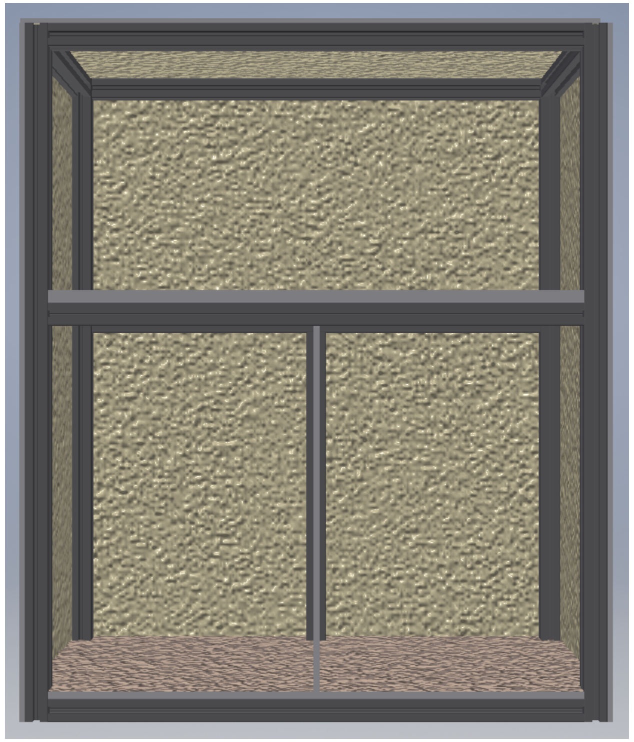
Storage system

Storage System

Rules:

- 2-10 bins
- 95,000 cm^3 bounding box
- Up to 32 items
- Max: 42 x 27 x 14 cm
- No actuators
- Sensors < 50 USD





Volume is 30% of previous years!

Storage System Design

Original design:

- As shallow as possible
- Easy to change bin sizes
- Many partitions to increase available surface

→Maximize used volume, minimize clutter

v1

v2
(after item size increase)

Storage System
Loading test

Empty

Filled

Still too cluttered!

Conclusion

Conclusion

- Systematic listing of potential failures and their impact
- Summarized good practices, heuristics and data from the past
- Showed the importance of storage density
- Suction force analysis and tests

  → Larger hose diameters and flow stabilize suction contact

Thank you for your attention

See you in Nagoya!