Human-Robot Interaction

from 2D desktop back to 3D space

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ROBOFIT

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Robo@FIT – Human-Robot Interaction team

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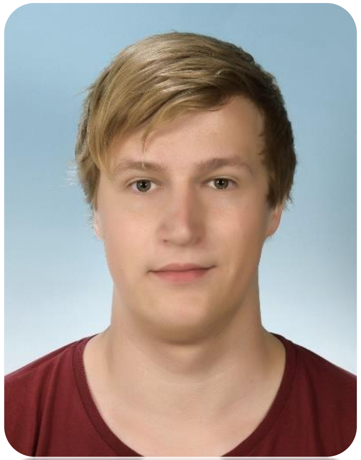
- Ing. Daniel Bambušek



Outline

- Motivation and Use-case
- Usability of modalities
- From desktop to workspace (in 2D)
- From 2D to 3D
- Next steps
- Augmented Virtuality in Drone control

Intro

Motivation, UX Protocols , Use-case + Persona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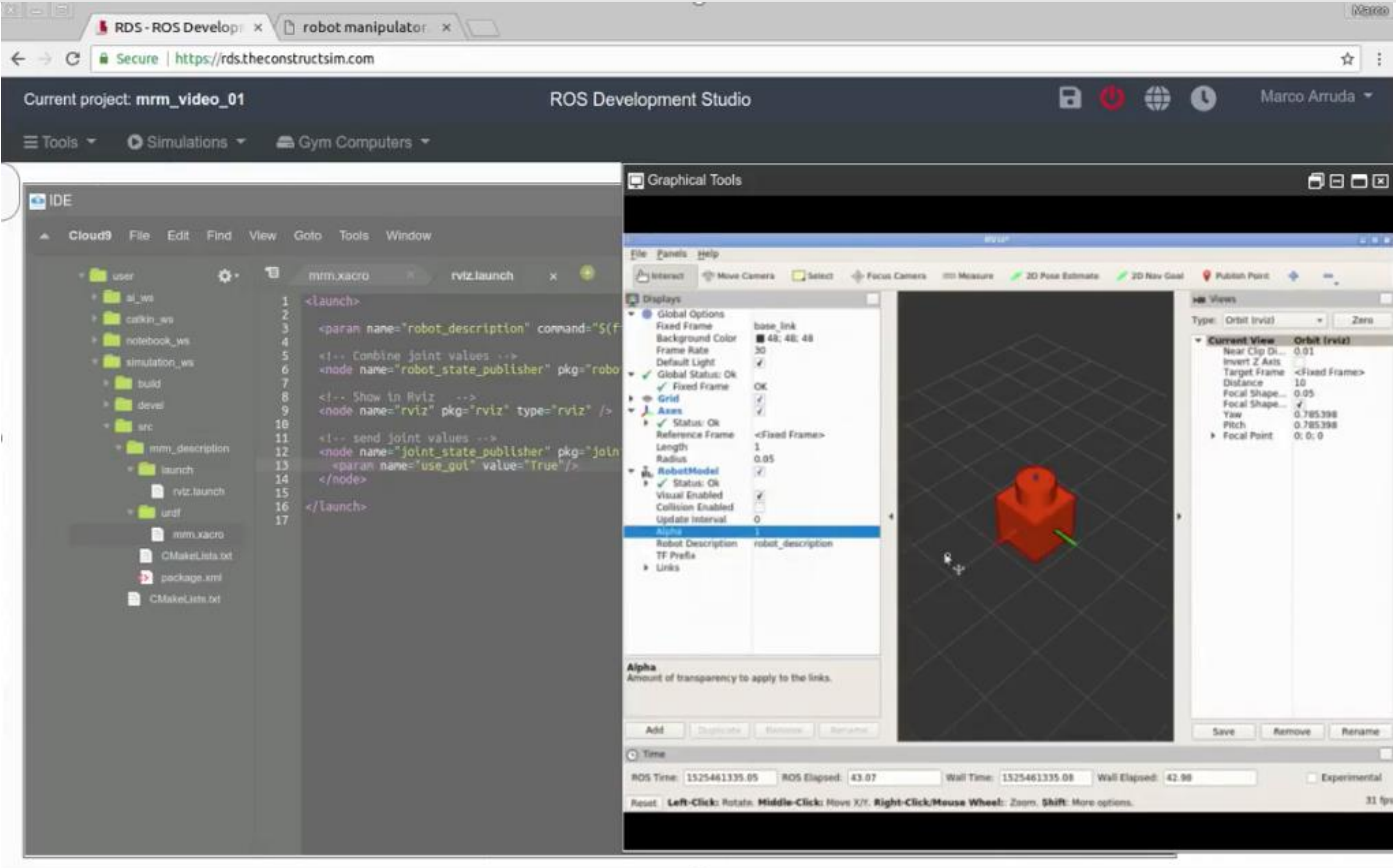
Motivation

Motivation

Programming

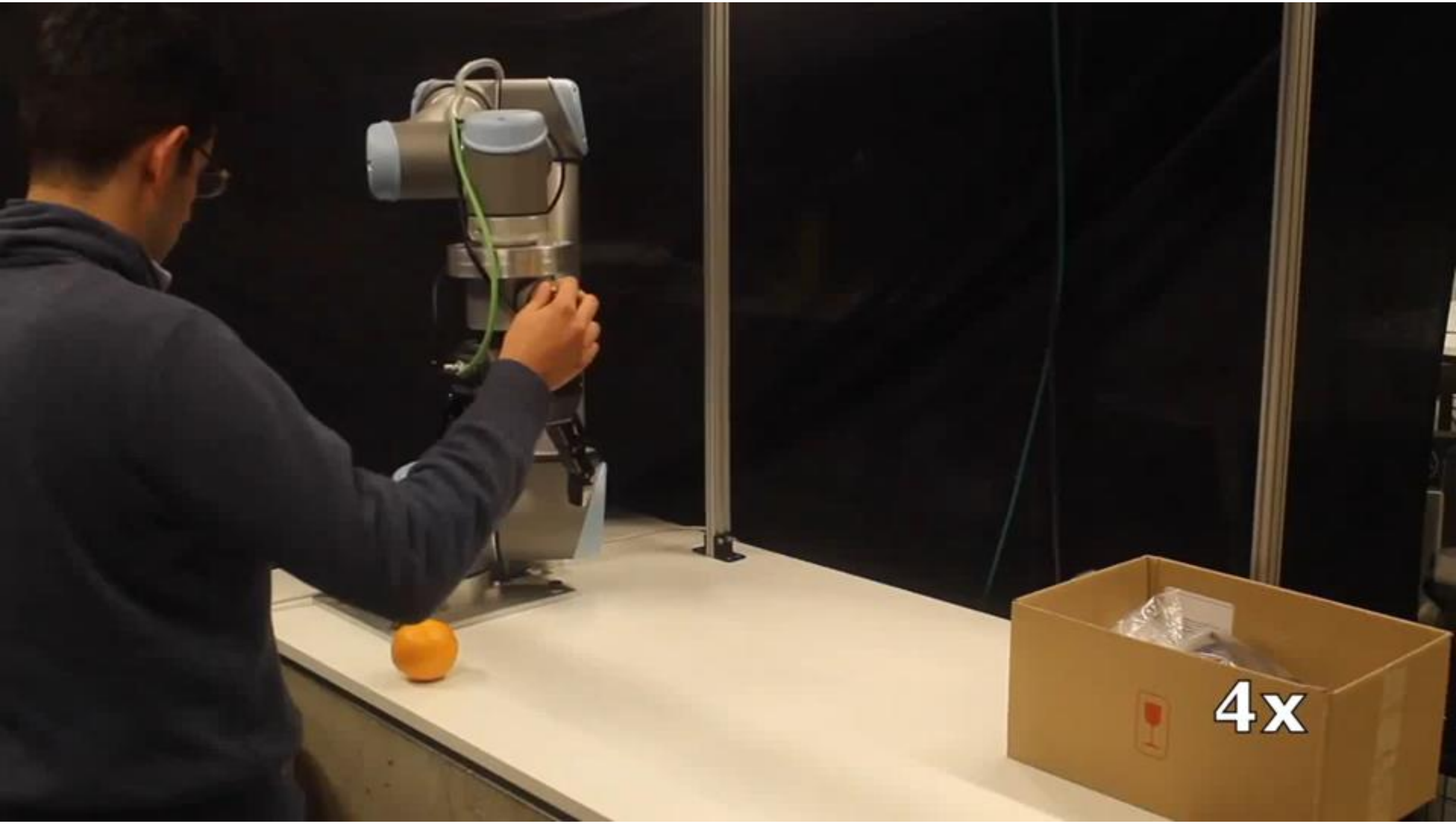
Related work, background

Programming by coding

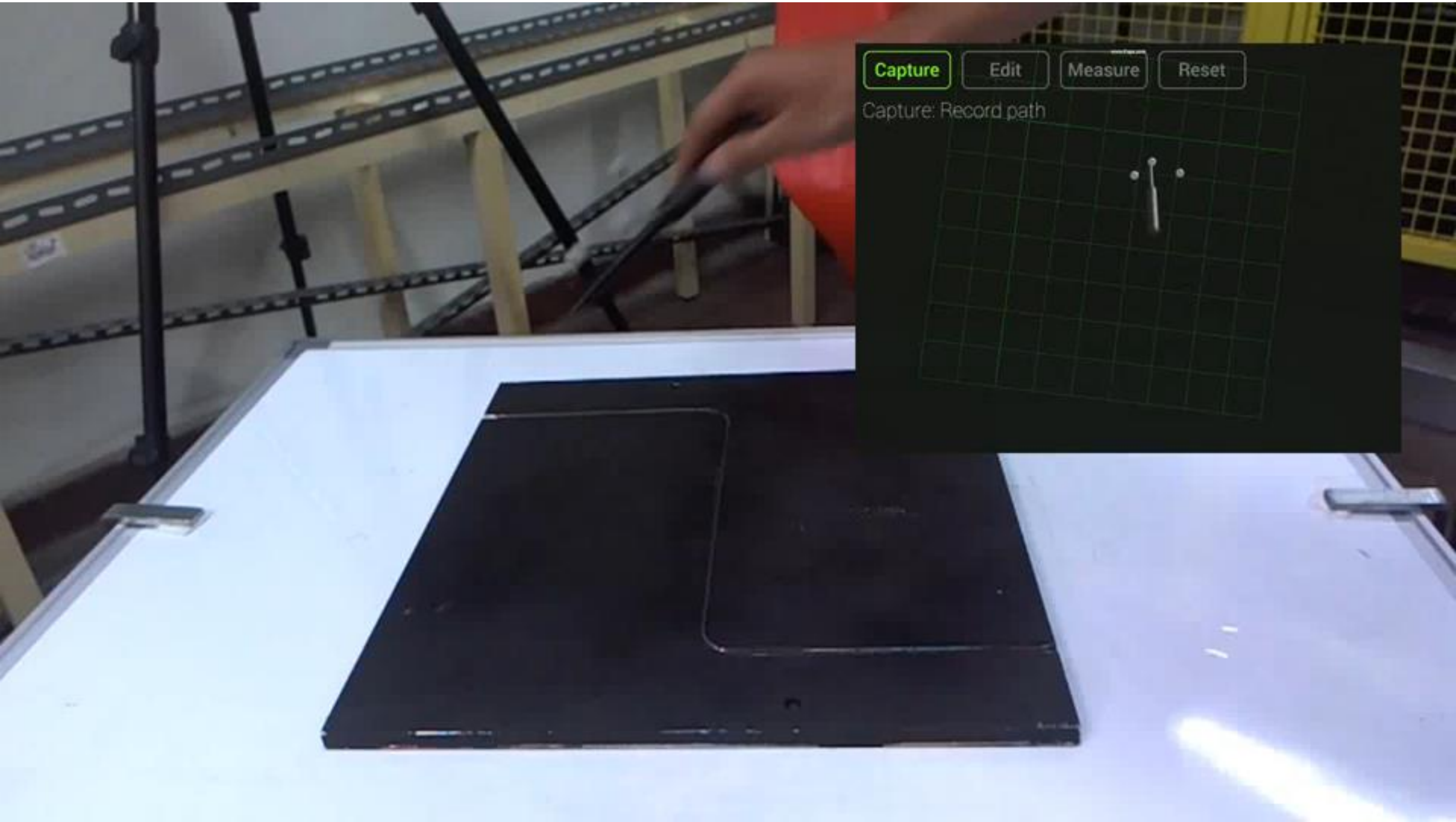


Programming by coding

Programming by demonstration

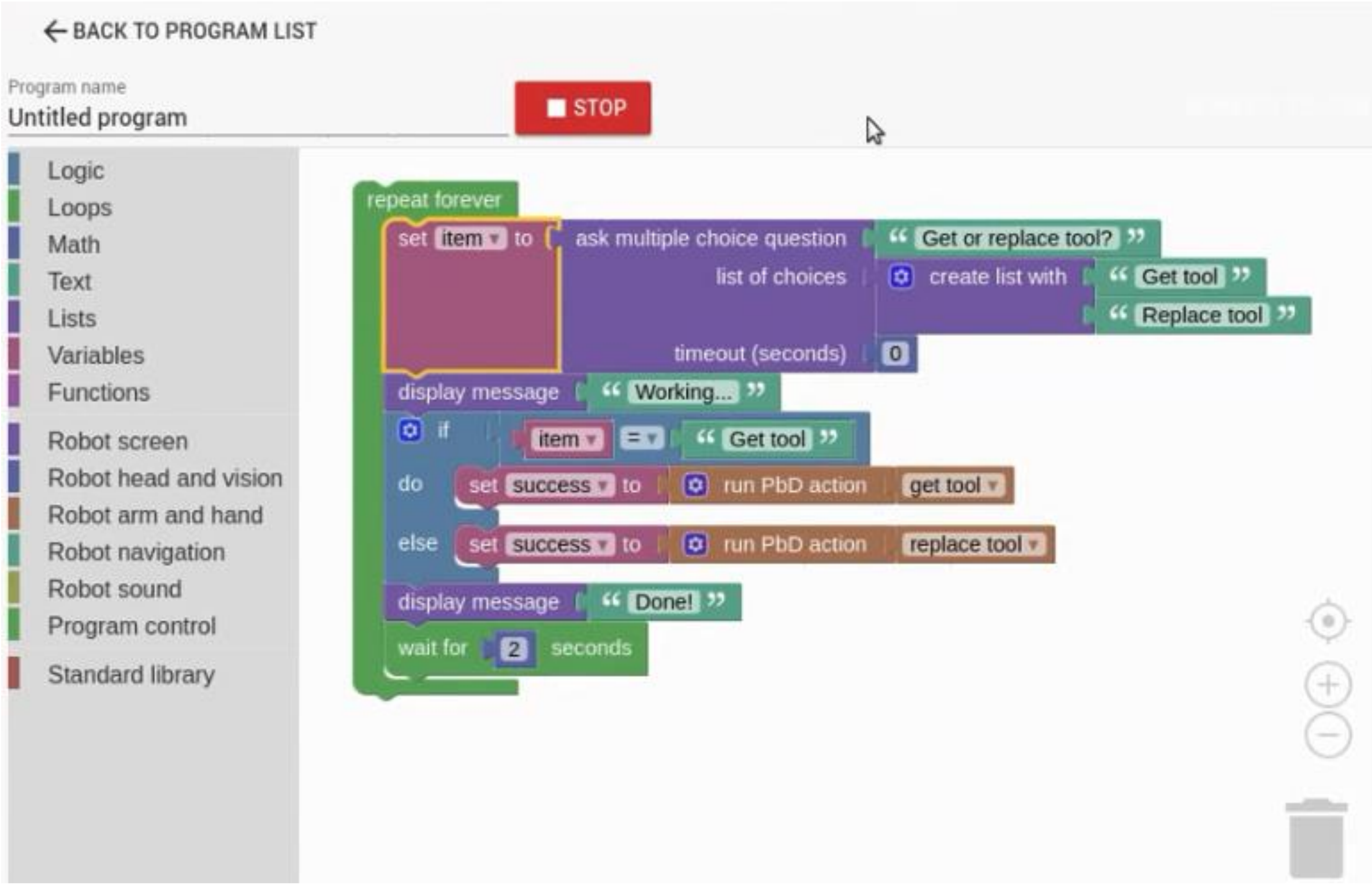


Programming by demonstration

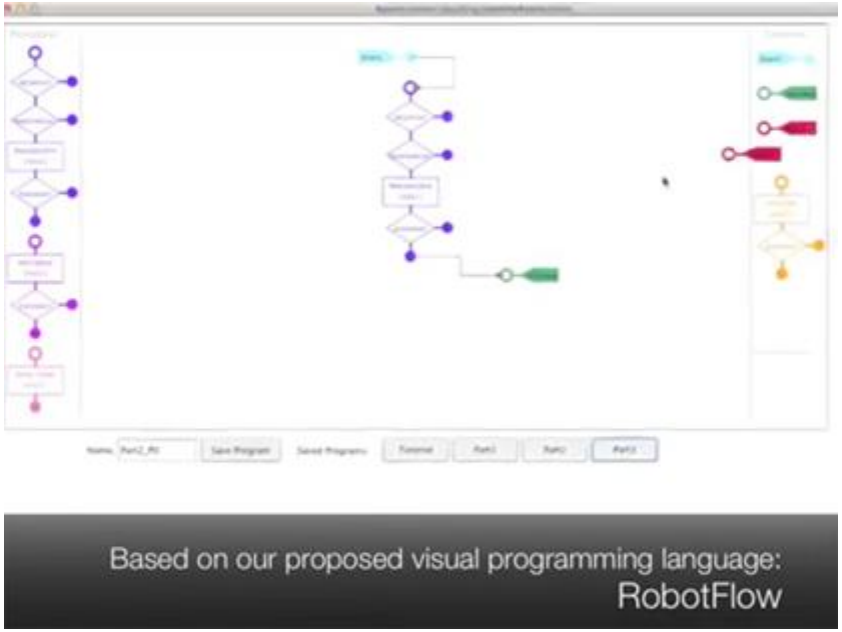


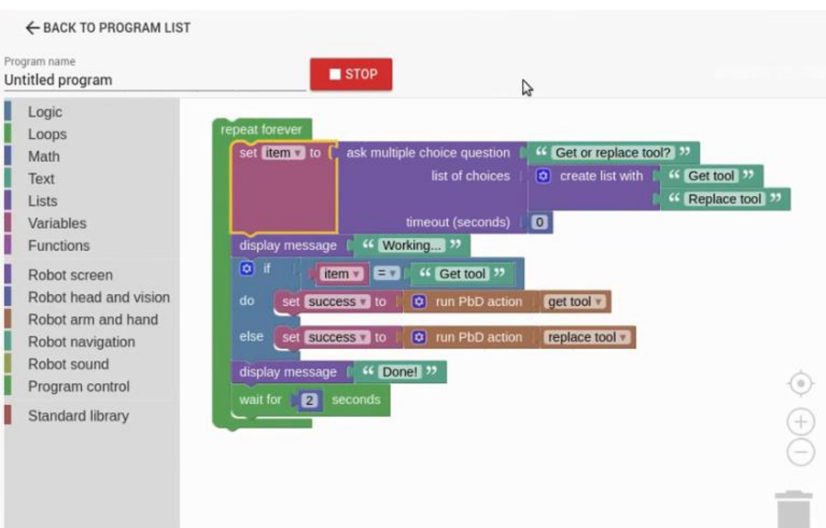
Programming by demonstration

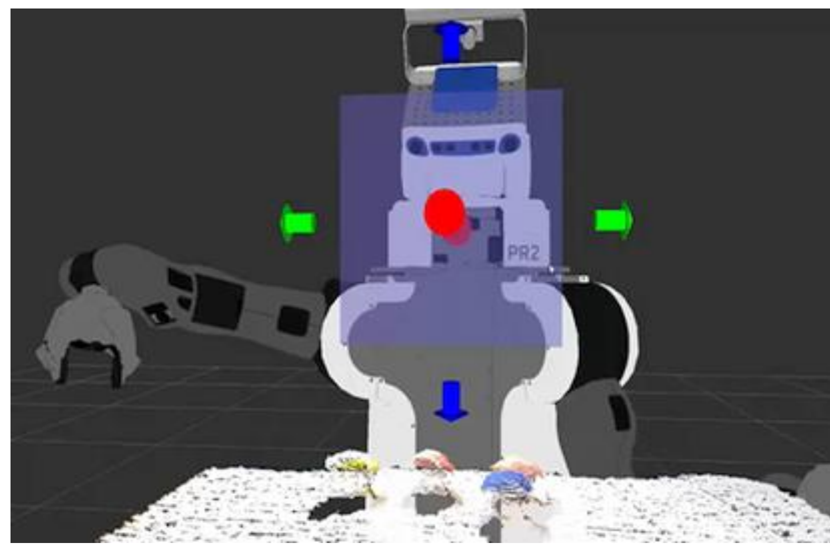
Visual programming



Visual programming



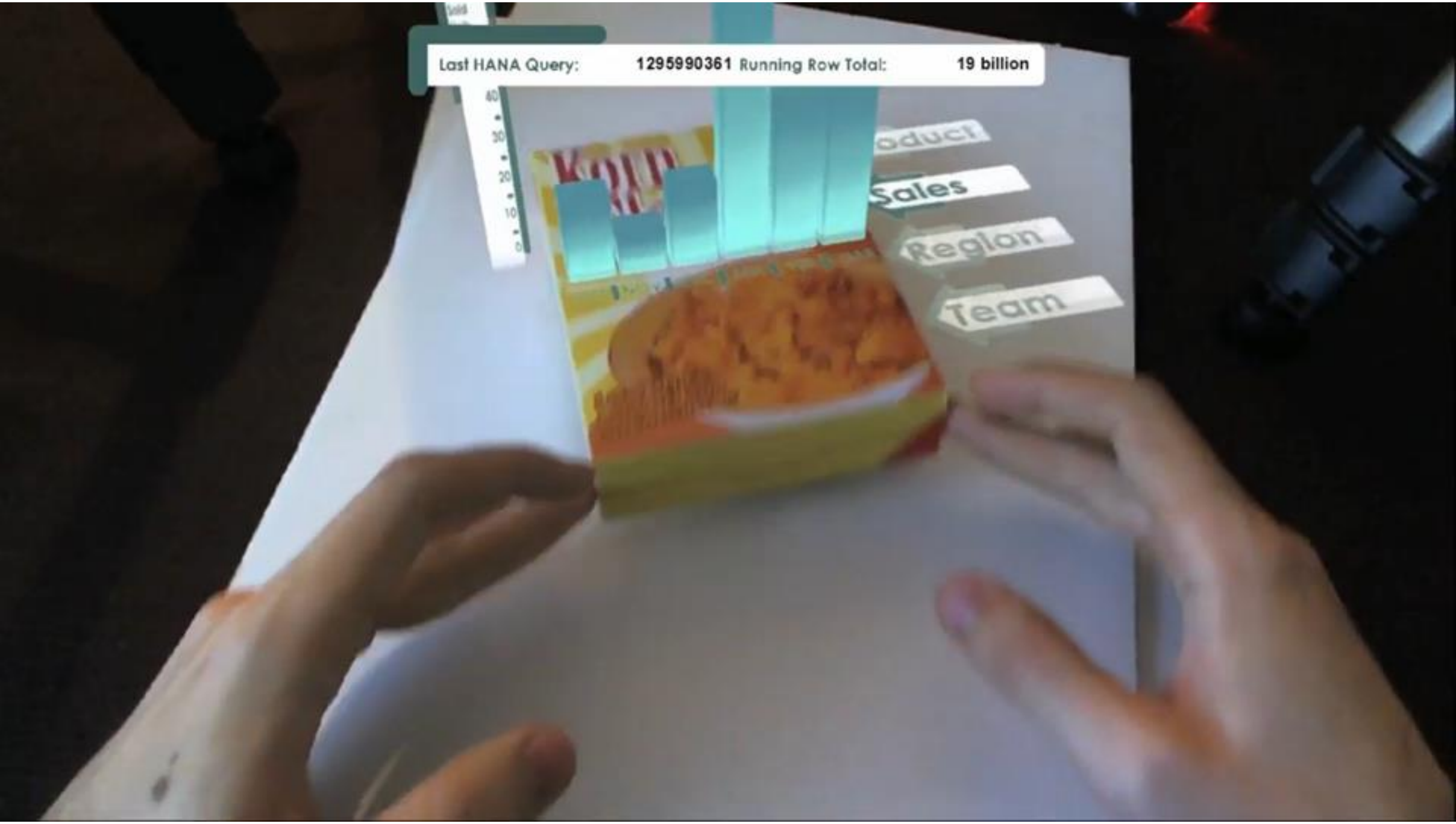




Augmented Reality

Devices, technologies


Drink&Food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Video: Hasso-Plattner Institute

Use-case

Methodology, persona

- The user will teach the collaborative robot to
- assist him in the task of **assembling** aircraft service trolleys. He needs to
- **show to the robot** which parts are needed in every step of assembling,
- **where** holes must be drilled, and
- **what** parts should be glued together.

Mojmír Tomek

"This phone runs the new android version? Can I try it?"

Age: 22
Work: Assembly worker
Family: Single, no siblings
Location: Pilsen, Czech Republic
Character: The Geek

Trait | Trait | Trait | Trait

Goals & Needs

- Working with cutting-edge technologies
- Assembling trolleys for airplane services
- To became a high-tech super-hero (like the Iron man)

Frustrations

- Delays in work caused by waiting for other processes to be done (i.e. other people finishing their tasks, components not ready etc.)
- Uncomfortable body positions while assembling parts of trolley
- Checking what type of trolley should be done at the moment

Bio

Mojmír studied technical secondery school and after his graduation he started to working at Clever Aero a.s.. He works as an assembly worker. Mojmír is responsible for final assembly of airplane service trolleys. He would love if there is some kind of automatization, as it is annoing for him to keep tracking of what kind of trolley should be done at the moment and thus which parts he will need.

Motivations

Fear

Achievement

Growth

Power

Social

Personality

Introvert — Extrovert

Analytical — Creative

Conservative — Liberal

UX protocols

- SUXES
  - Expectation vs. Experience

- SUS
  - System Usability Scale
  - Questionaire, Likert scale
  - Quick and dirty, but valid

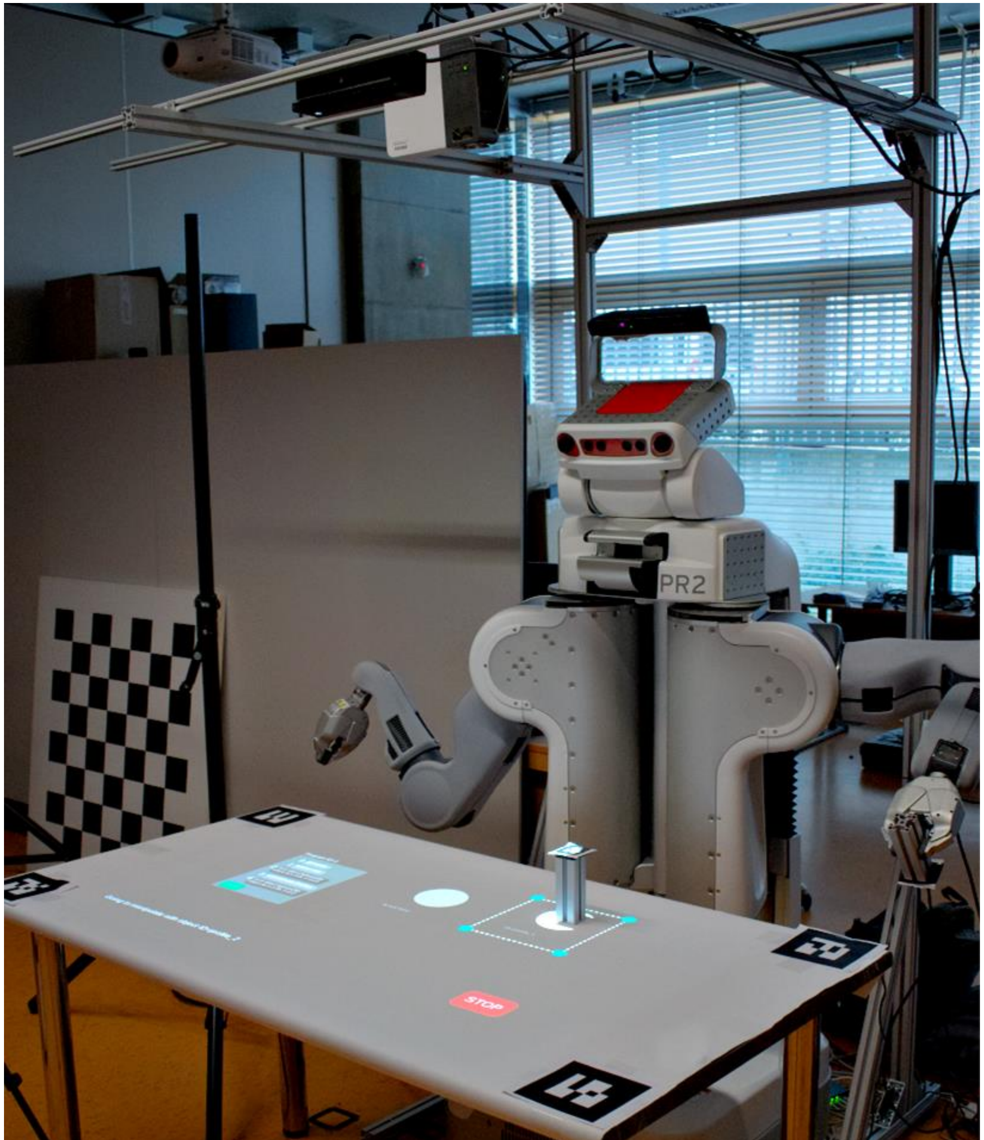
- NASA TLX (part of full NASA TLS)
  - Task Load Index

- UEQ
  - User Experience Questionaire
  - 3 parts: Attractiveness, Pragmatic Quality, Hedonic Quality

Usability of modalities

Effect of errors, Mock-up, WoZ experiment

Goals for new Interaction device



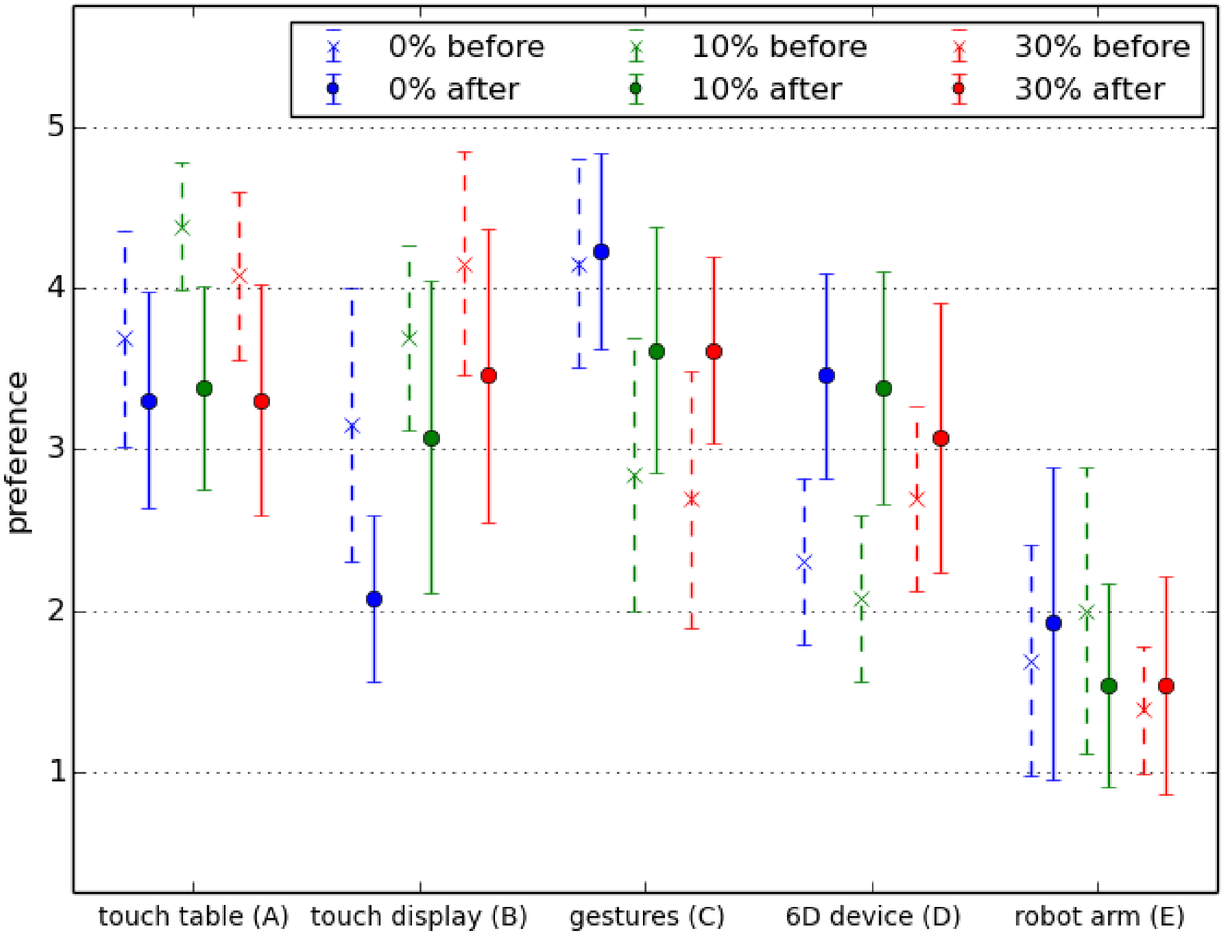
- Reducing the mental load for the user
- Speed up the new user's learning process
- Accelerate the process of creating a new program and/or
  modifying the existing program

Effect of still-not-perfect Modalities

- Touch table
- Touch display
- Hand gestures
- 6D pointing device
- Direct robot arm

1. Assembly two objects and set constraints
2. Stack objects into boxes
3. Select a box and its 4 corners
4. Select a box and its 4 edges

Effect of still-not-perfect Modalities



- 36 participants
- 3 groups with various amount of errors
  - 0%, 10%, 30%

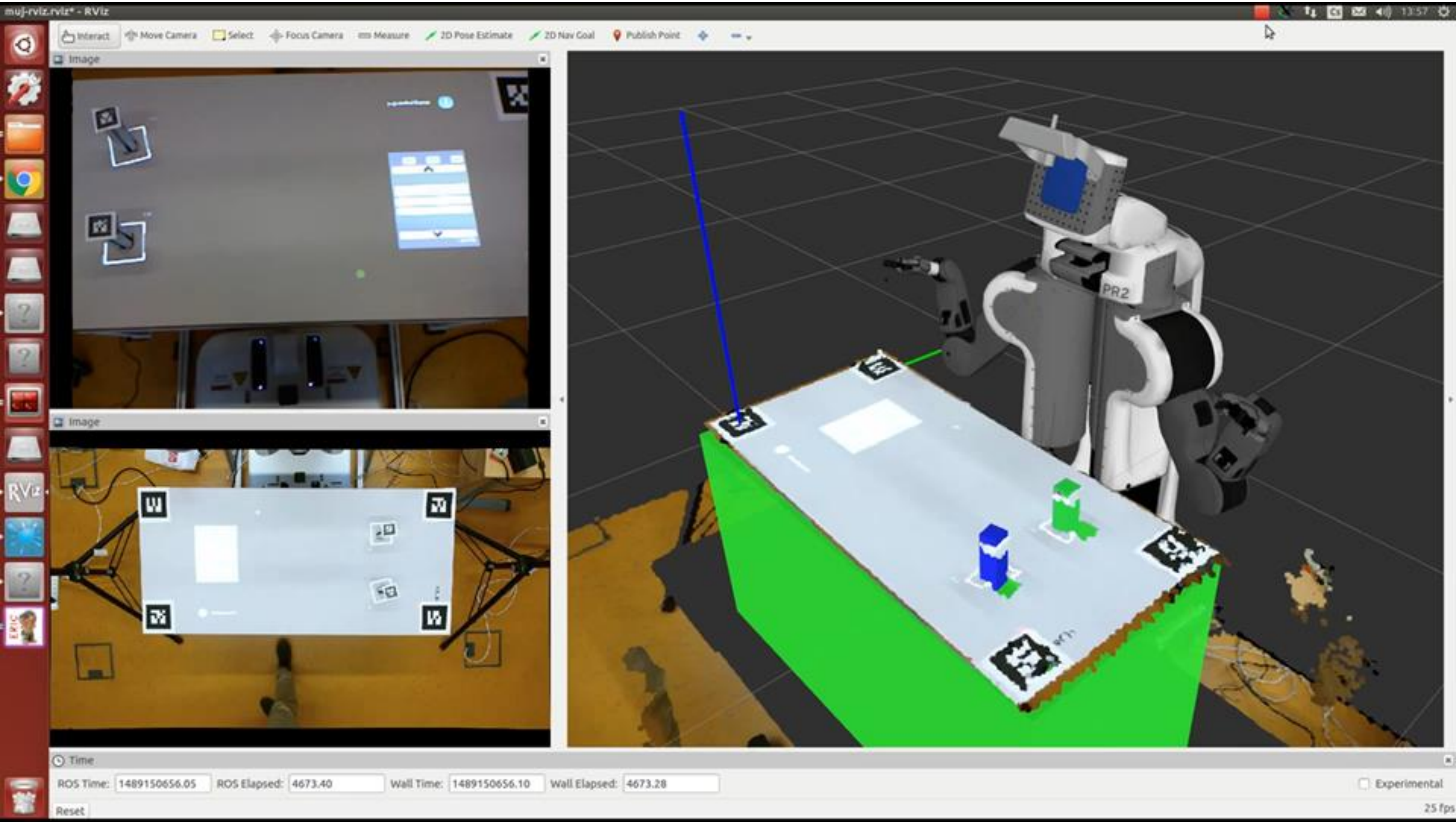
From desktop to workspace (in 2D)

Program, Tasks, Parameters,

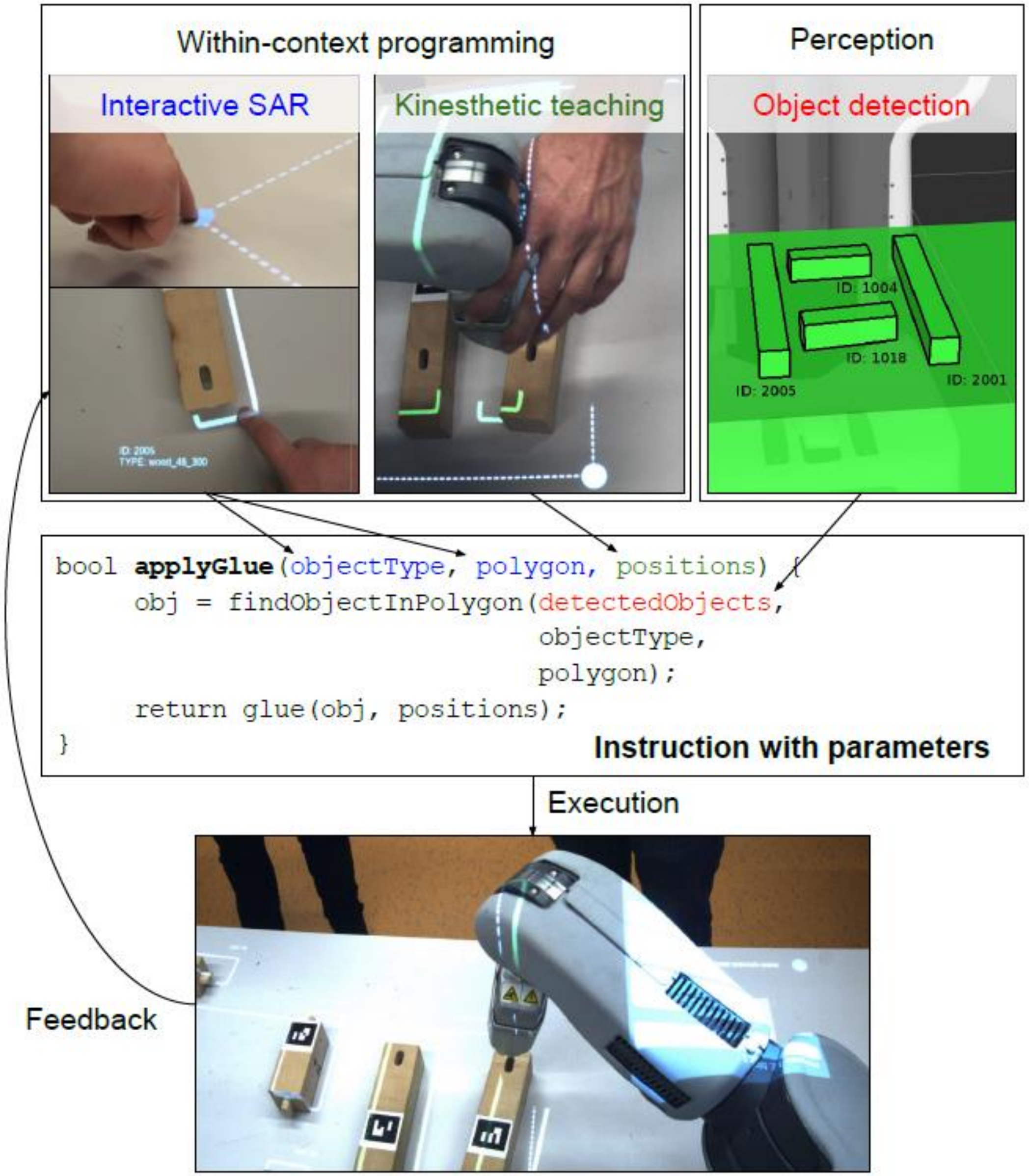
GUI/UI design, Working prototype

Industry application

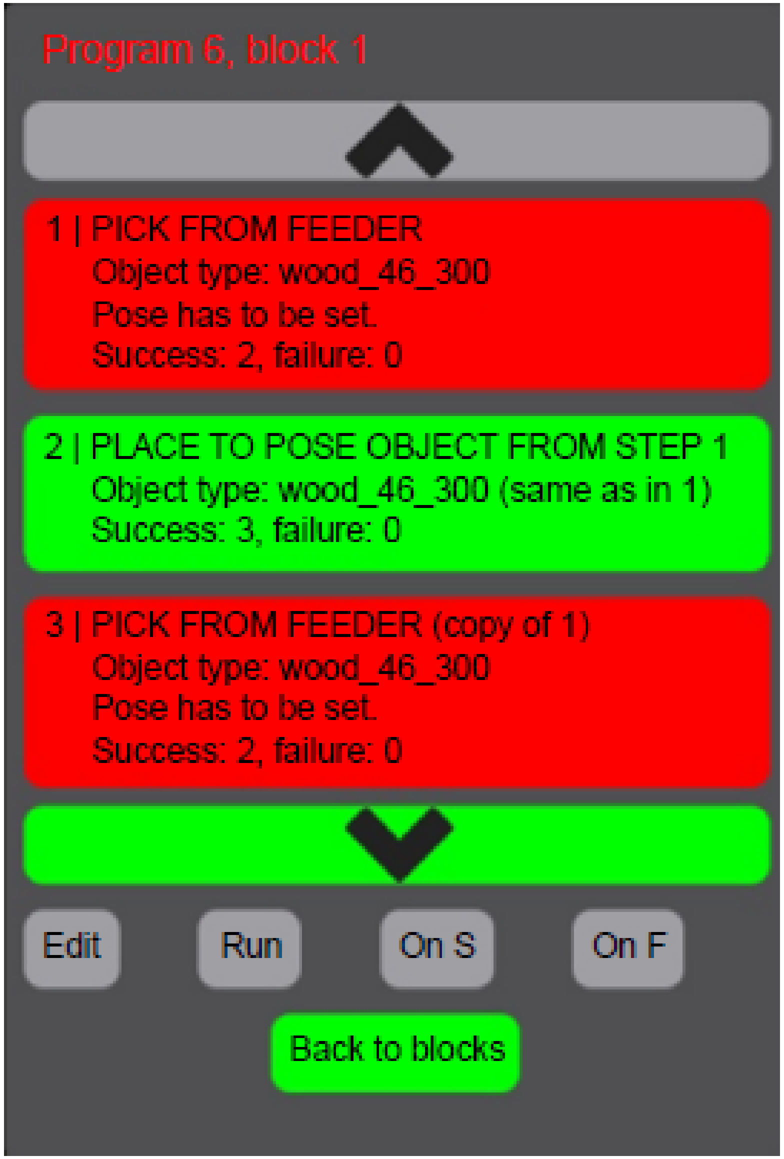
ARCOR - augmented reality cooperative robot

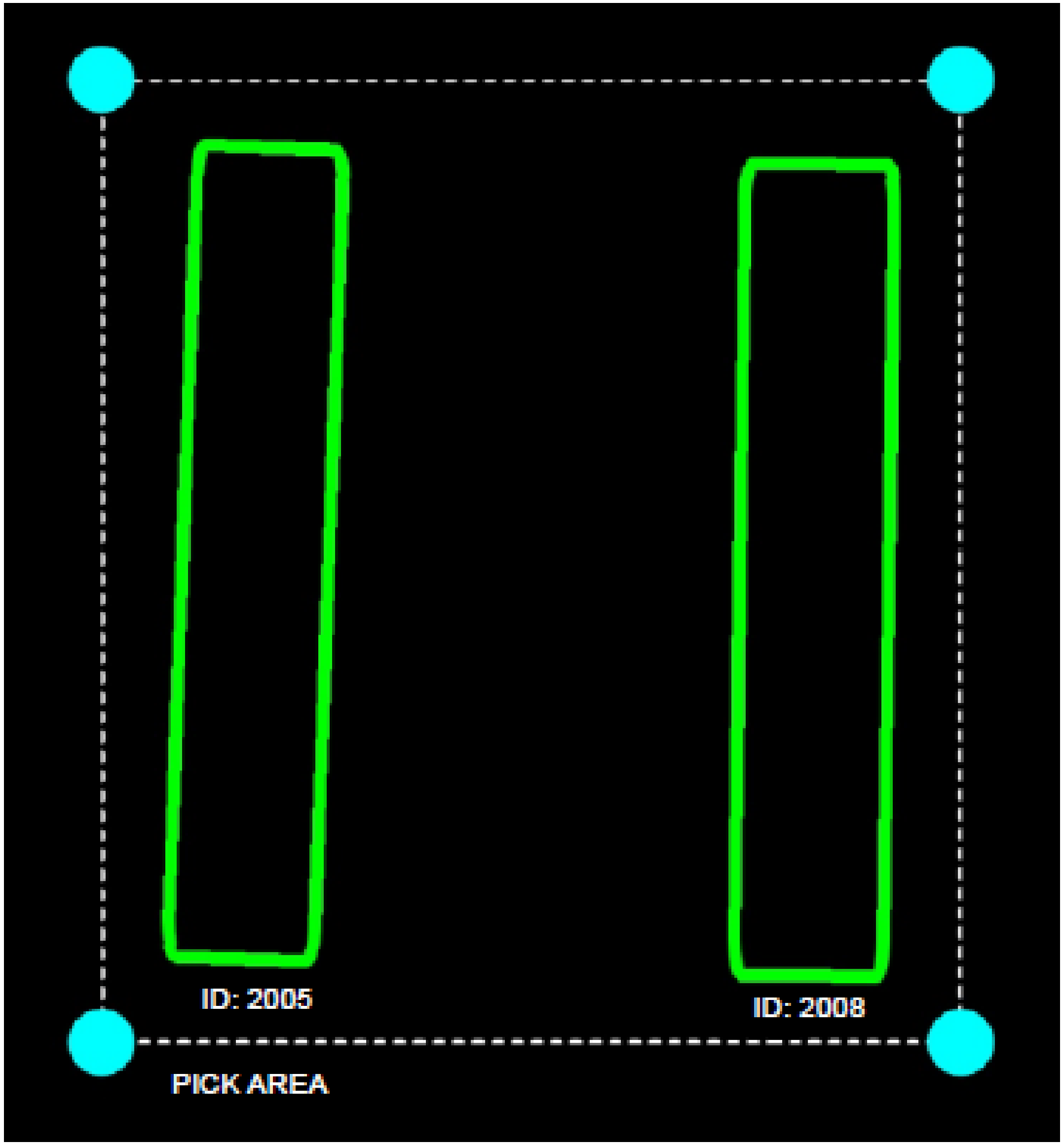


Tasks and parametrization



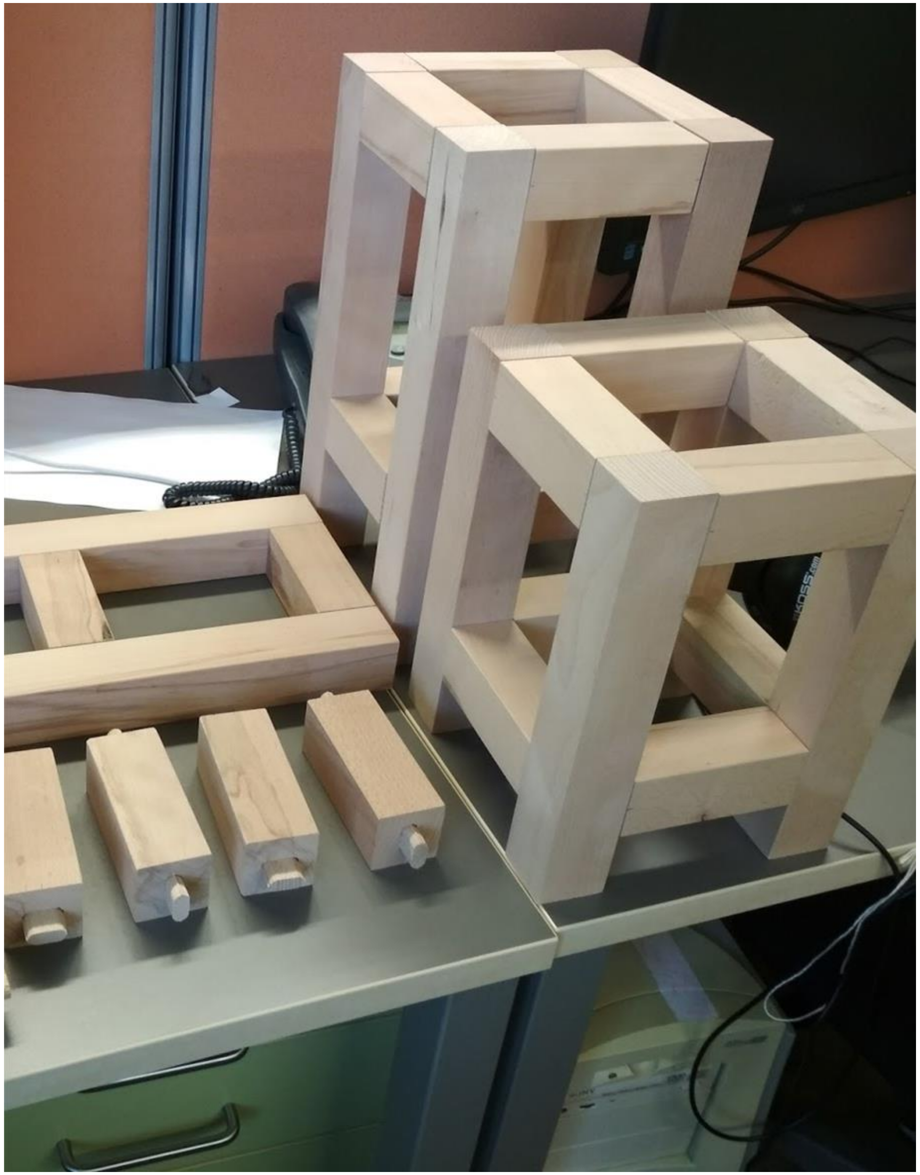
Example of GUI elements





Experiment - Wooden stool assembly

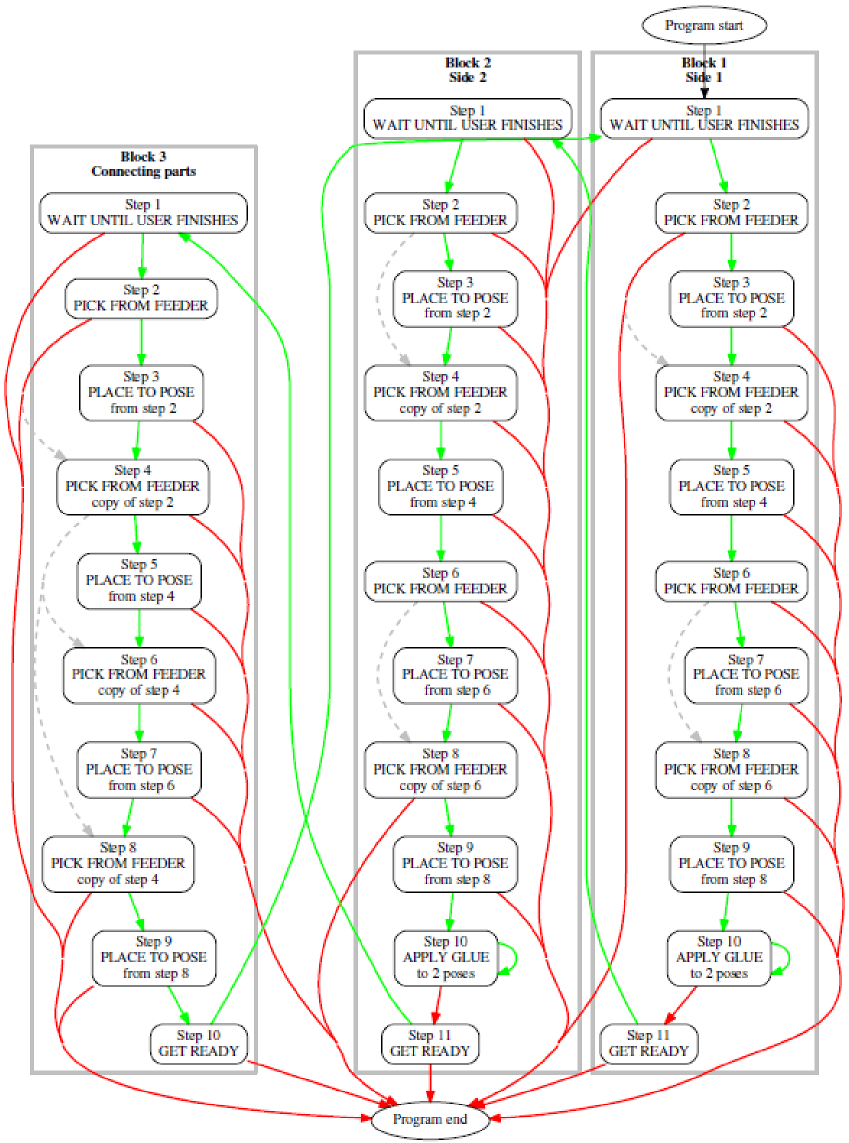
- Two stool variants
- Easy assembly – no special instruction needed for the user
- Manipulator with low precision – handles only larger parts
- Fasteners and tools handled by the user



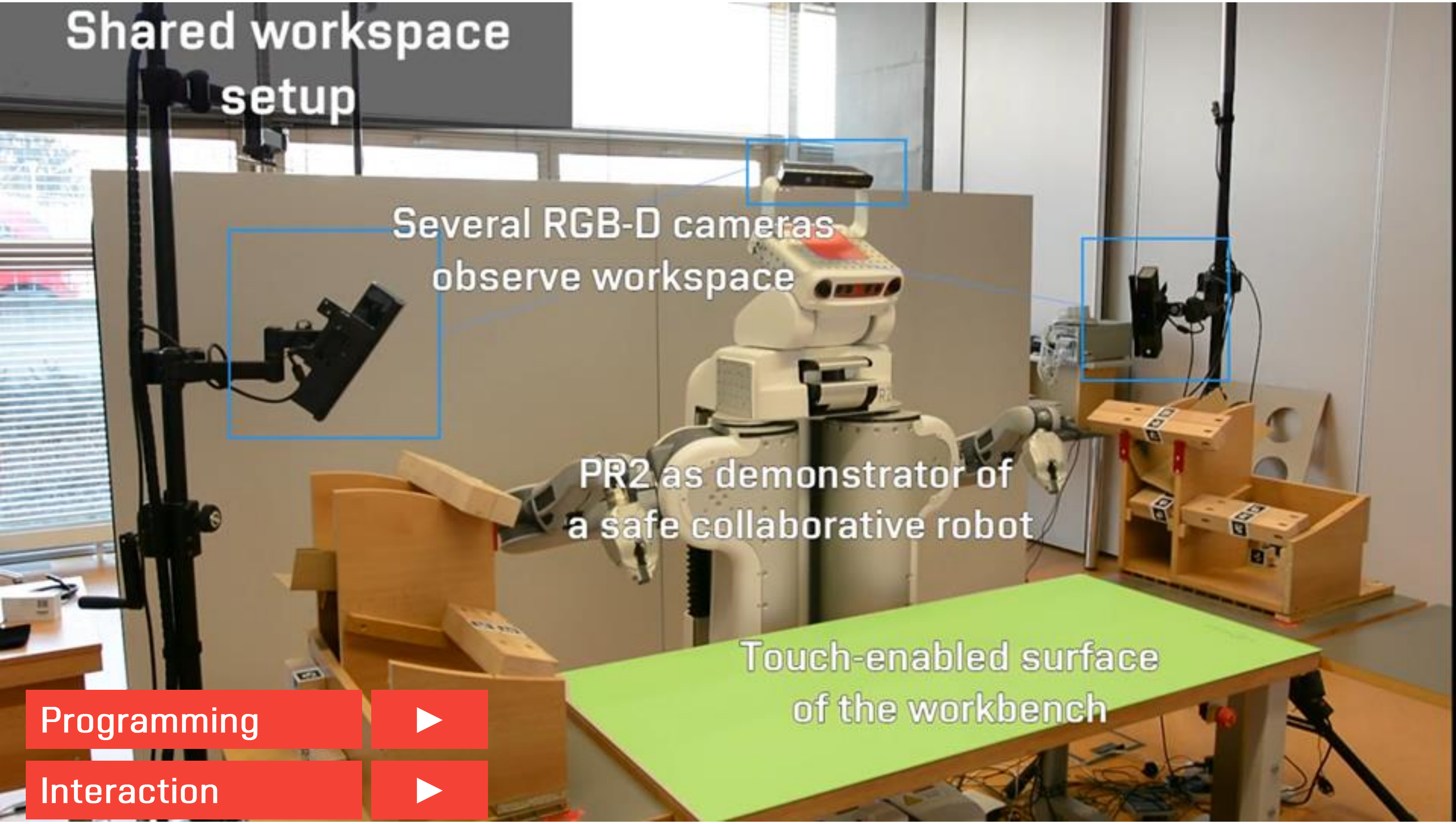
Experiment – blocks of procedure

- Parametrization
  - Pick from feeder
  - Place to pose
  - Apply glue

- Program execution
  - Error feedback
  - „Try again“ button



ARCOR - augmented reality cooperative robot



- Programming ▶
- Interaction ▶
- Touch input ▶

- 6 regular shop-floor workers
- selected out of 27 volunteers
- various ages, genders and technical backgrounds

Measure	A	B	C	D	E	F
System Usability Scale	87.5	67.5	77.5	75.0	85.0	62.5
Simplified TLX	25.0	33.3	30.6	22.2	41.7	47.2

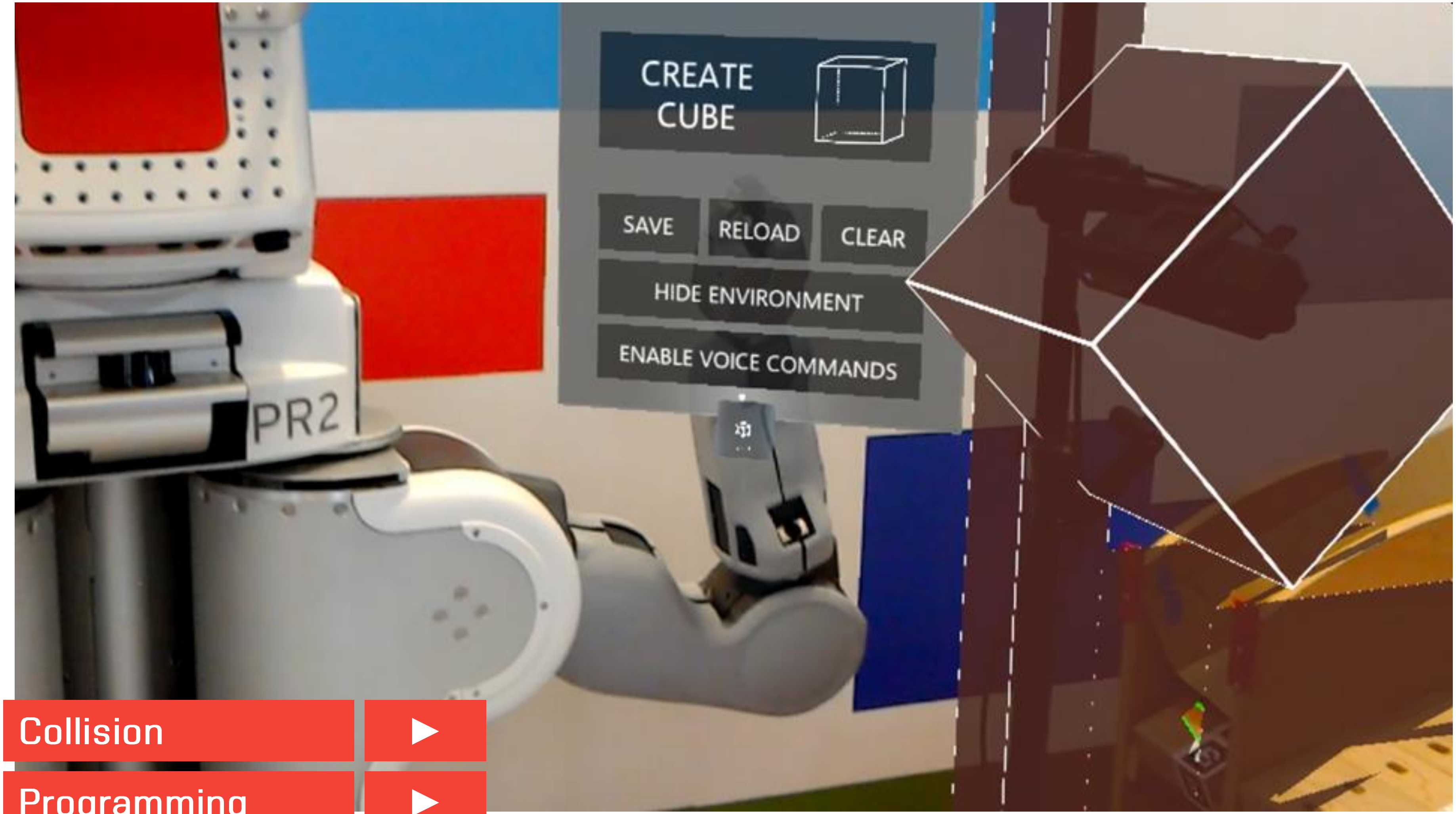
Statement	A	B	C	D	E	F
Collaboration was effective.	5	4	5	5	4	4
I felt safe.	4	5	5	5	5	5
Robot motions were uncomfortable.	2	1	1	1	1	1
It was easy to see what the robot was about to do.	4	5	5	4	4	2
The robot hindered me at work.	1	2	1	1	1	1
I watched every movement of the robot.	3	1	2	3	4	2
Learning the robot using its arm was intuitive.	4	4	5	5	5	4
Learning the robot using the interactive table was intuitive.	4	4	5	5	5	3
Interactive table shows all necessary information.	5	2	5	5	5	4
Sometimes I did not know what to do.	5	5	4	2	4	4

ARCOR – industry application (PCB Testing)

From 2D to 3D

Mobile AR, Hololens

ARCOR – Collision Environment



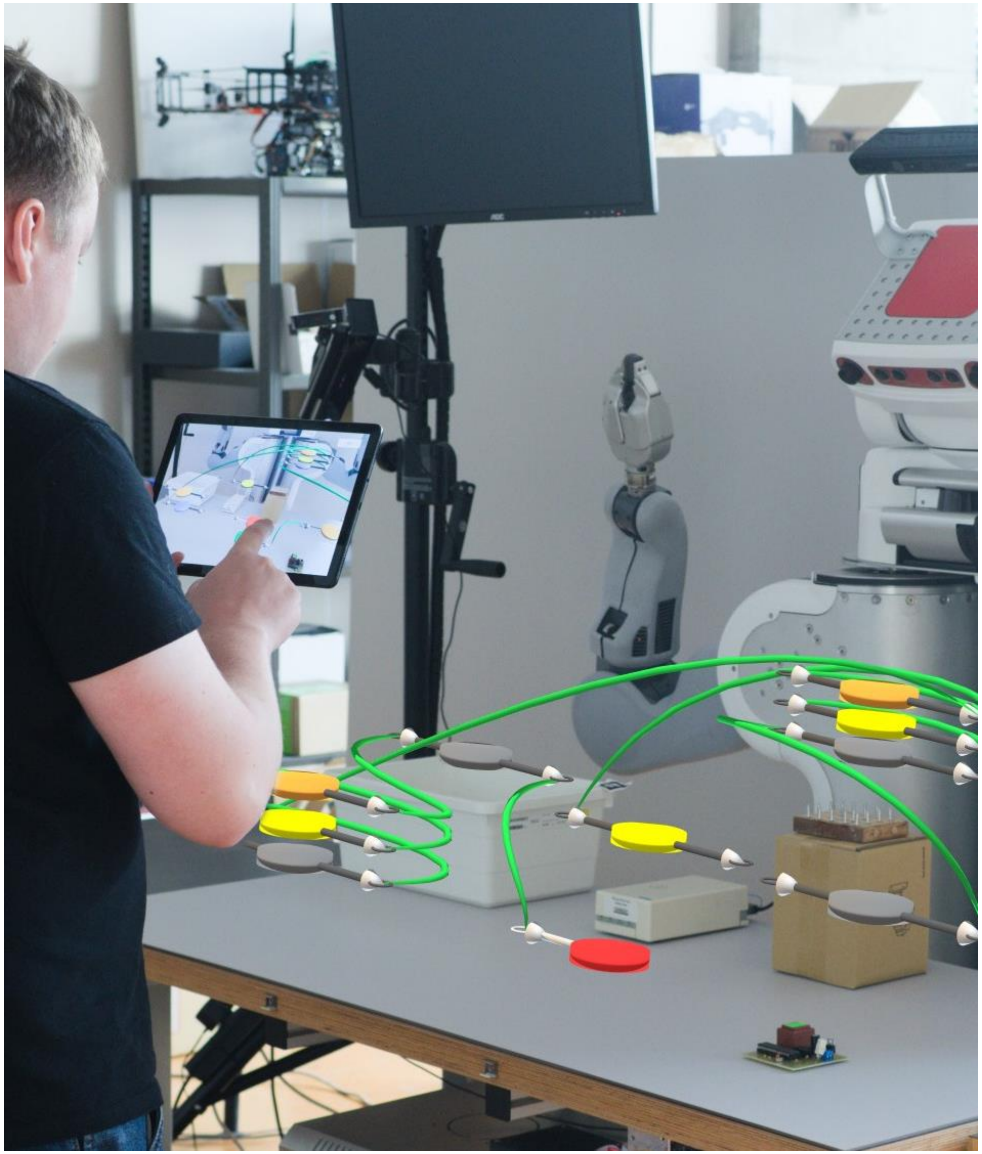
Collision ▶

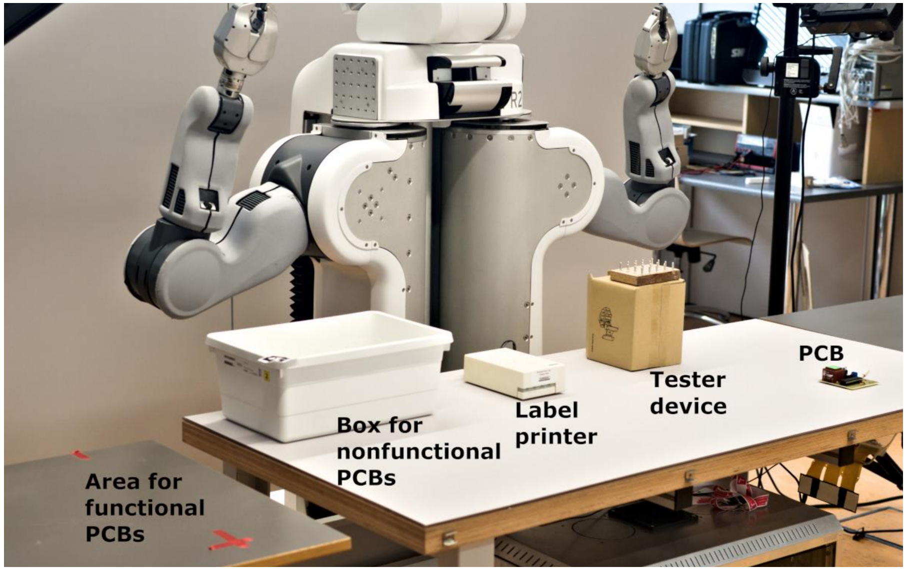
Programming ▶

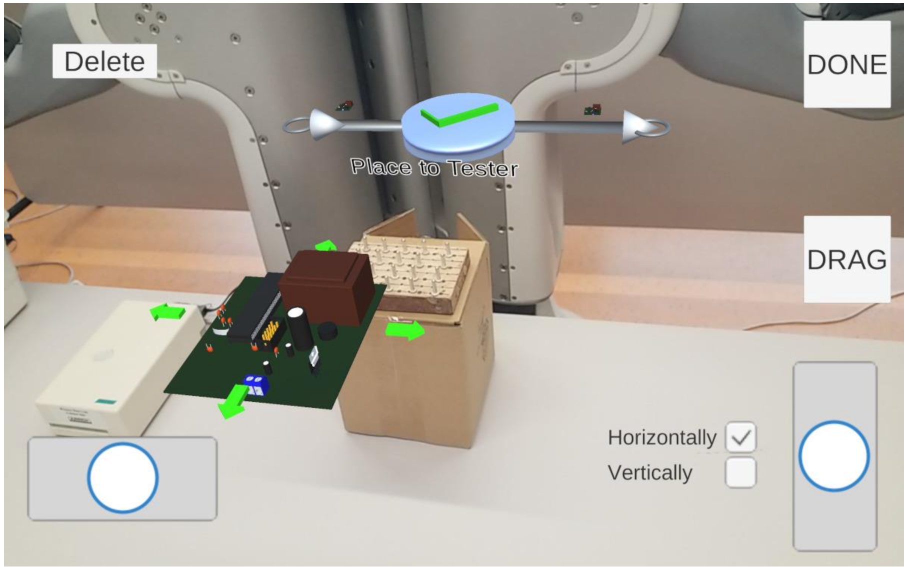
Visualization ▶

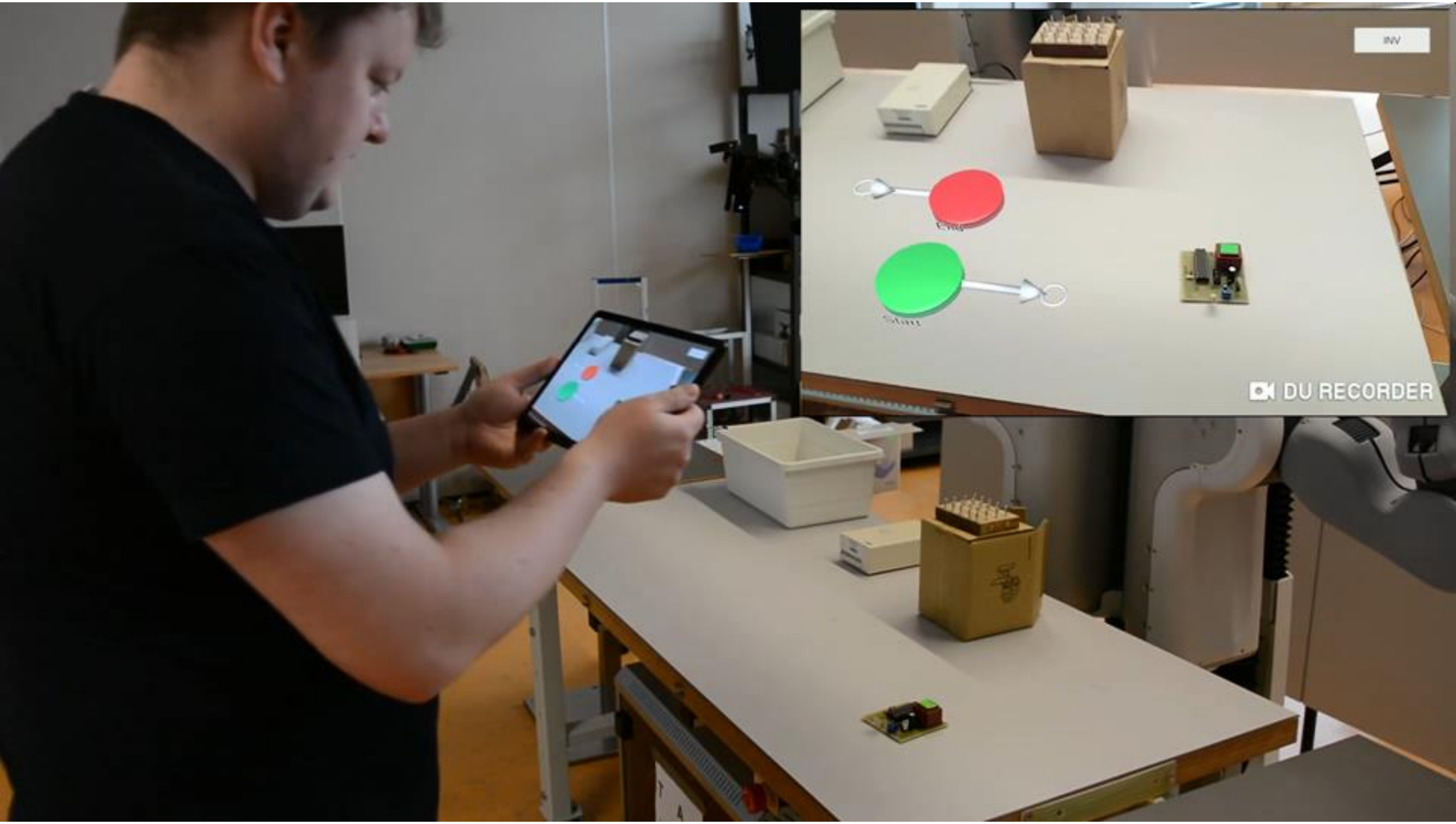
Missing Robot? Use HoloLens

3D programming in working space





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3D programming in working space

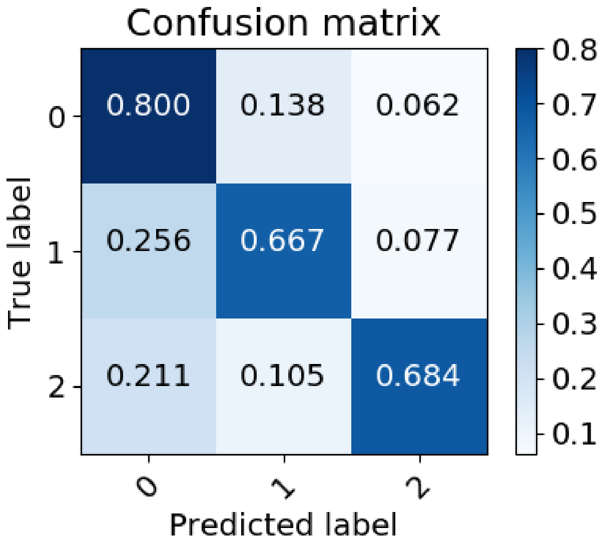
Participant	SUS	NASA TLX	UEQ ATT	UEQ PRA	UEQ HED	time to set (s)
A	95.00	25.00	2.67	2.50	2.12	535
B	80.00	25.00	2.00	2.42	0.75	427
C	67.50	47.22	1.17	2.00	1.75	460
D	85.00	27.78	1.67	2.25	2.25	507
E	92.50	27.78	2.67	2.75	2.88	431
F	82.50	19.44	2.00	2.08	2.38	521
G	77.50	19.44	1.33	1.83	0.88	806

- Excellent in all UEQ categories (1-best, 5-worst)
  - Attractiveness (mean score 1.93, SD=0.58),
  - Pragmatic attributes (mean score 2.26, SD=0.28) and
  - Hedonic attributes (mean score 1.86, SD=0.72)

Next steps

Cooperation sync (Biosignals, Body-gestures)

ARCOR – Realtime UX („I see your feeling“)

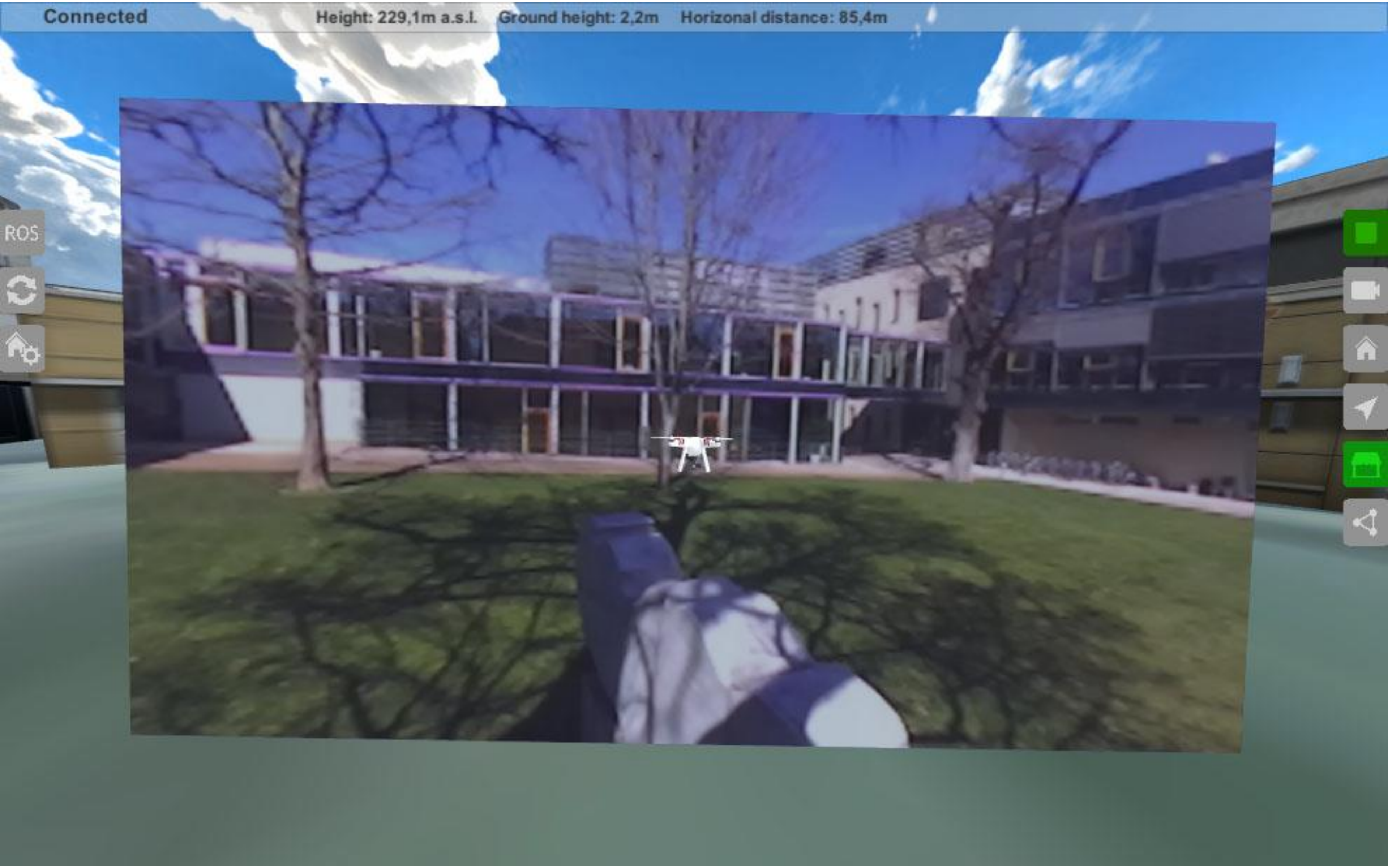


Drone control

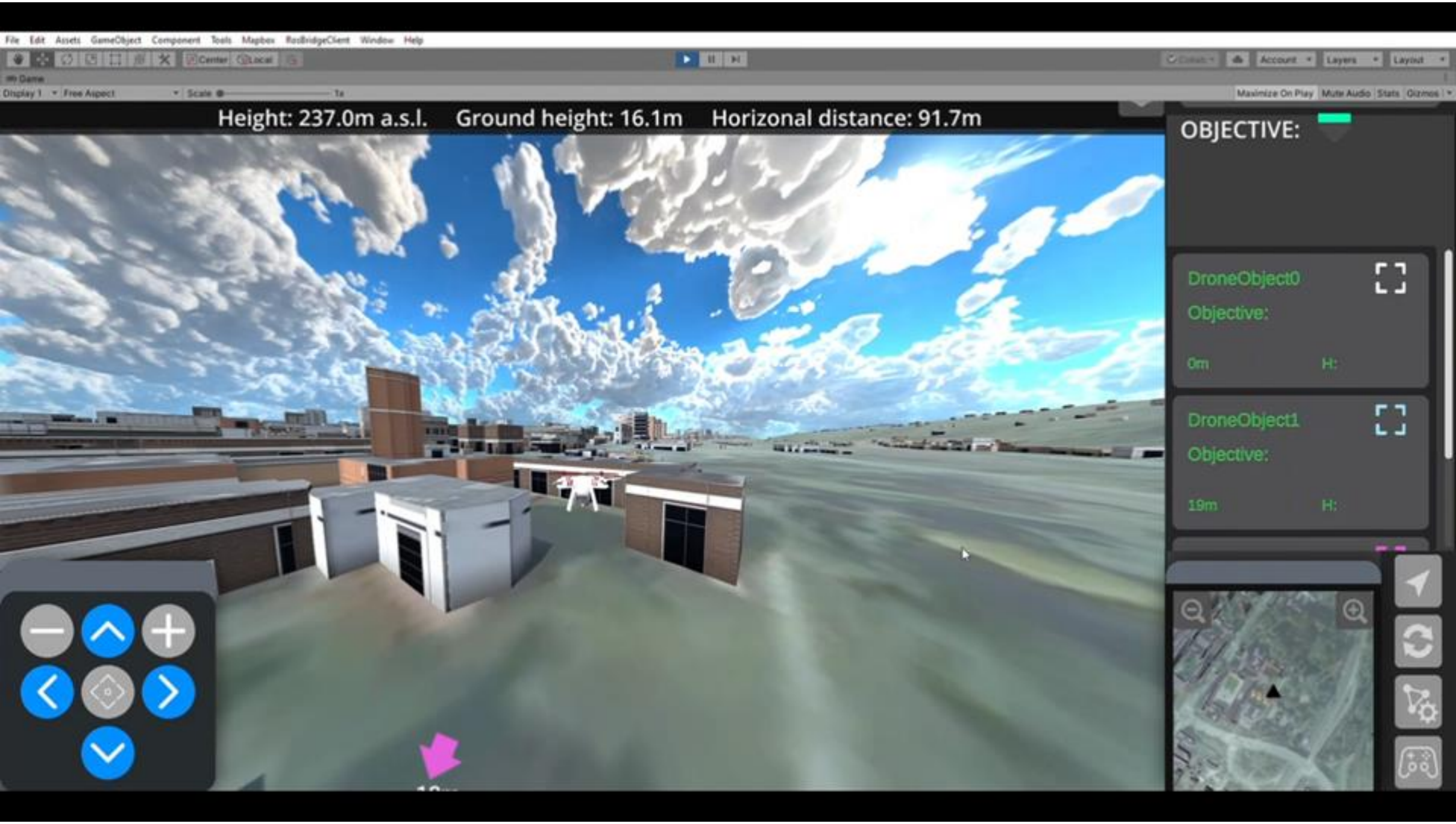
Augmented Virtuality

DroCo – Augmented Virtuality for Drone Control

DroCo – Application Interface



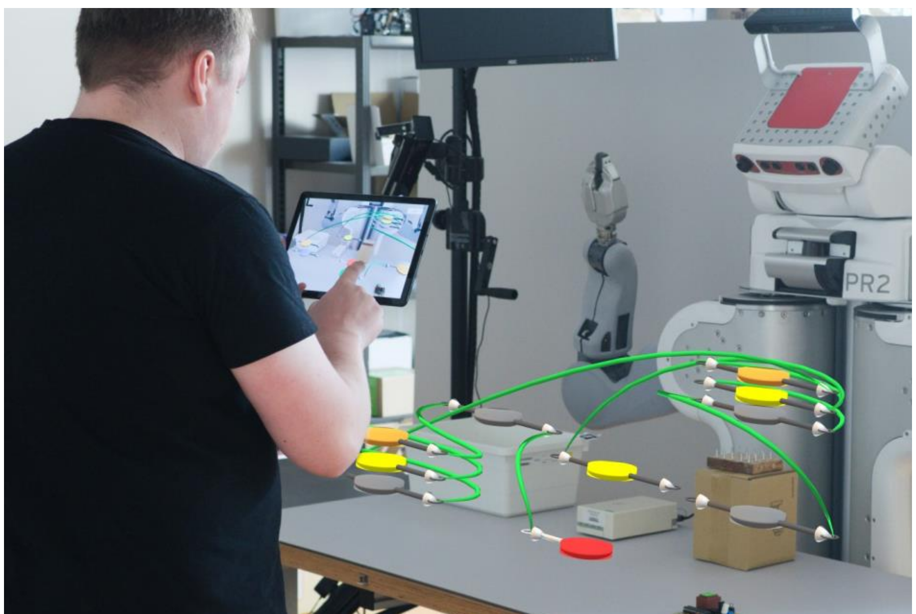
AV4DC – Effective Pilot Navigation & Orientation



Conclusion

Human-Robot Interaction

- Cobots task programming and re-parametrization
- AR (Spatial, glasses, mobile)
- 3D semantic annotations
- Adaptation with biosignals
- Simulations



Publications

- KAPINUS Michal, MATERNA Zdeněk, BAMBUŠEK Daniel and BERAN Vítězslav. **End-User Robot Programming Case Study: Augmented Reality vs. Teach Pendant.** In: Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction. Cambridge: Association for Computing Machinery, 2020, pp. 281-283. ISBN 978-1-4503-7057-8.
- BAMBUŠEK Daniel, MATERNA Zdeněk, KAPINUS Michal, BERAN Vítězslav and SMRŽ Pavel. **Combining Interactive Spatial Augmented Reality with Head-Mounted Display for End-User Collaborative Robot Programming.** In: *Robot and Human Interactive Communication (RO-MAN)*. New Delhi, 2019, pp. 1-9.
- KAPINUS Michal, BERAN Vítězslav, MATERNA Zdeněk and BAMBUŠEK Daniel. **Spatially Situated End-User Robot Programming in Augmented Reality.** In: *Robot and Human Interactive Communication (RO-MAN)*. New Delhi, 2019, pp. 1-9.
- MATERNA Zdeněk, KAPINUS Michal, BERAN Vítězslav, SMRŽ Pavel and ZEMČÍK Pavel. **Interactive Spatial Augmented Reality in Collaborative Robot Programming: User Experience Evaluation.** In: *Robot and Human Interactive Communication (RO-MAN)*. NanJing: Institute of Electrical and Electronics Engineers, 2018, pp. 330-338. ISBN 978-1-5386-7980-7.
- MATERNA Zdeněk, KAPINUS Michal, BERAN Vítězslav and SMRŽ Pavel. **Using Persona, Scenario, and Use Case to Develop a Human-Robot Augmented Reality Collaborative Workspace.** In: *HRI 2017*. Vienna: Association for Computing Machinery, 2017, pp. 1-2. ISBN 978-1-4503-4885-0.
- MATERNA Zdeněk, KAPINUS Michal, ŠPANĚL Michal, BERAN Vítězslav and SMRŽ Pavel. **Simplified Industrial Robot Programming: Effects of Errors on Multimodal Interaction in WoZ experiment.** In: *Robot and Human Interactive Communication (RO-MAN)*. New York City: Institute of Electrical and Electronics Engineers, 2016, pp. 200-205. ISBN 978-1-5090-3929-6.
- SEDLMAJER Kamil, BAMBUŠEK Daniel and BERAN Vítězslav. **Effective Remote Drone Control Using Augmented Virtuality.** In: Proceedings of the 3rd International Conference on Computer-Human Interaction Research and Applications 2019. Vienna: SciTePress - Science and Technology Publications, 2019, pp. 177-182. ISBN 978-989-758-376-6.