

Prototype of a virtual reality test environment in a Lunar Agricultural Module for evaluating work processes

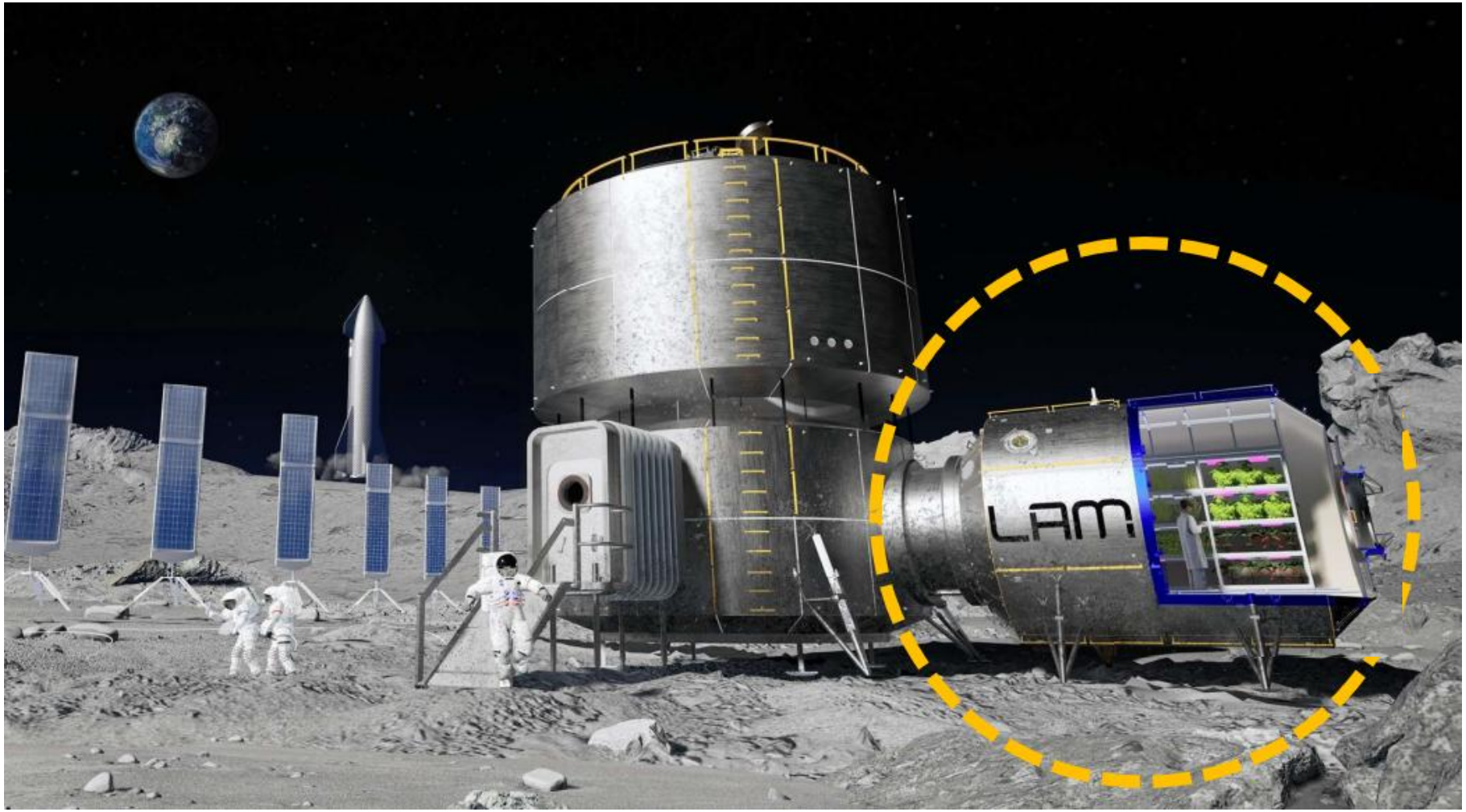
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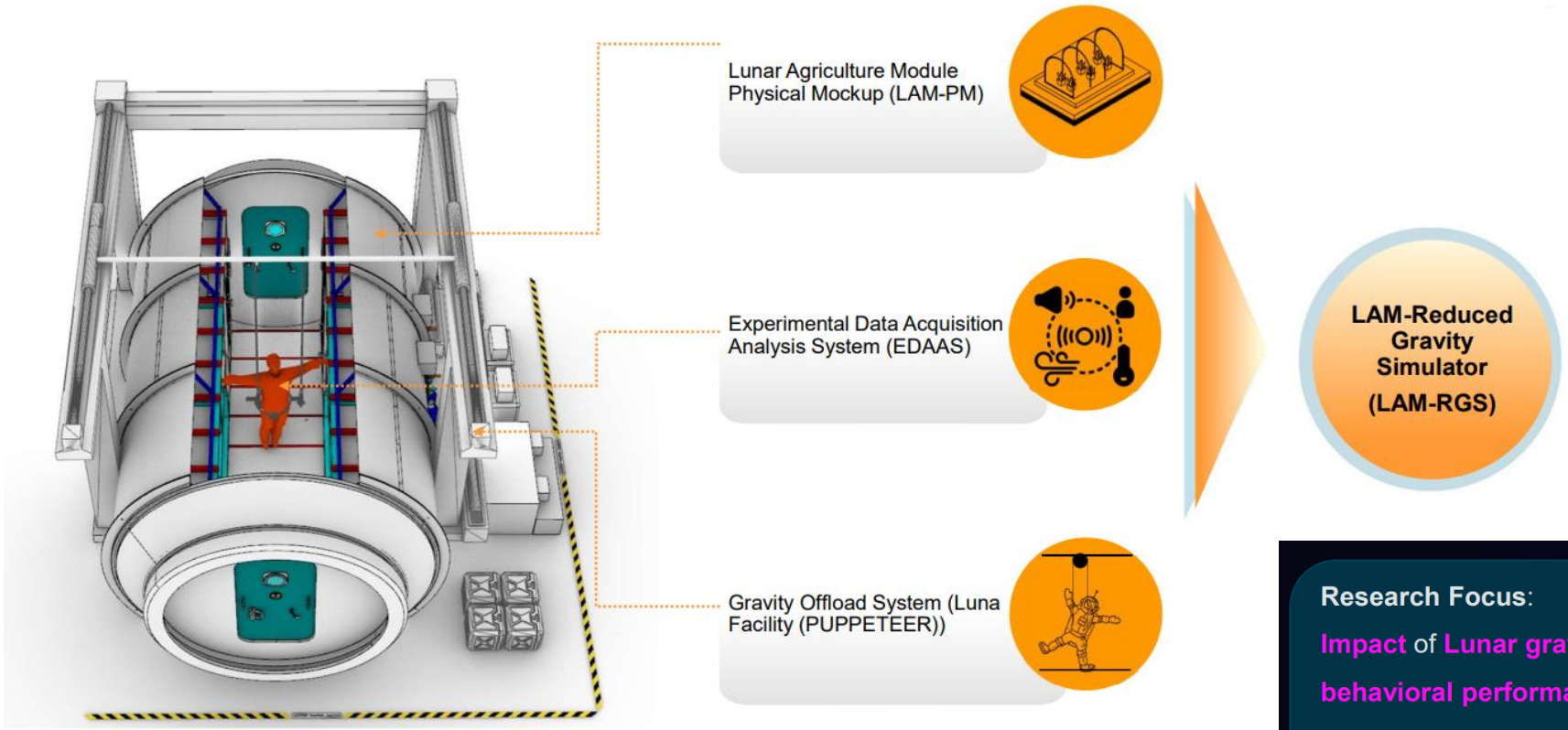
German Aerospace Center (DLR),
Institute of Space Systems (RY)

Background



Kyunghwan Kim, DLR, Institute of Space Systems

Background – Early concept of a LAM reduced gravity simulator



Kyunghwan Kim, DLR, Institute of Space Systems

Research Focus:

Impact of **Lunar gravity** on **human factors & behavioral performance** (HFBP) during **astronaut task execution within the LAM** under simulated lunar mission conditions

Goal

- VR application in lunar agricultural module (LAM)
- Multiple tasks within the virtual environment for the user to complete
- Support for overlaying virtual LAM on physical object

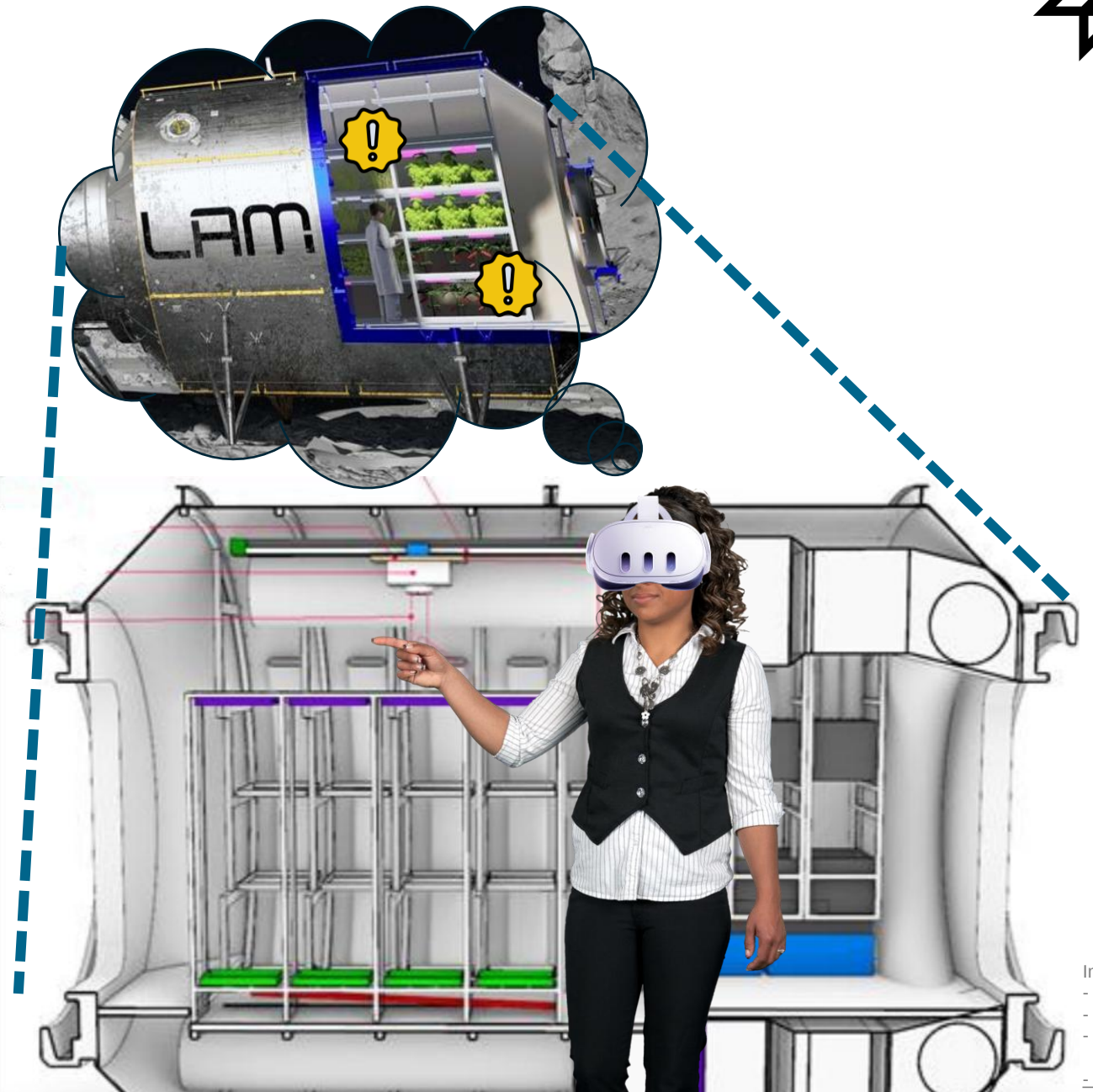


Image sources:
- Powerpoint
- Meta
- DLR, Institute of Space Systems
- flaticon.com

Approach

- Meta Quest 3
- Unreal Engine



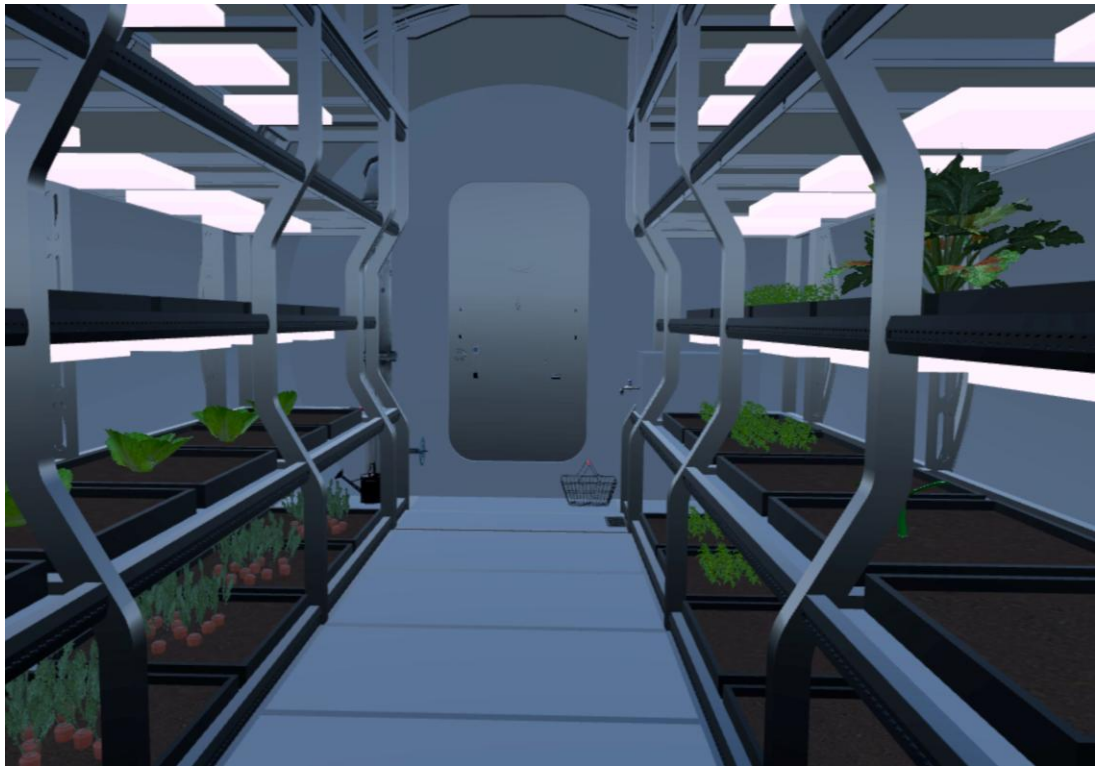
Meta

- Development aspects:
  - Interface for developing and completing tasks
  - Virtual environment and tasks themselves
  - Object overlaying
- Literature reviewed about existing VR training simulations
- User study conducted to evaluate the application and identify possible areas of improvement

Environment

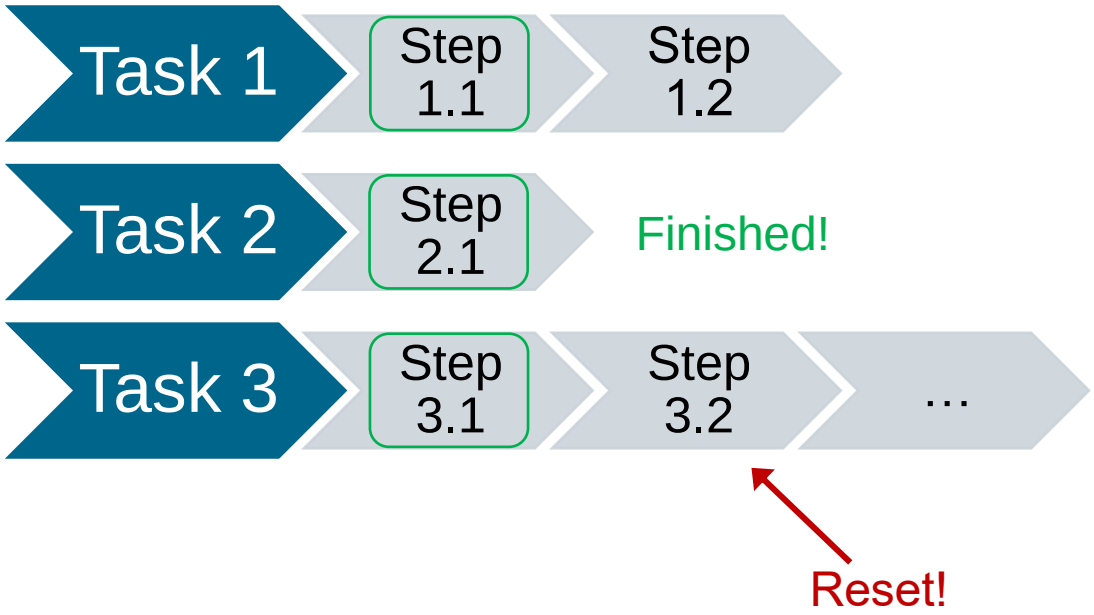


LAM CAD model



VR

Task interface: design



Task interface: implementation

- Classes implemented in C++
- Exposed to Blueprint for straightforward interfacing with interactions



Tasks: design

- Work with different plants 🪴
  - Cultivating and harvesting should play a role 👩‍🌾
  - Also caring for a sick plant 👩‍⚕️
- Maintenance work 👷

Tasks: design

Task 1

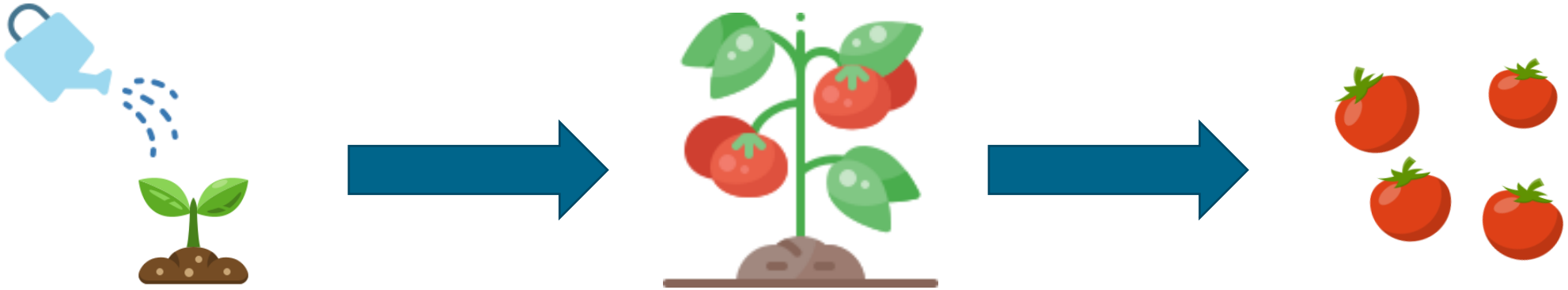
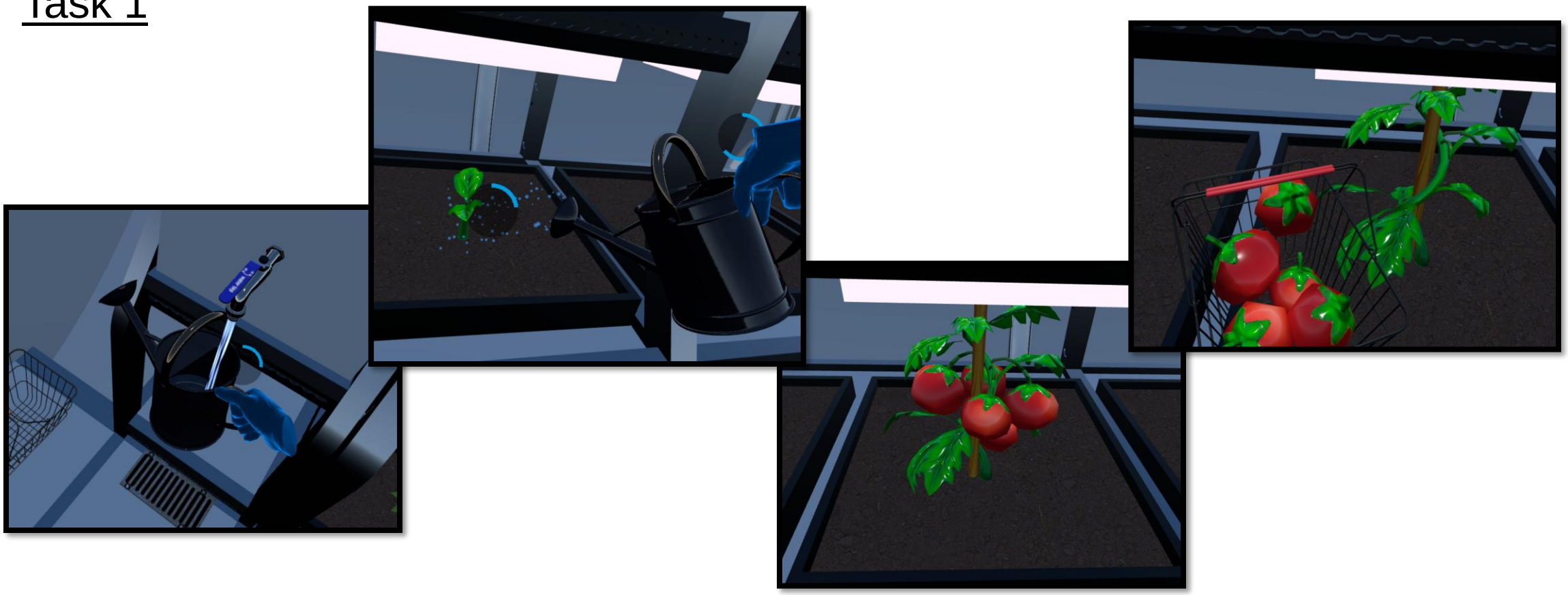


Image source: Flaticon.com

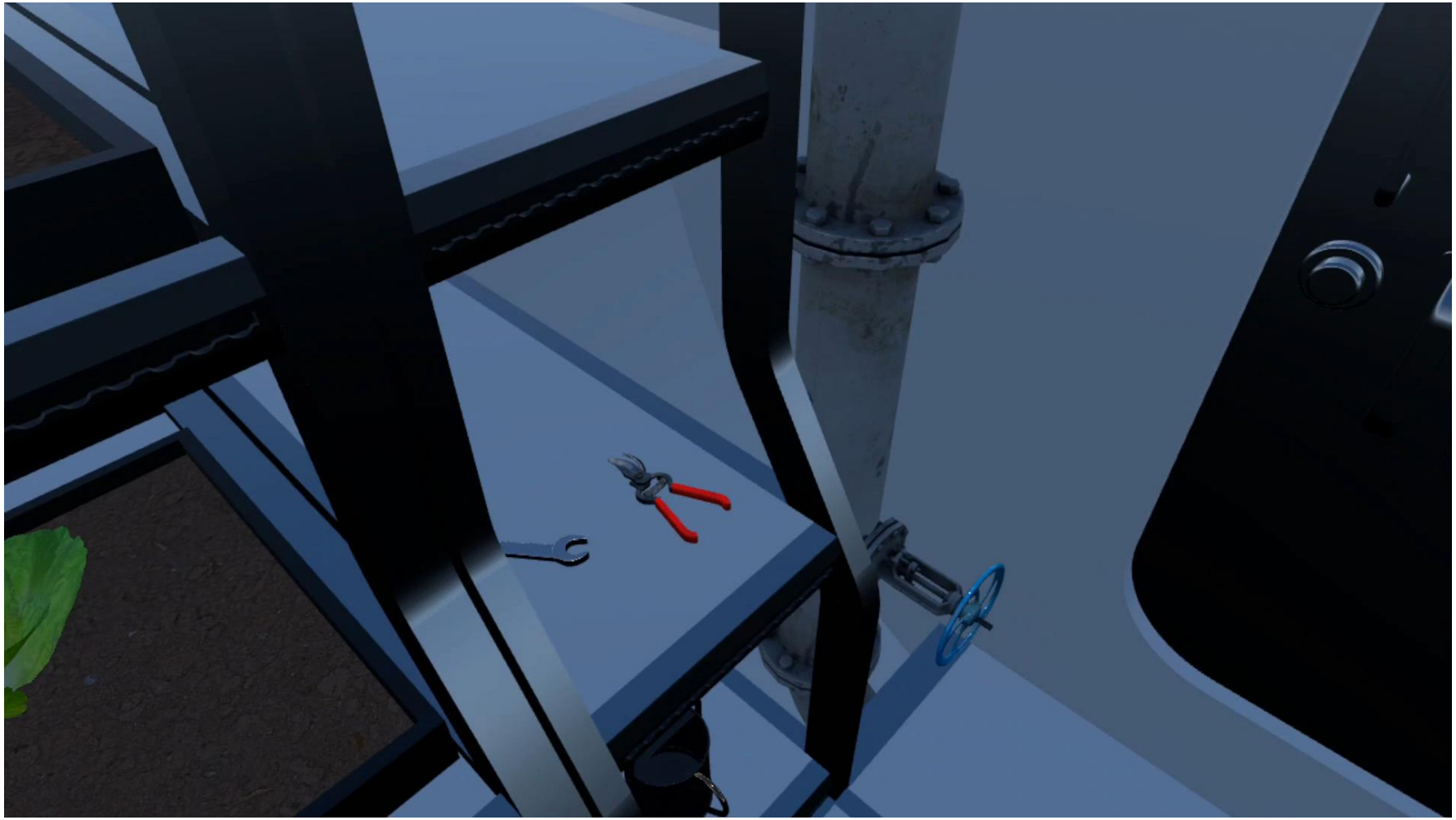
Tasks: implementation

Task 1



Tasks: implementation

Task 1



Tasks: design

Task 2

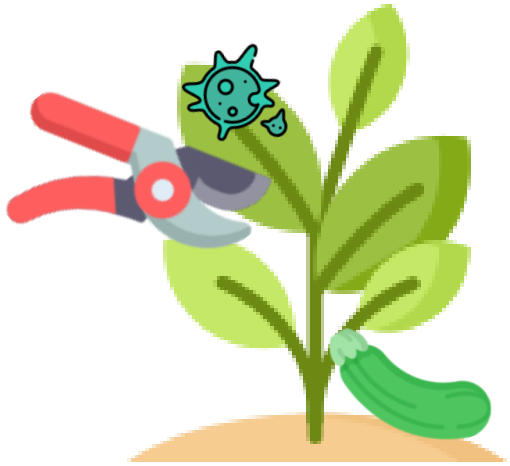
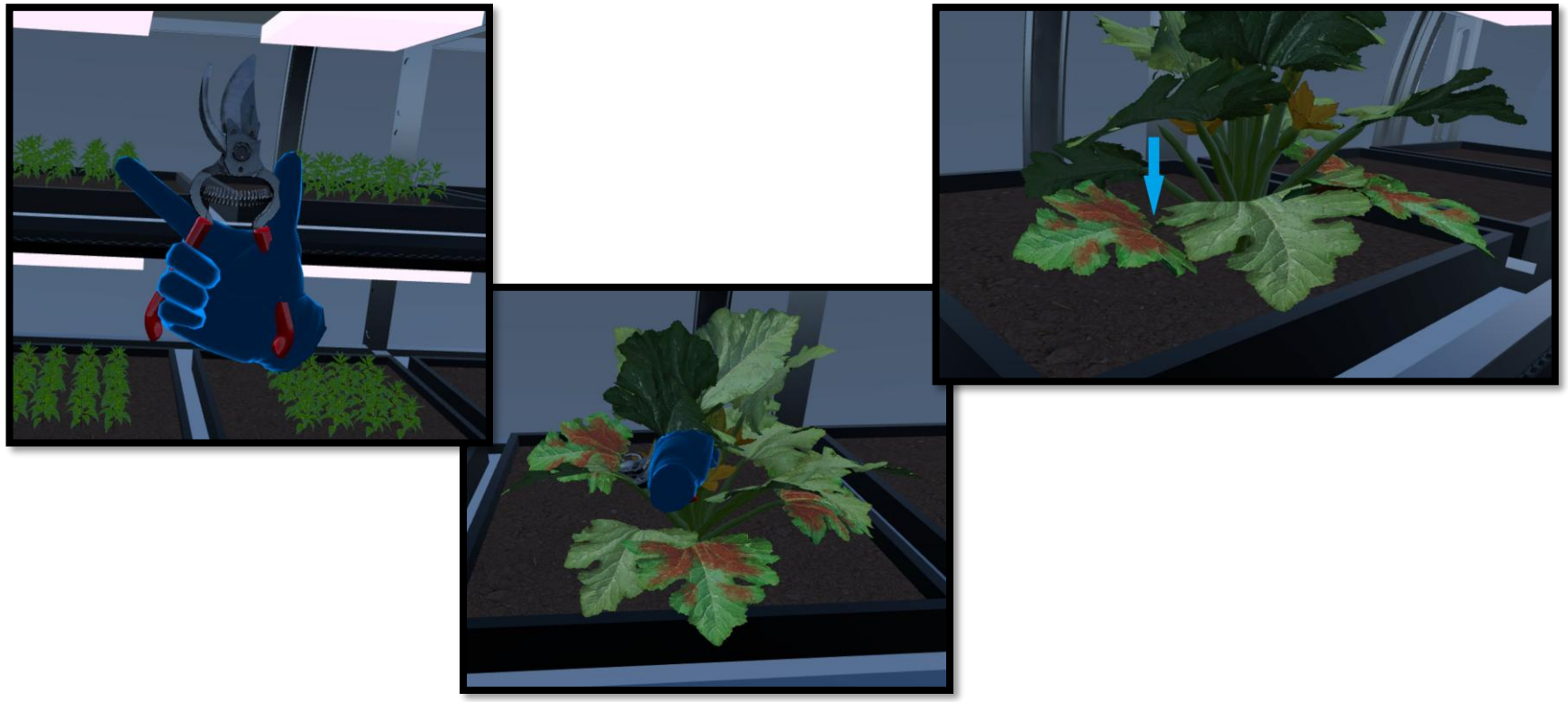


Image source: Flaticon.com

Tasks: implementation

Task 2



Tasks: implementation

Task 2



Tasks: design

Task 3

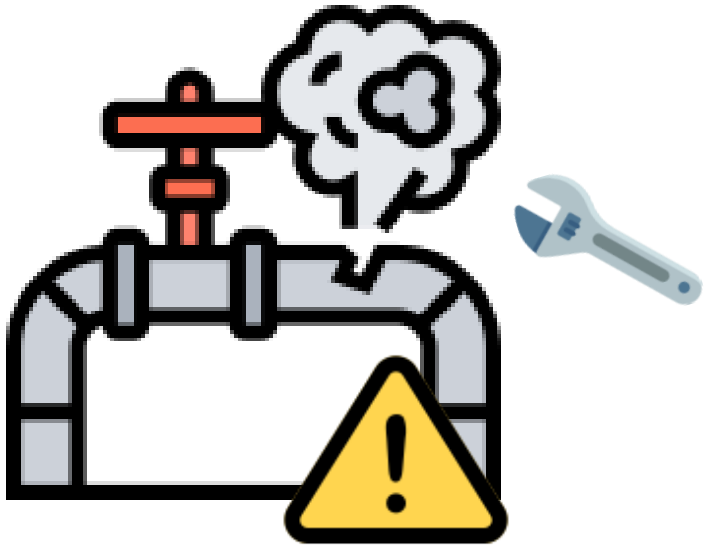
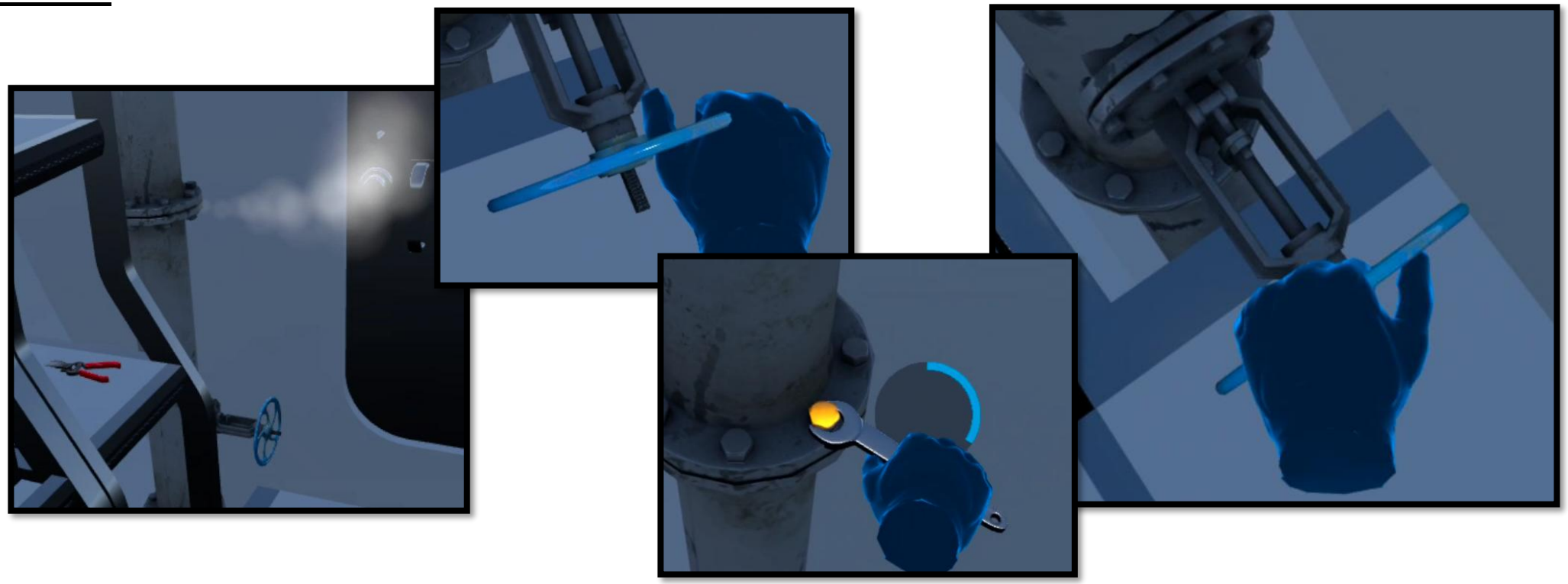


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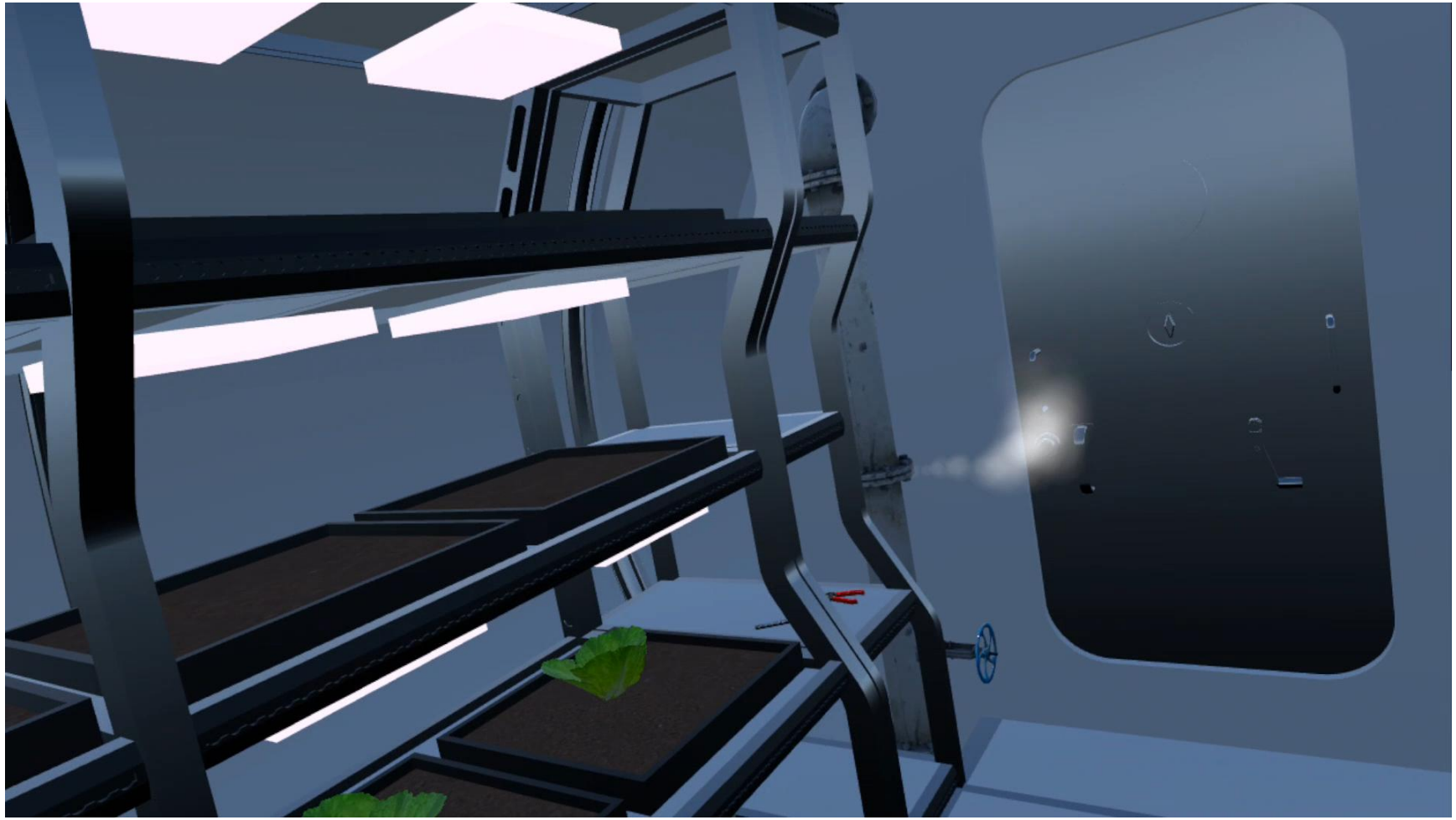
Tasks: implementation

Task 3



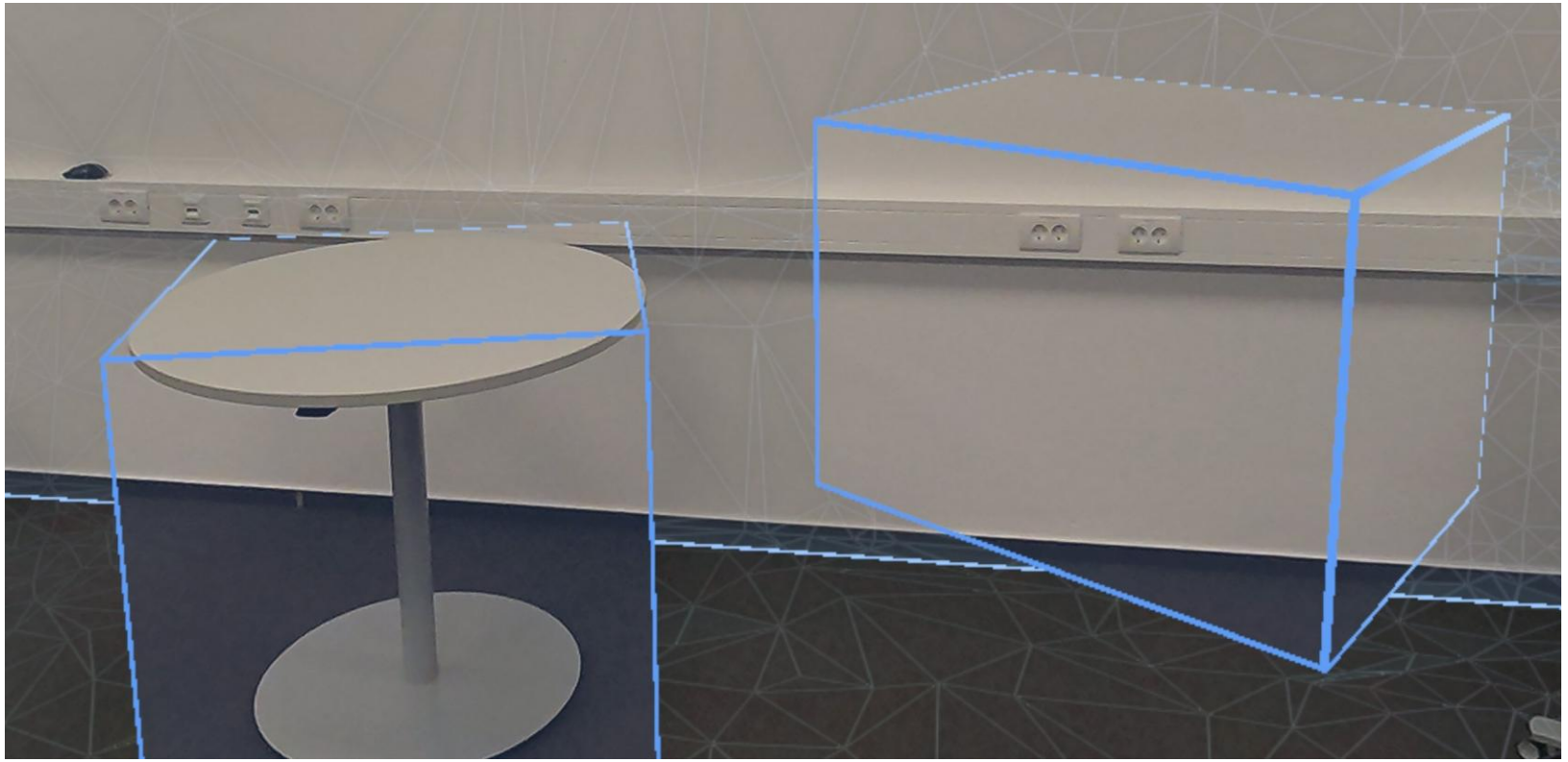
Tasks: implementation

Task 3



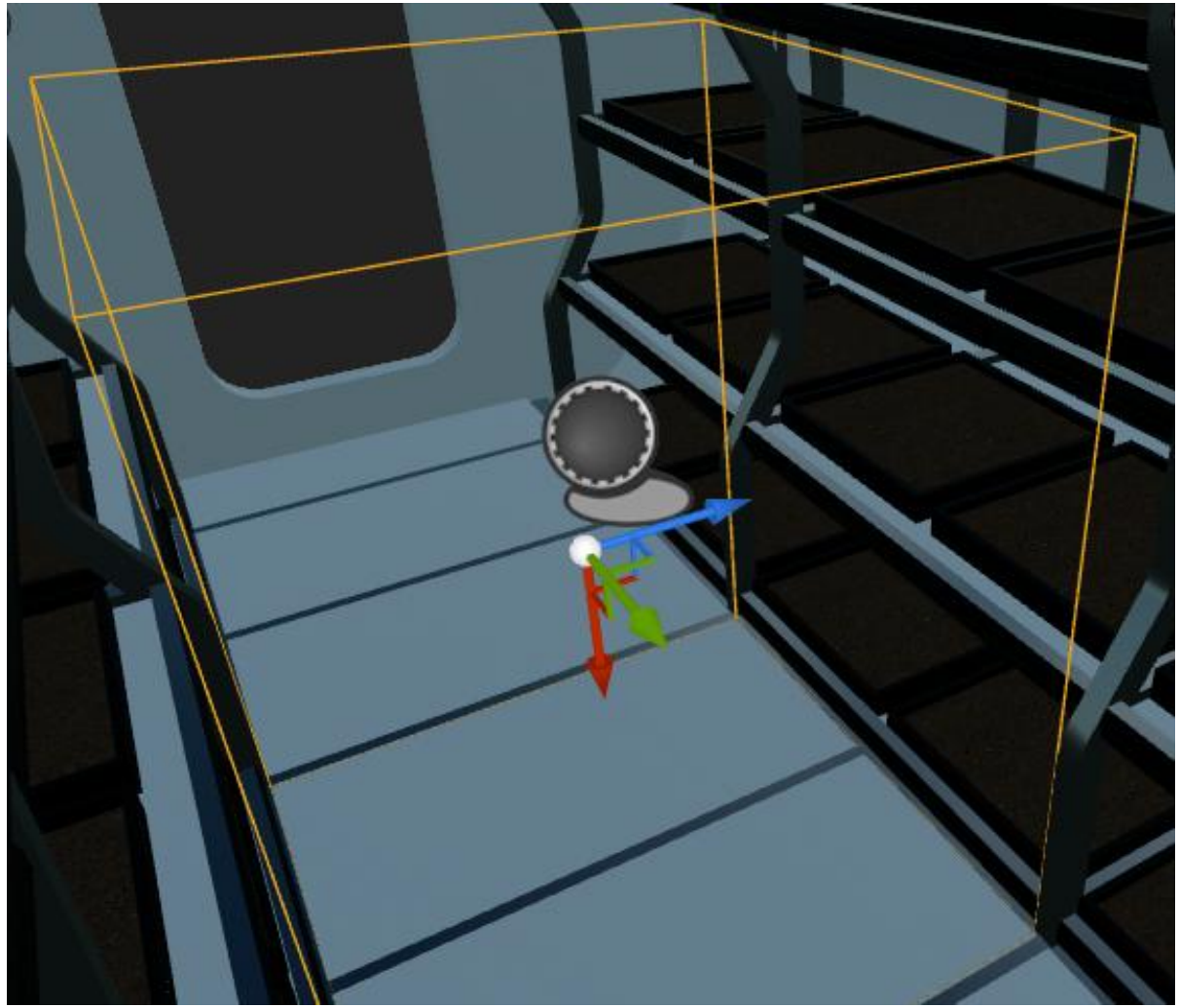
LAM overlaying

- Meta Quest scene model

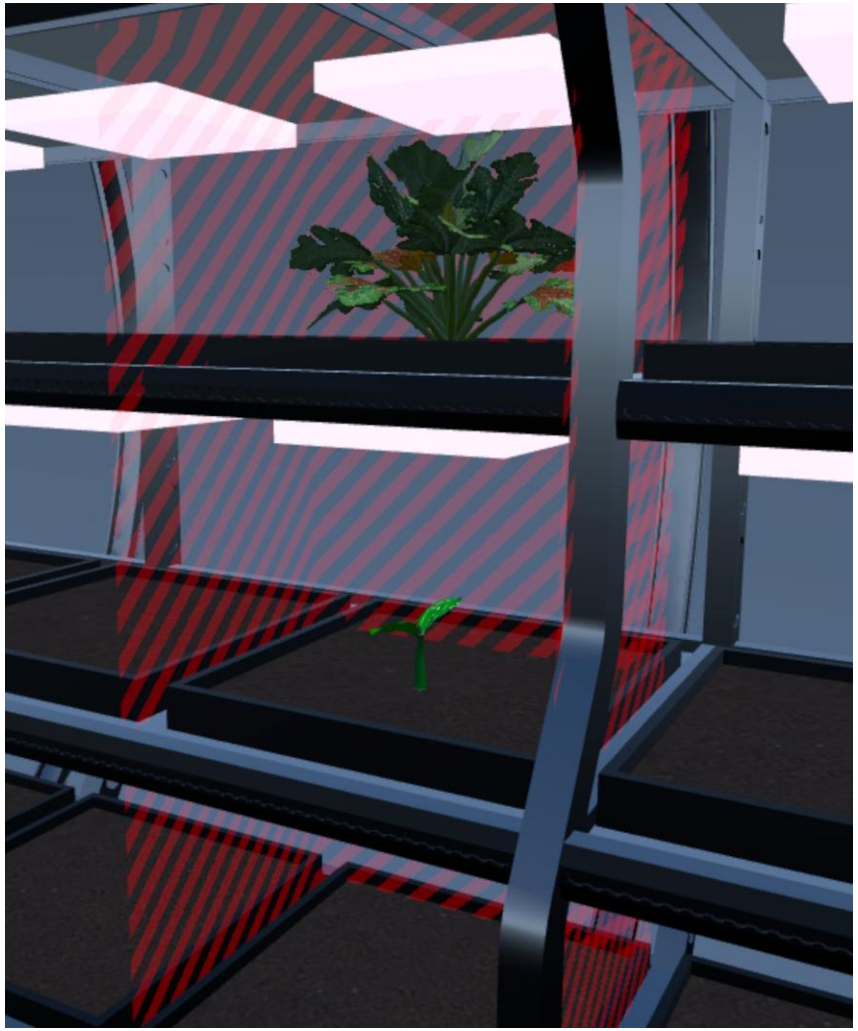


LAM overlaying

- Equivalent in virtual LAM
- Calculate necessary transformation



User study setup





User study questionnaire

- Usability
- Presence/immersion

- Interaction
- Overlaying
- Presentation of information
- Audio-visual content
- Task design
- Open questions



Flaticon.com

User study questionnaire: example questions

I found the various functions in this system were well integrated.

I felt dizzy, motion sickness, or a headache while experiencing virtual reality.

The haptic feedback of touching real world objects (the cabinet specifically) matched the observed virtual touch.

What would you change in order to improve the VR application?

time of the experience, strongest on the whole, e of being in the LAM, or of being in the real world of the laboratory?

It felt natural to use the handheld controllers.

The wrist-bound UI was easy to read, understand and use.

Having completed the VR experience could help me perform similar activities in a real-world scenario or to navigate a similar environment.

use of audio was sistent with what I saw.

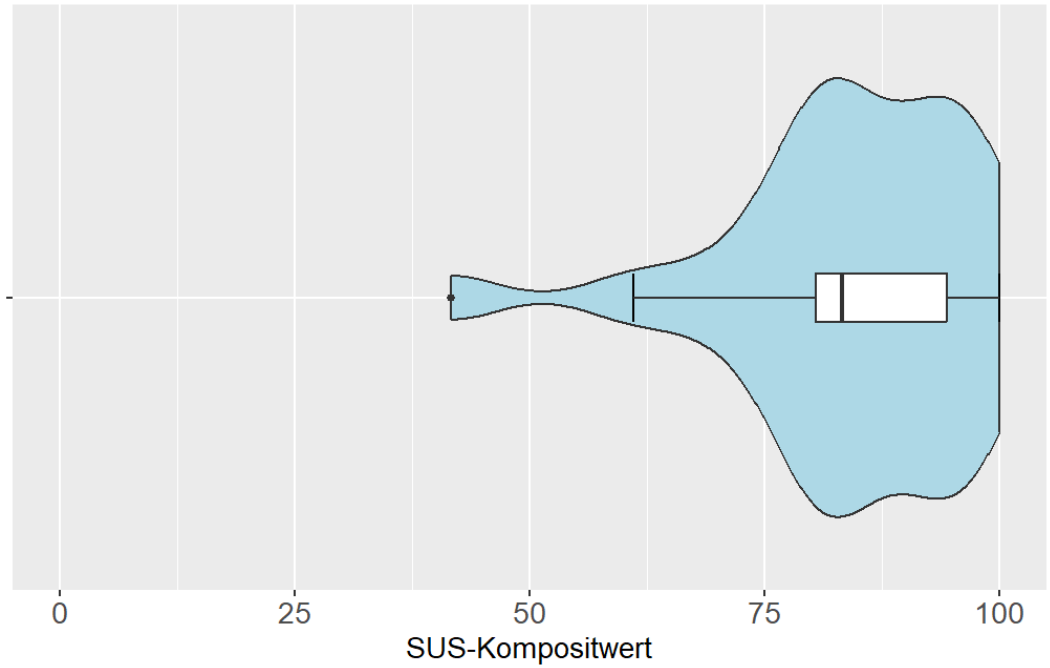
Conducting the user study

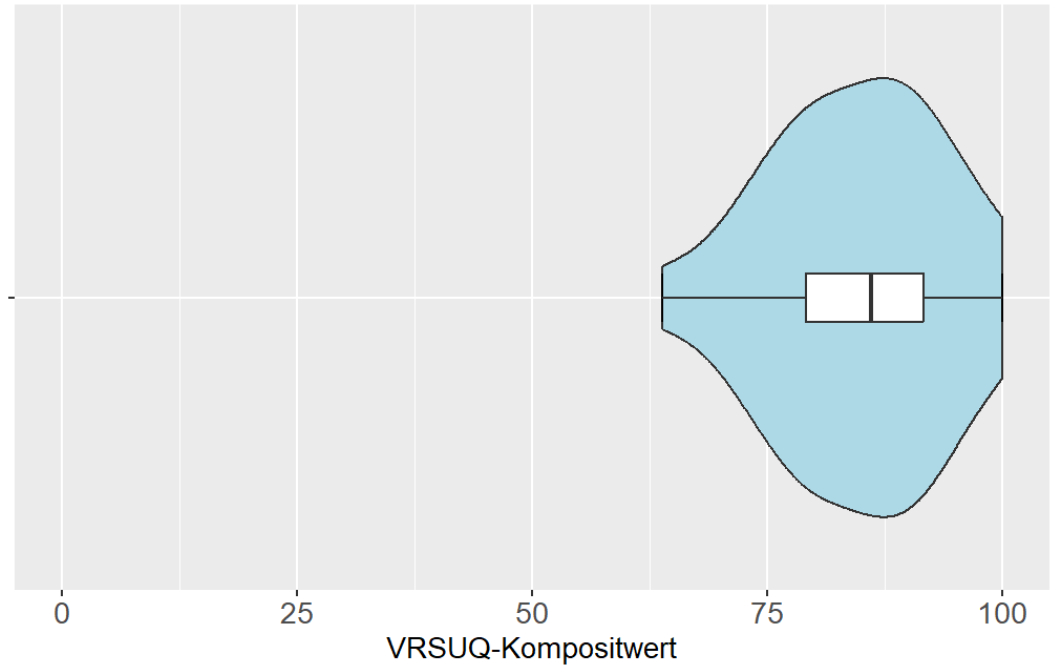




User study results

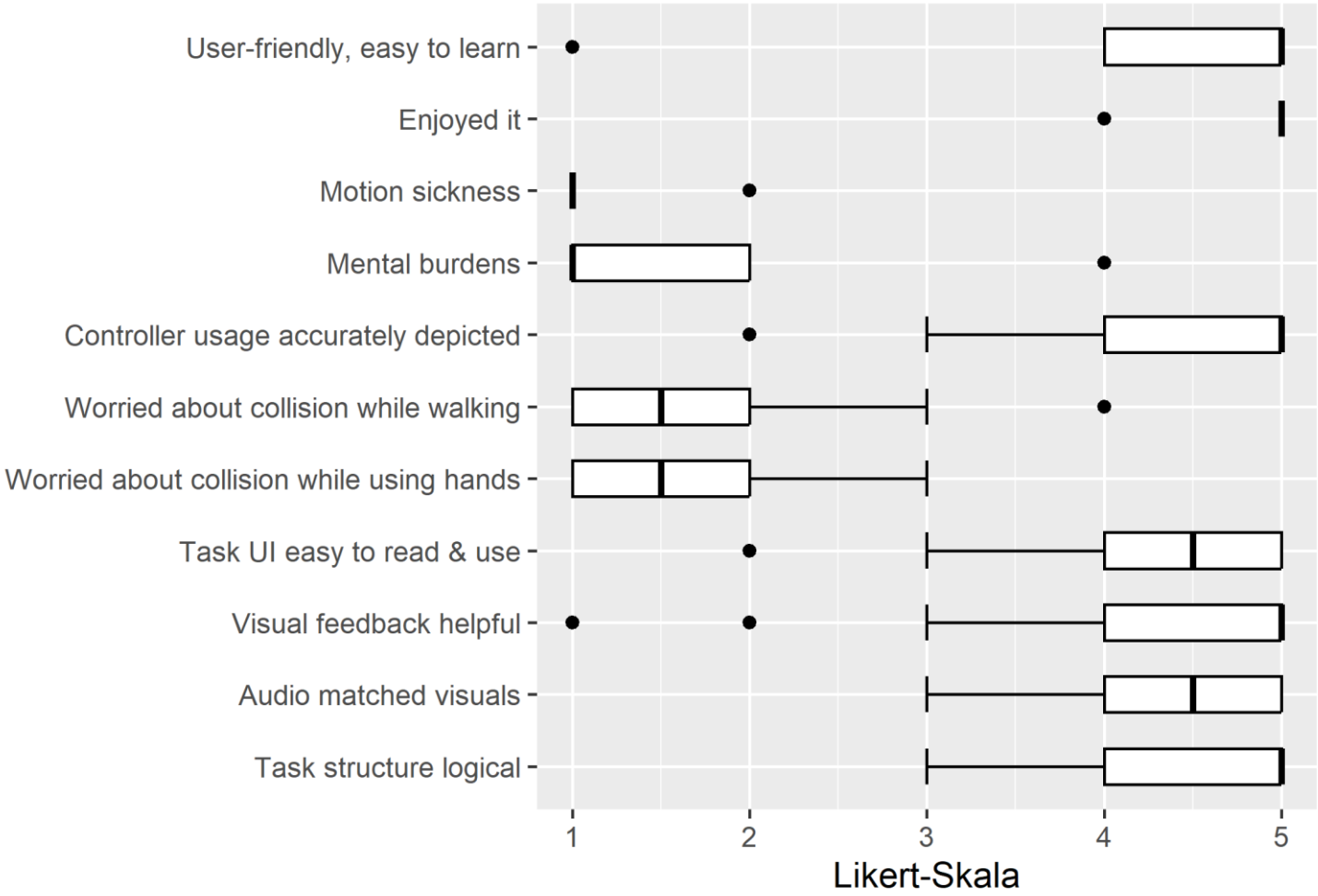
Usability





User study results

Highlights



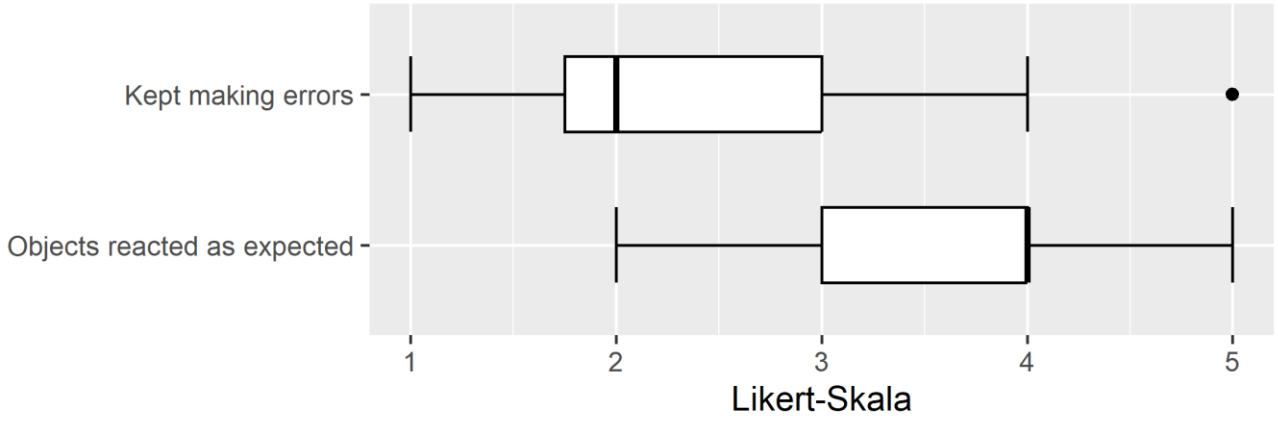
User study results

Highlights

Positive feedback to open questions	Mentions (of 24 total participants)
Realism	5
Interaction	4
Immersion	3
Task design	3
Task UI	3
Audio	3
Environment	3

User study results

Potential improvements

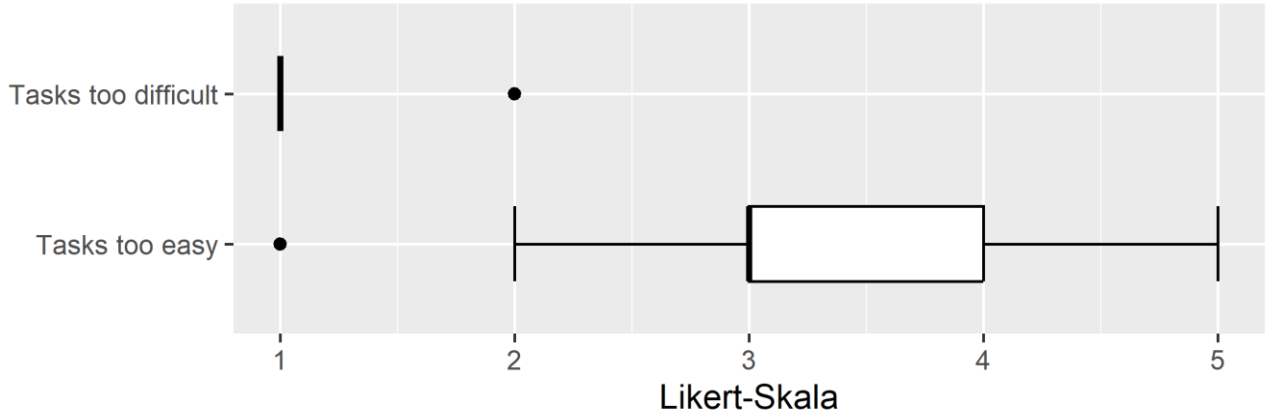


From open questions:

- (8/24) zucchini's cutting point was only at the leaf
- (7/24) zucchini leaves should be movable (with hands)
- (6/24) wrench should be usable from all directions
- (6/24) unexpected impulses from collision

User study results

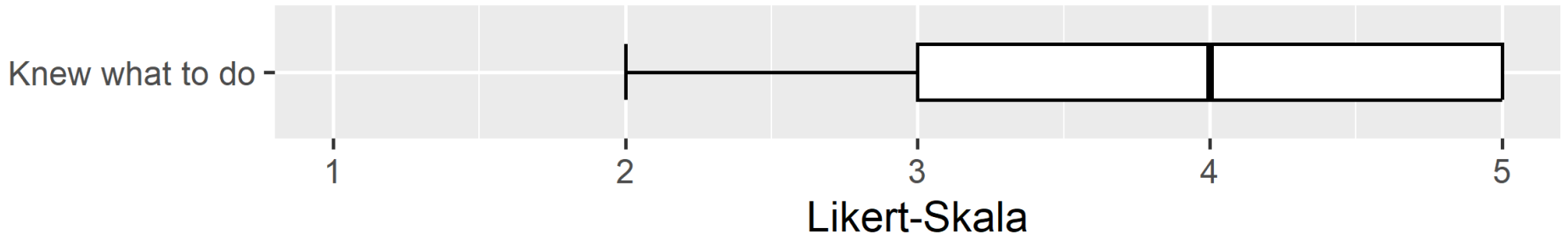
Potential improvements



- Open questions: 5/24 wished for more complex tasks
- 2/24 made mistake during zucchini task

User study results

Potential improvements



Open questions: 9/24 wished for cues/signs, where objects (esp. plants) are

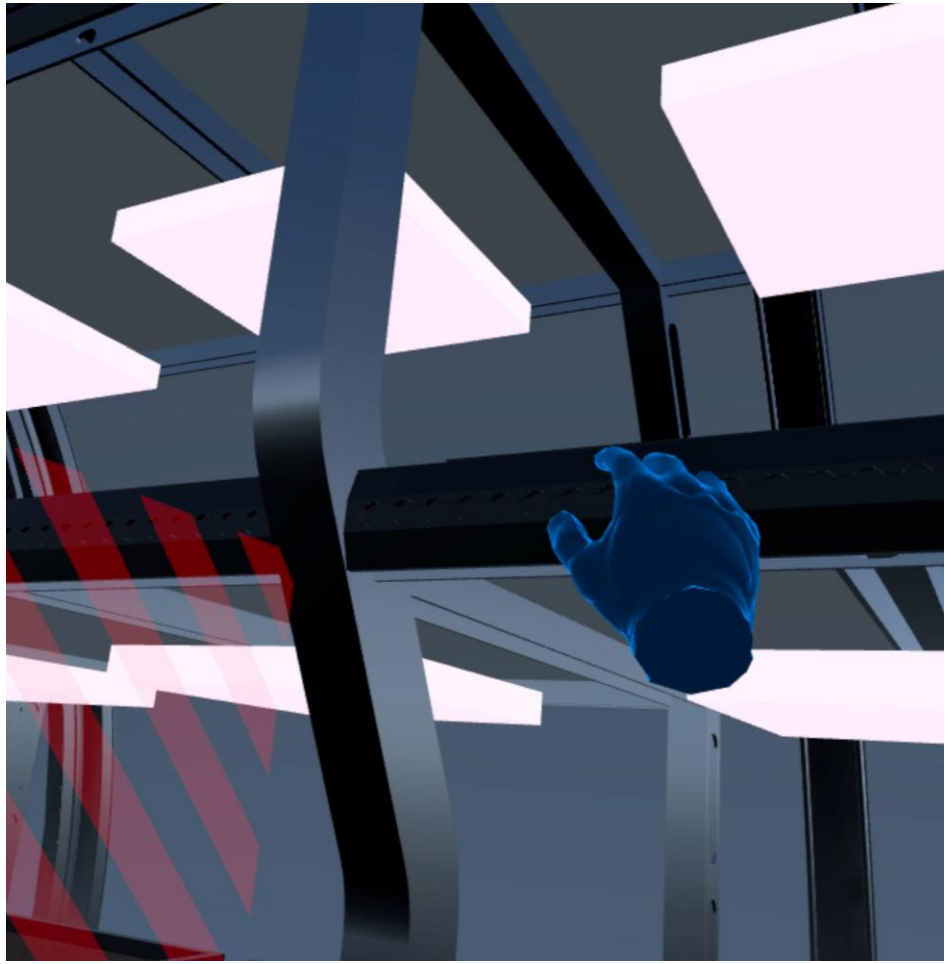
Testing in Bremen



LAM RGS mockup at institute of Space System in Bremen

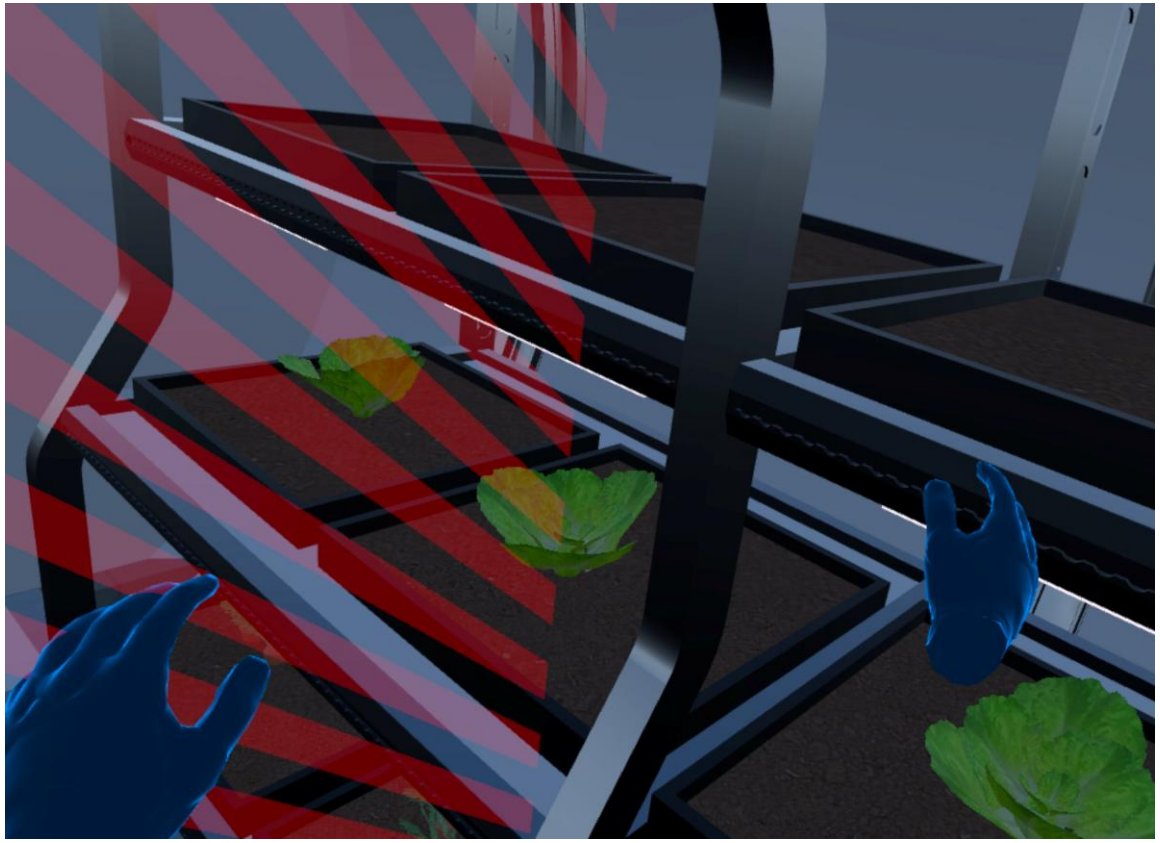
Testing in Bremen



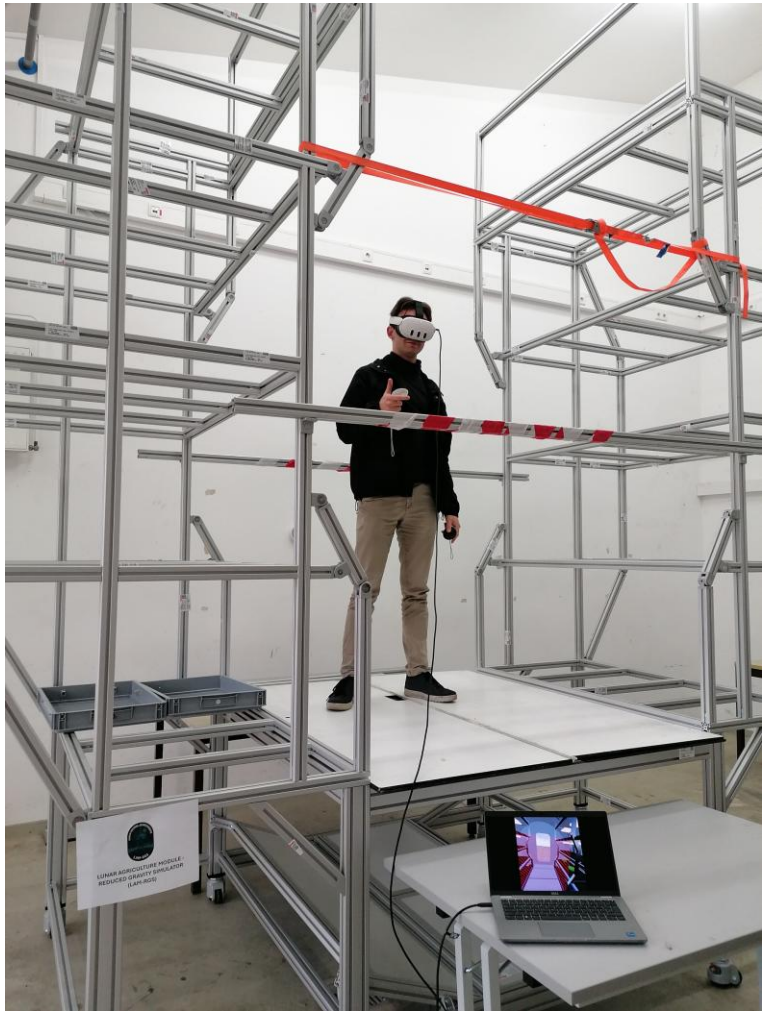


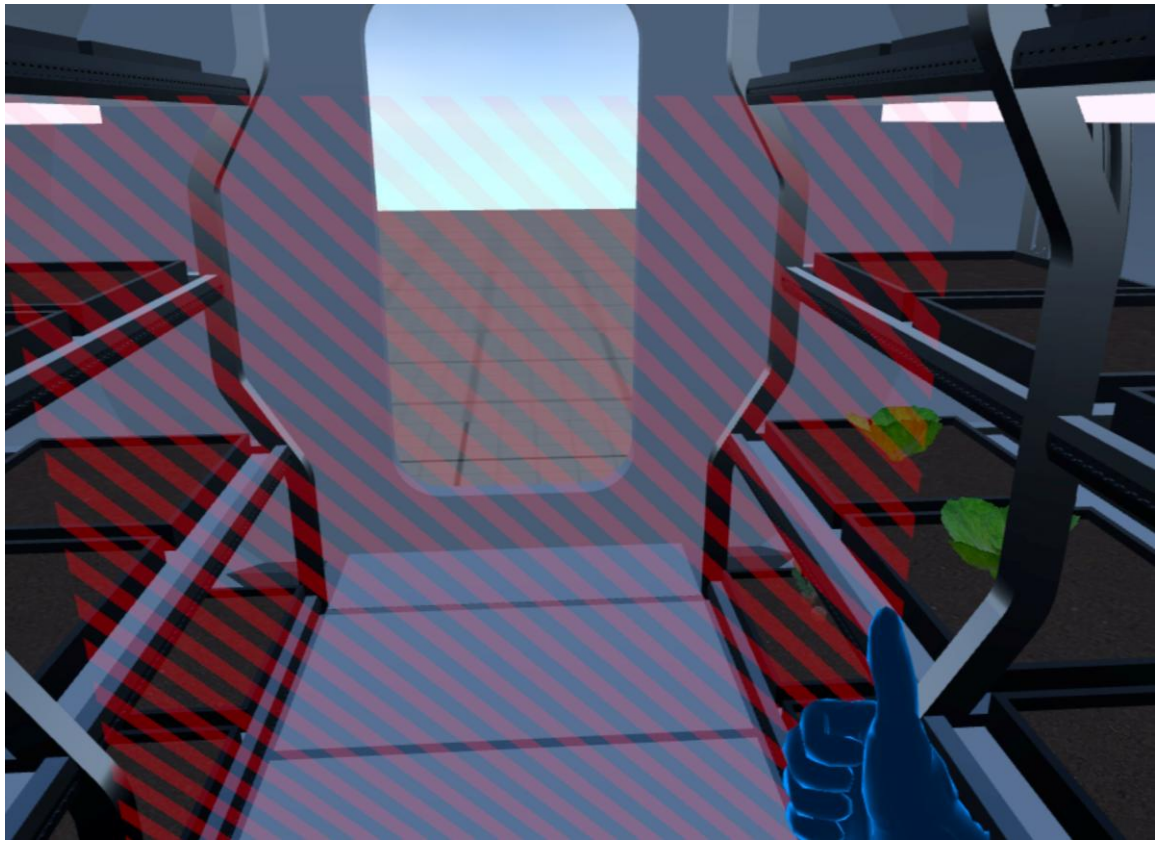
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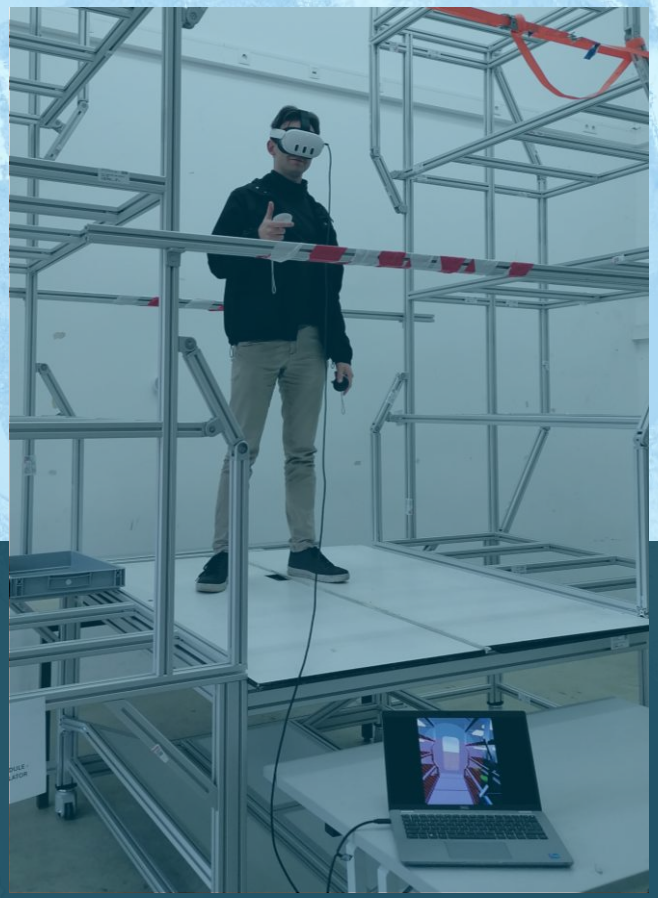




Testing in Bremen







Thank you for your attention!

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Visual Computing and Engineering

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