TraceBot
Traceable robotic handling of sterile medical products

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TraceBot context

- **Considering a process still done manually**

- **Showcase robotic capability in manipulation, verification and traceability**

- **Bring agile production concept into laboratory domain**

- **Address domain specific challenges**

Project state

Healthcare & industrial robotics (ES)   Robotic sensing (AT)   Robotic integrator (UK)

Cluster in medical domain (DE)   Healthcare robotics (FR)   Task-based reasoning (DE)   Use case & regulation (DE)

TRACEBOT

- ☐ Perception
- ☐ Dexterity
- ☐ Control
- ☐ Learning
- ☐ Tracing & Verifying
- ☐ Reasoning

TraceBot highlights - Perception

TRACEBOT

- ☒ Perception
- ☐ Dexterity
- ☐ Control
- ☐ Learning
- ☐ Tracing & Verifying
- ☐ Reasoning

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How to perceive the pharmaceutical items?
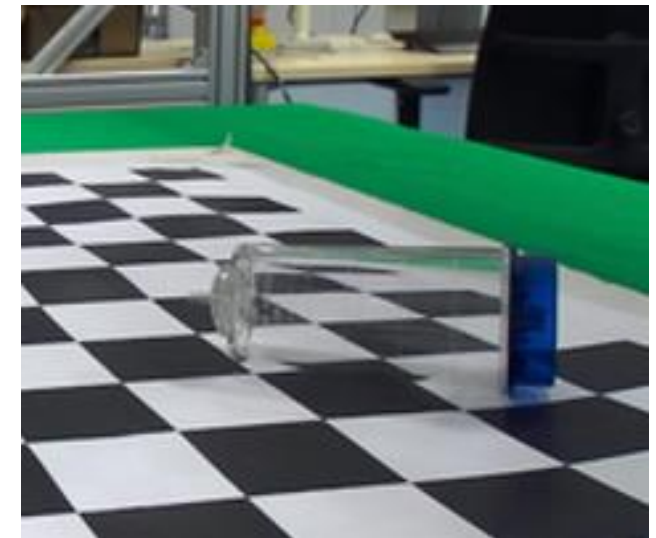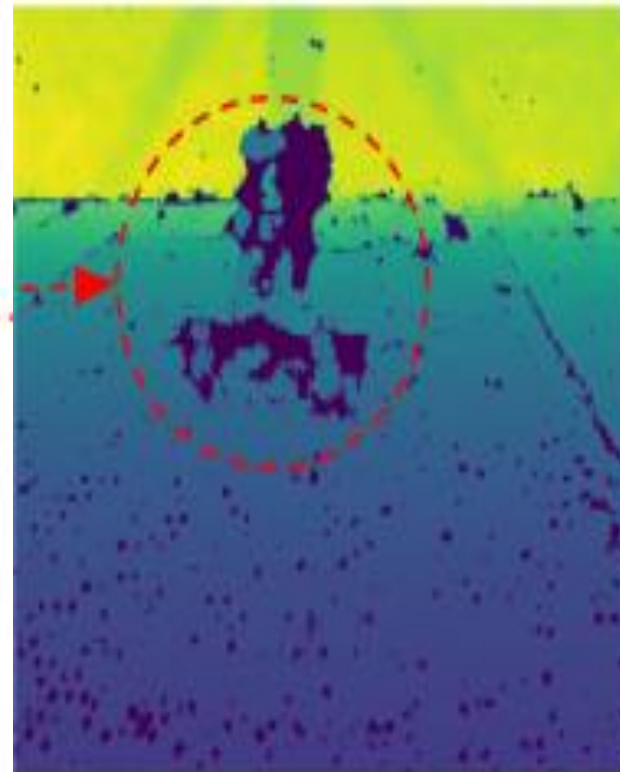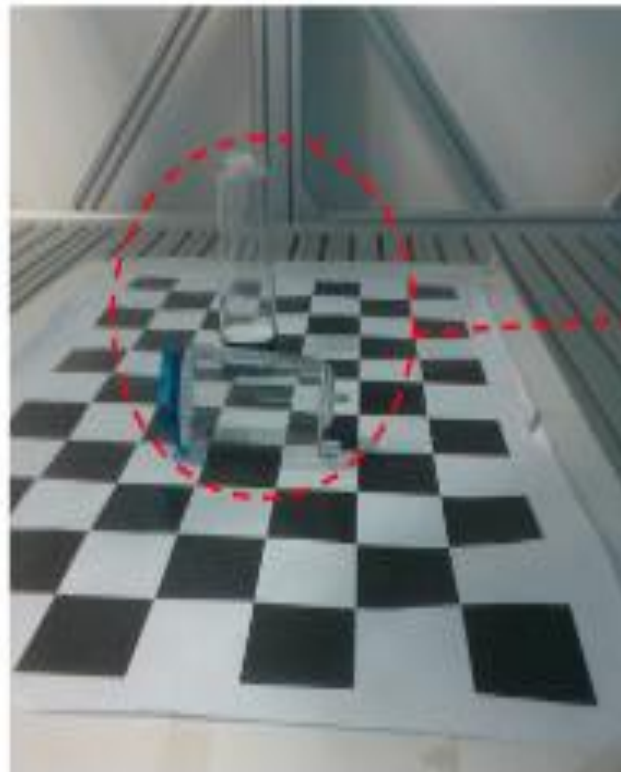
TraceBot highlights - Perception

RGB Image   GT/GDRN Pose   GT/ Ours. Pose
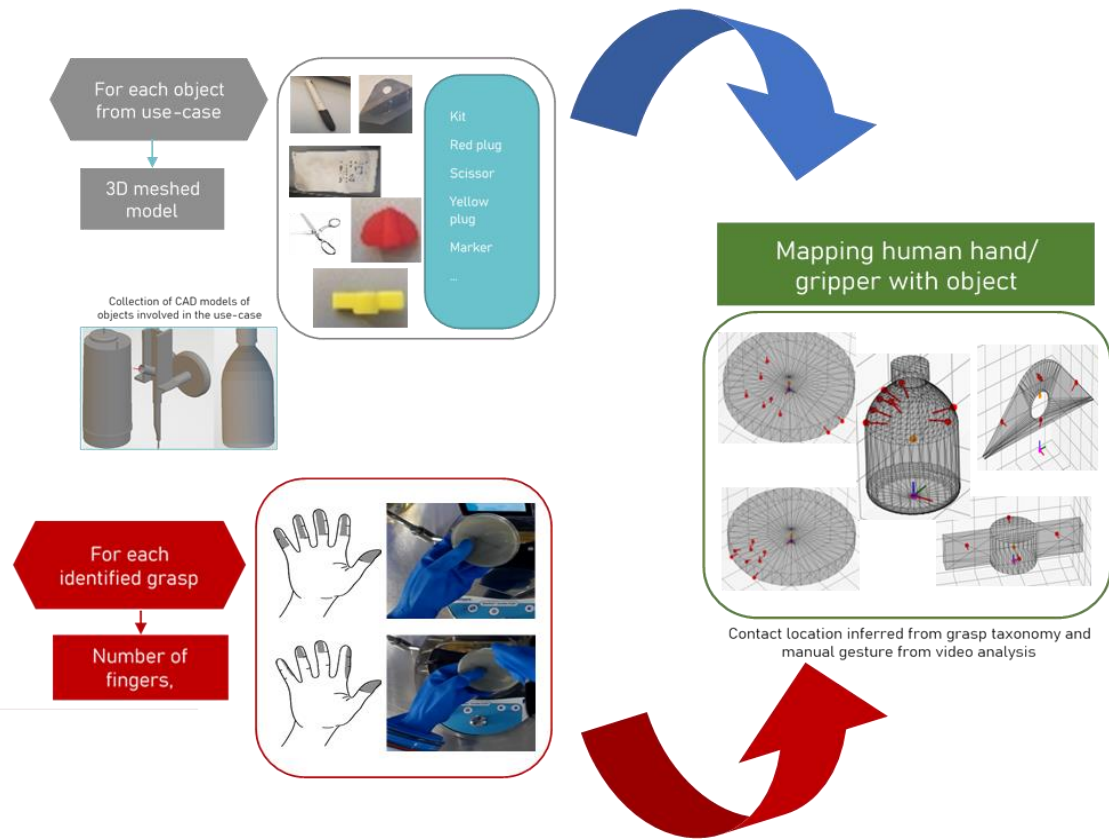
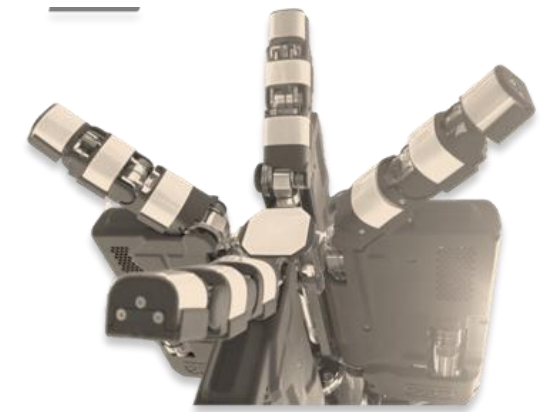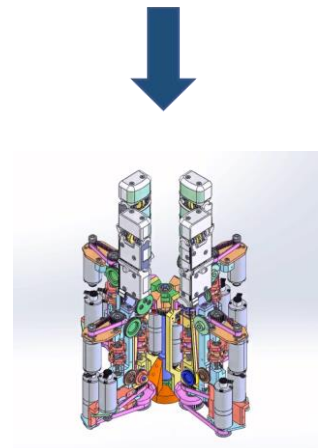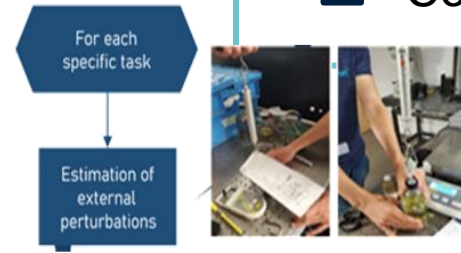# TraceBot highlights - Dexterous manipulation

How to manipulate the pharmaceutical items?

Perception ☐   Learning ☐
Dexterity ☒   Tracing & Verifying ☐
Control ☐   Reasoning ☐

For each object from use-case → 3D meshed model

Kit
Red plug
Scissor
Yellow plug
Marker
...

Collection of CAD models of objects involved in the use-case

For each identified grasp → Number of fingers,

Mapping human hand/ gripper with object

Contact location inferred from grasp taxonomy and manual gesture from video analysis

For each specific task → Estimation of external perturbations
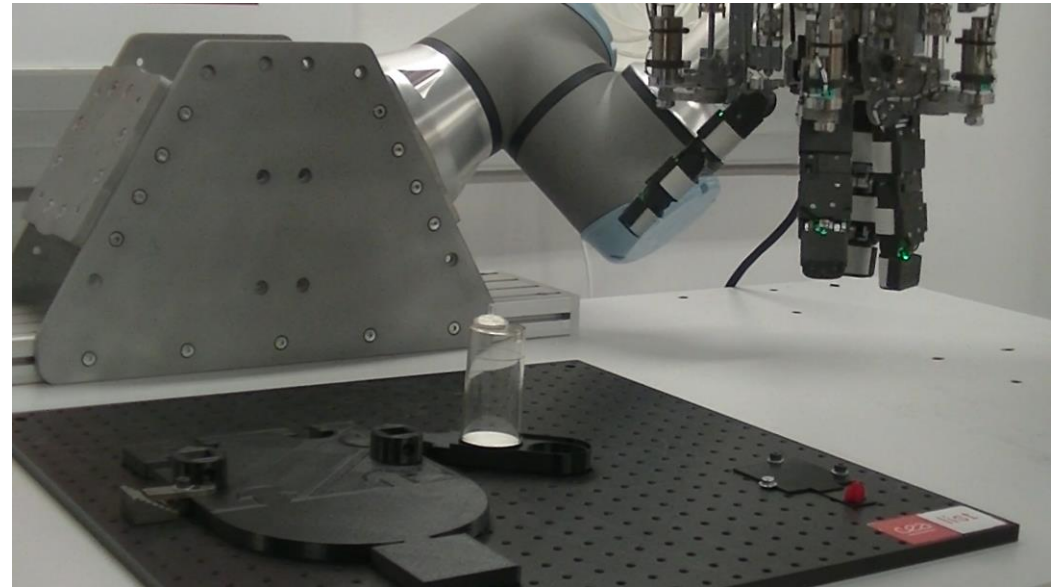
TraceBot highlights - Dexterous manipulation

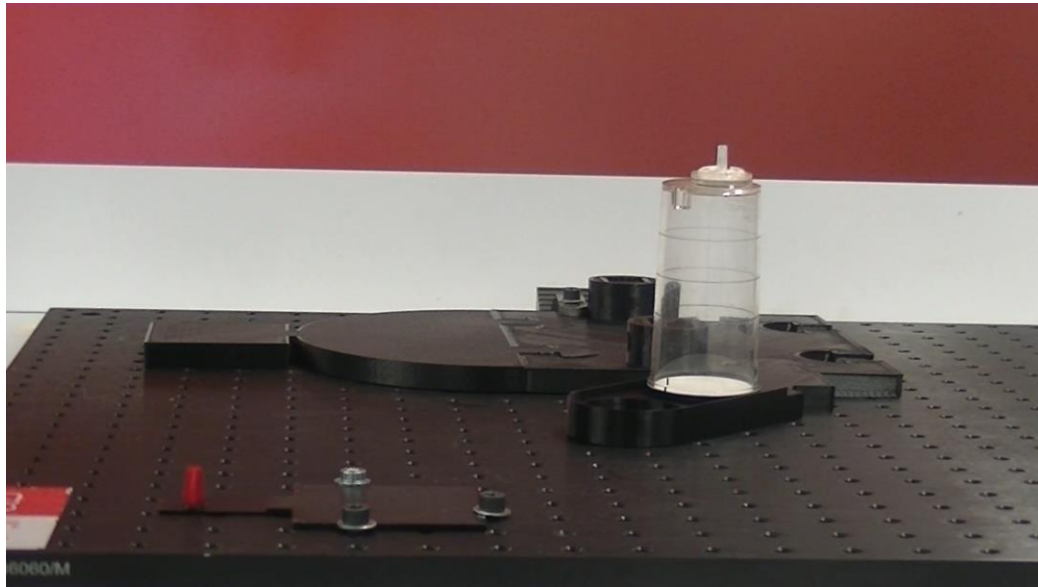Bottle in holder

Canister

Clamp

Connecting   Pharmaceutical   Knowledge
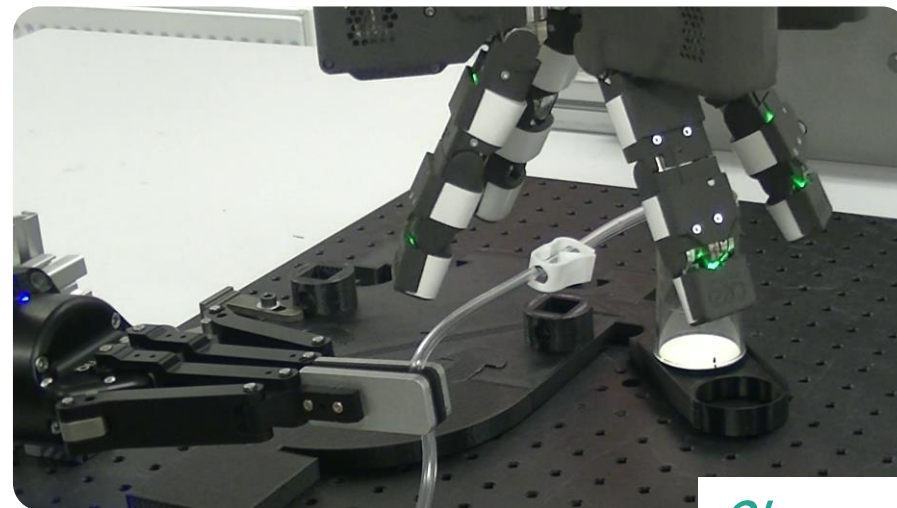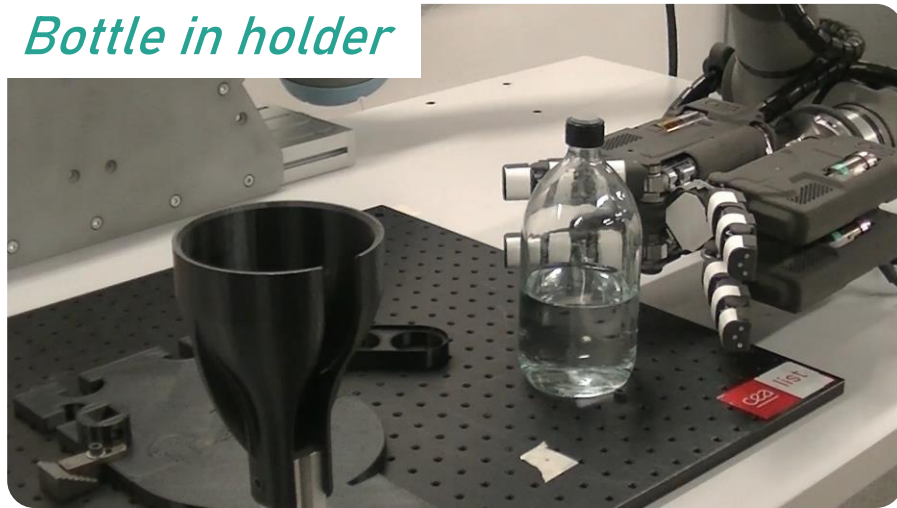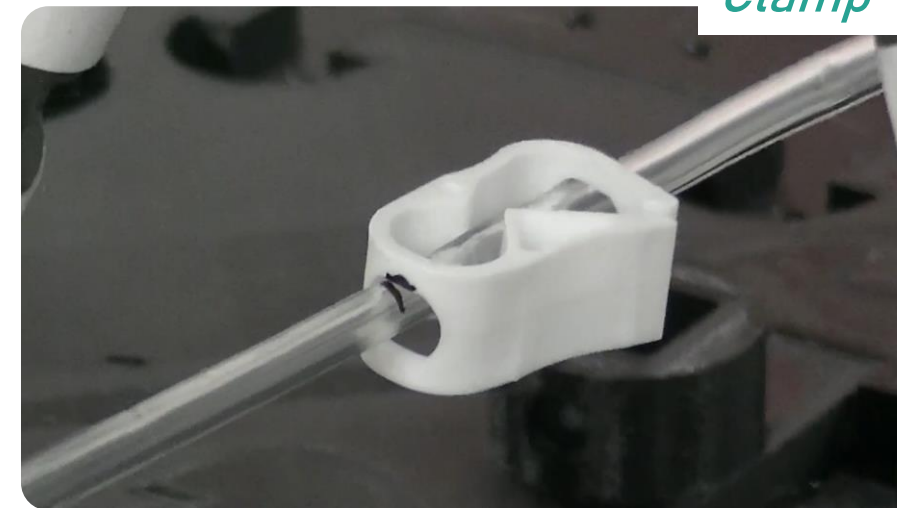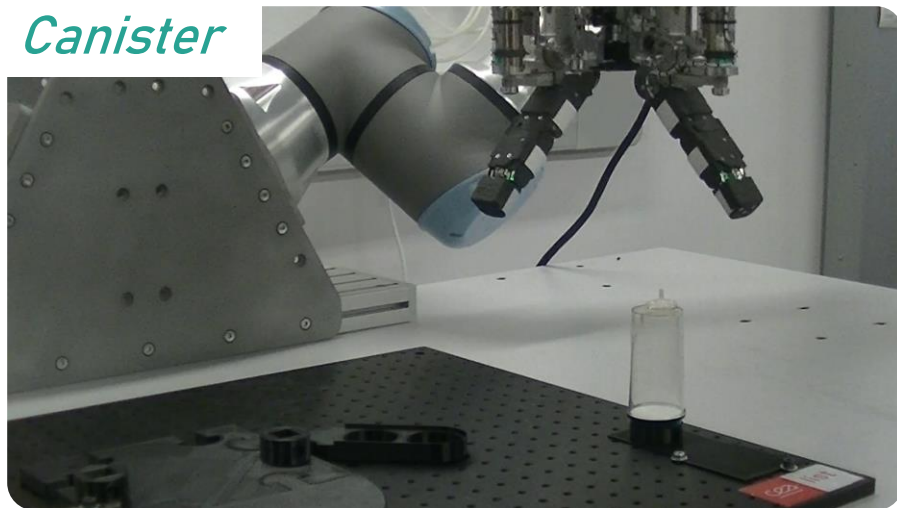
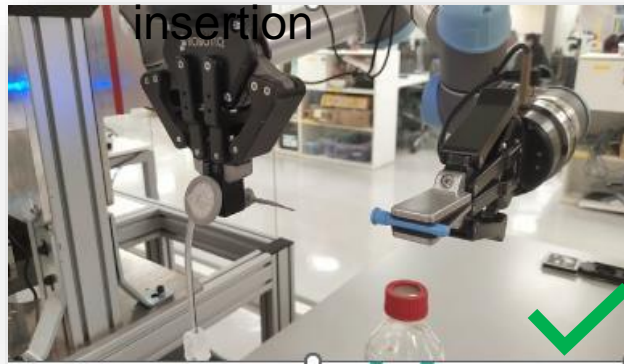# TraceBot highlights - Dexterous manipulation
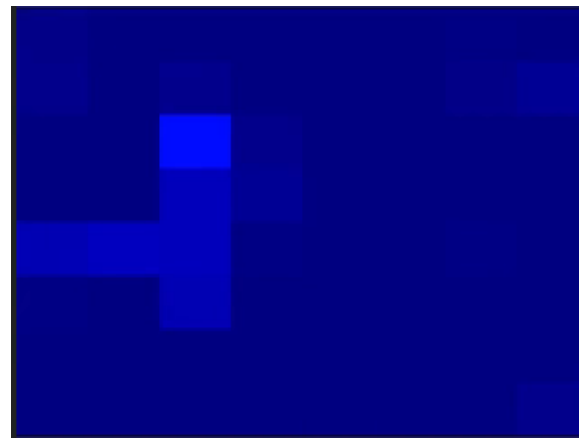
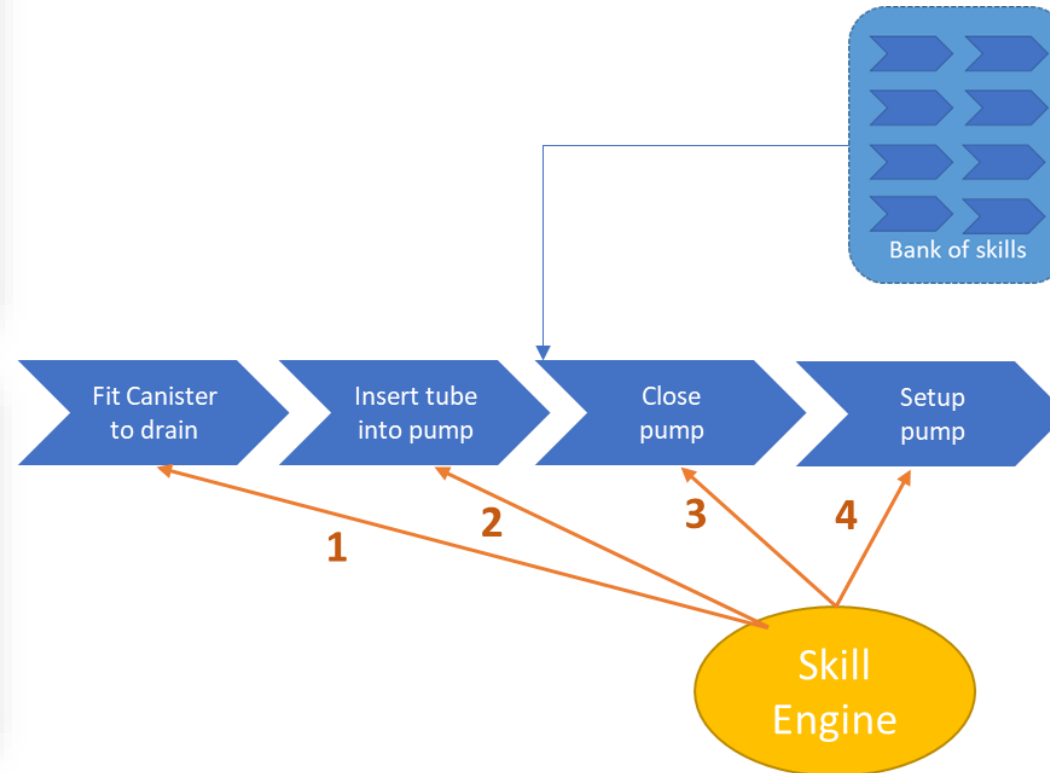# TraceBot highlights - Robot Control

How to control the robot - System control through skill framework (and ROS)
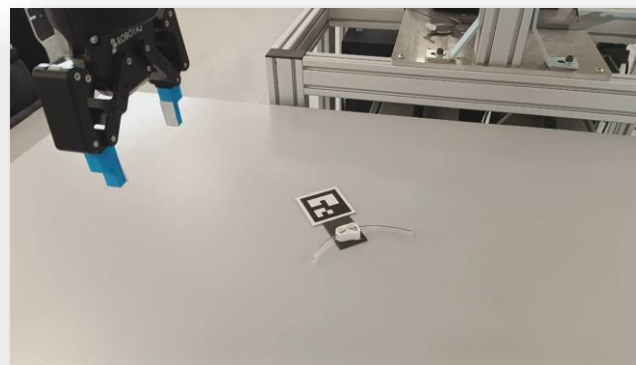

Canister insertion

Needle manipulation

TRACEBOT

- ☐ Perception
- ☐ Dexterity
- ☒ Control
- ☐ Learning
- ☐ Tracing & Verifying
- ☐ Reasoning

Bank of skills

| Fit Canister to drain | Insert tube into pump | Close pump | Setup pump |

1   **2**   **3**   **4**

Skill Engine

TraceBot highlights - Robot Control

Canister insertion

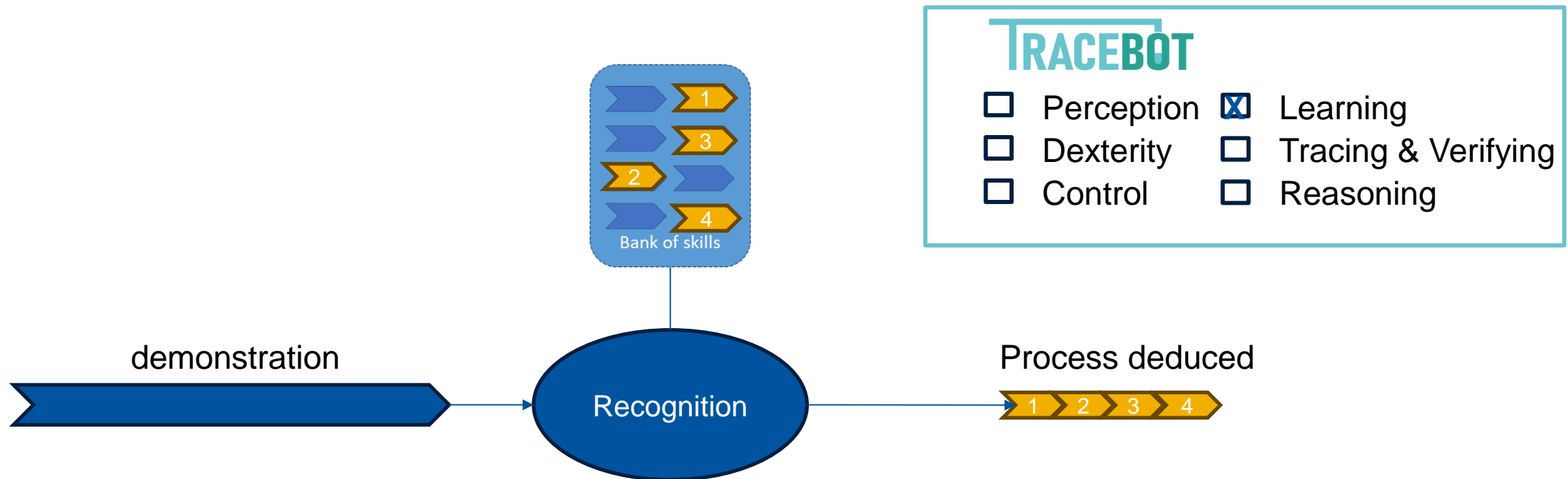Clamp manipulation

Needle manipulation

TraceBot highlights - Robot Control
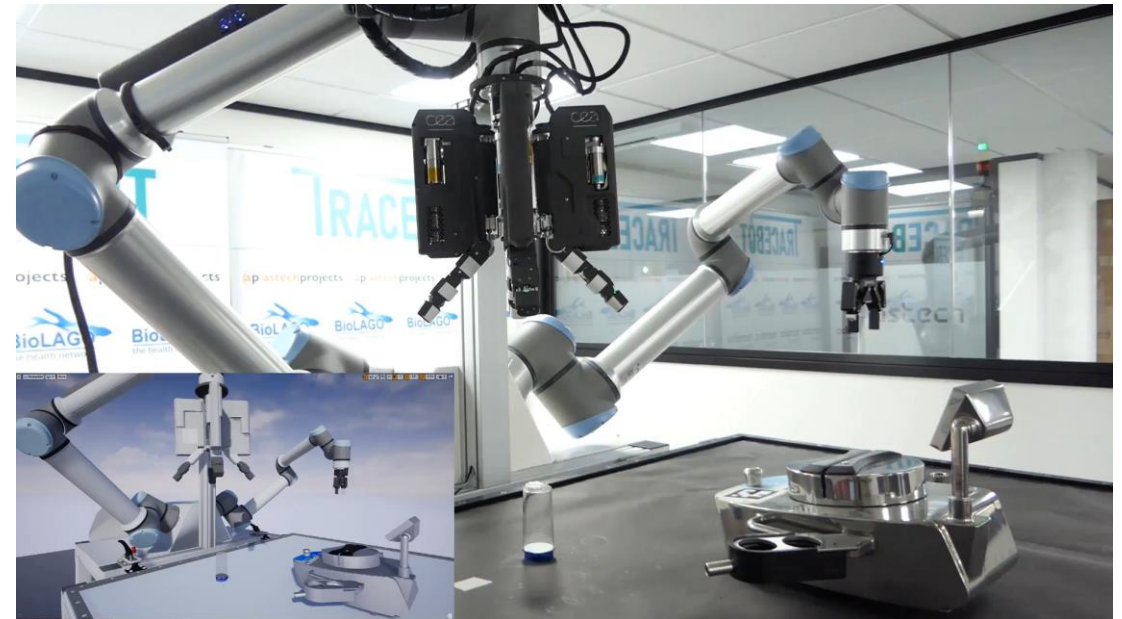
TraceBot highlights - Learning

How to teach new behavior - Process demonstration & recognition
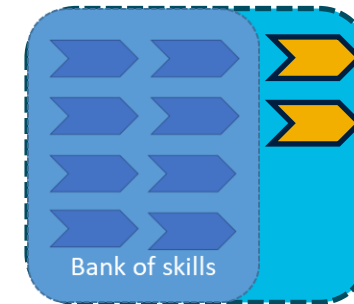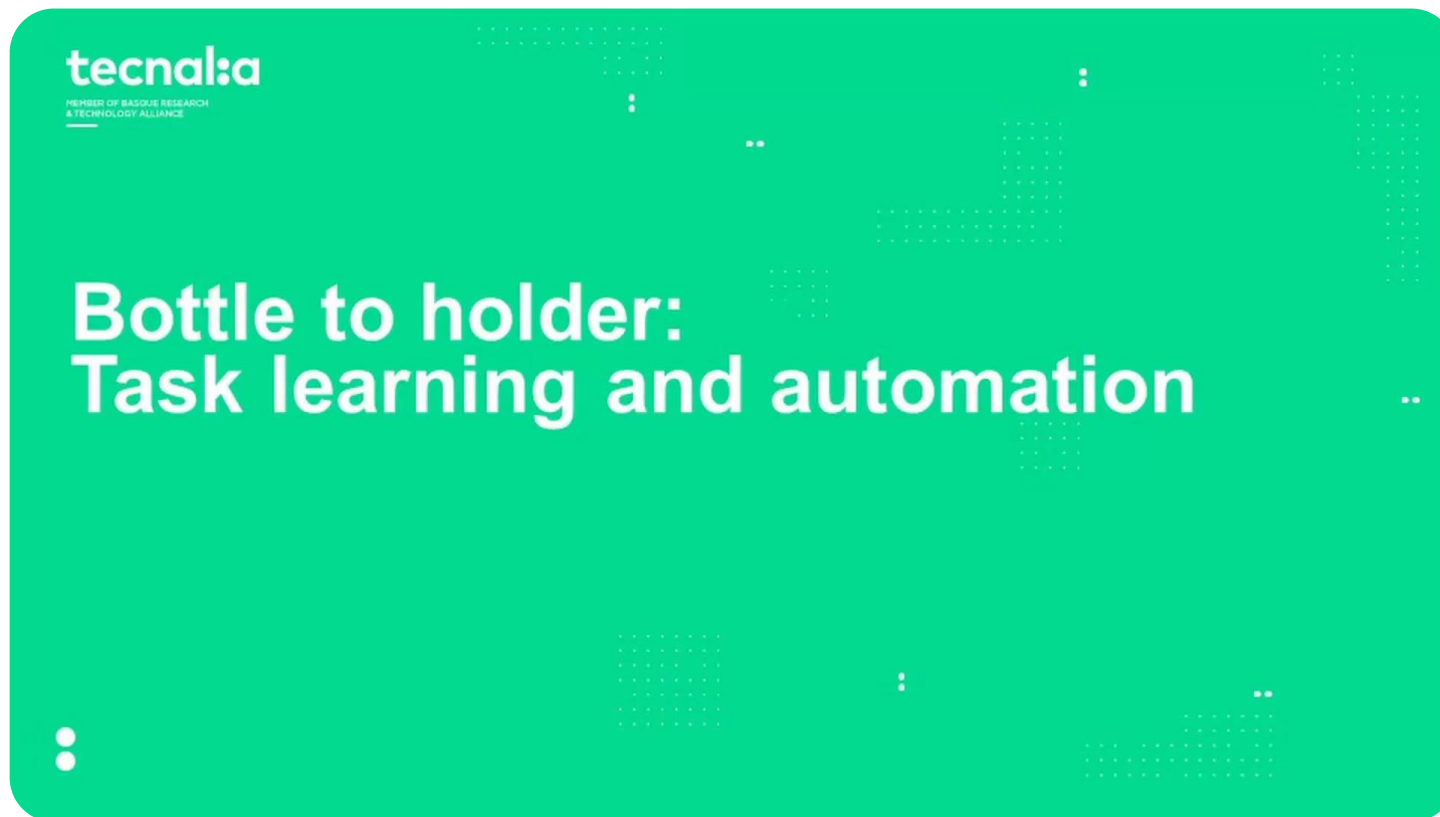

- ☐ Perception ☒ Learning
- ☐ Dexterity ☐ Tracing & Verifying
- ☐ Control ☐ Reasoning

Bank of skills

demonstration

Recognition

Process deduced

1 2 3 4

TraceBot highlights - Learning

Robot camera view

To start programming, the user only needs to perform the task with the robot.

TraceBot highlights - Learning

How to teach new behavior - Specific motion learning through (teleoperated) demonstration

Bottle to holder:
Task learning and automation

Bank of skills

TraceBot highlights - Reasoning

Universität Bremen

How to understand and control what is going on?

TRACEBOT

☐ Perception
☐ Dexterity
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☒ Reasoning

Traceable Semantic Twin – Digital Twin
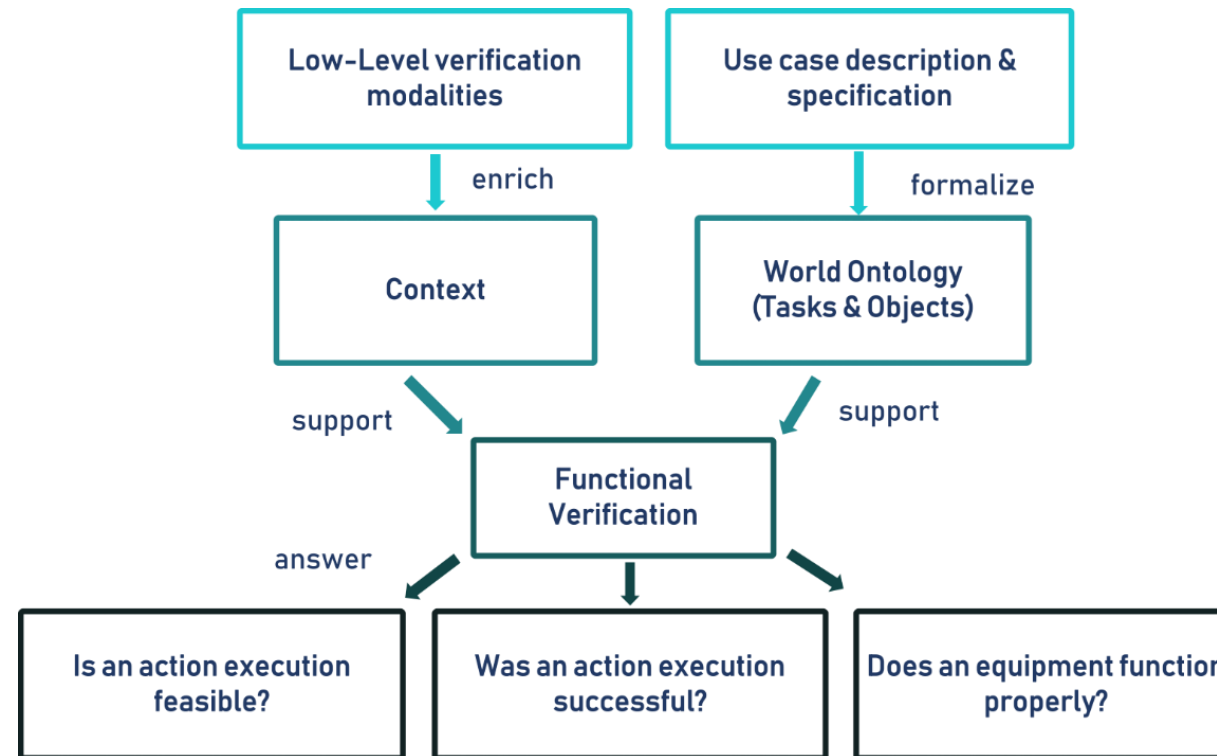
Functional verification

TraceBot highlights – Reasoning for verification
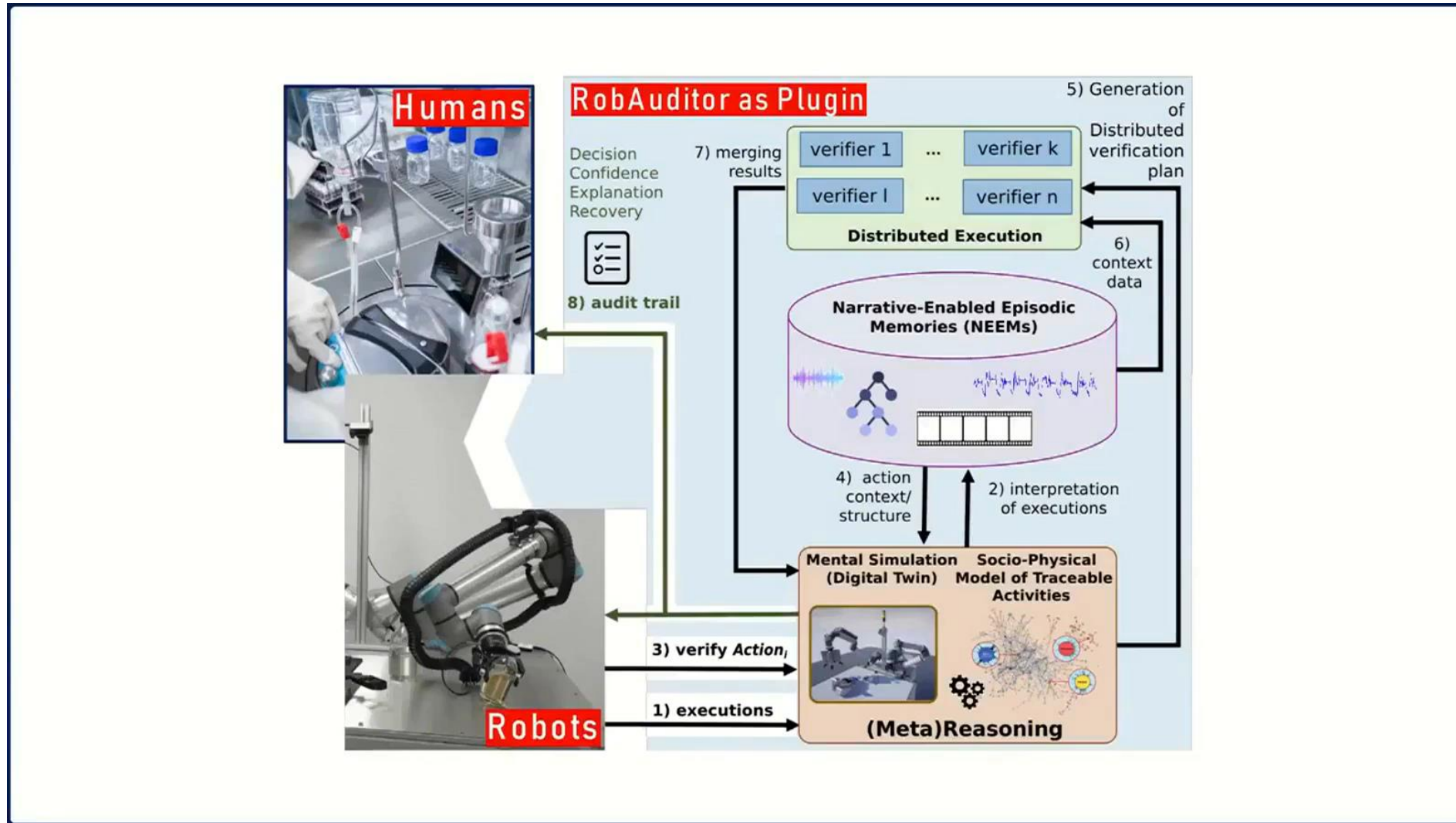
TraceBot highlights – Reasoning for verification
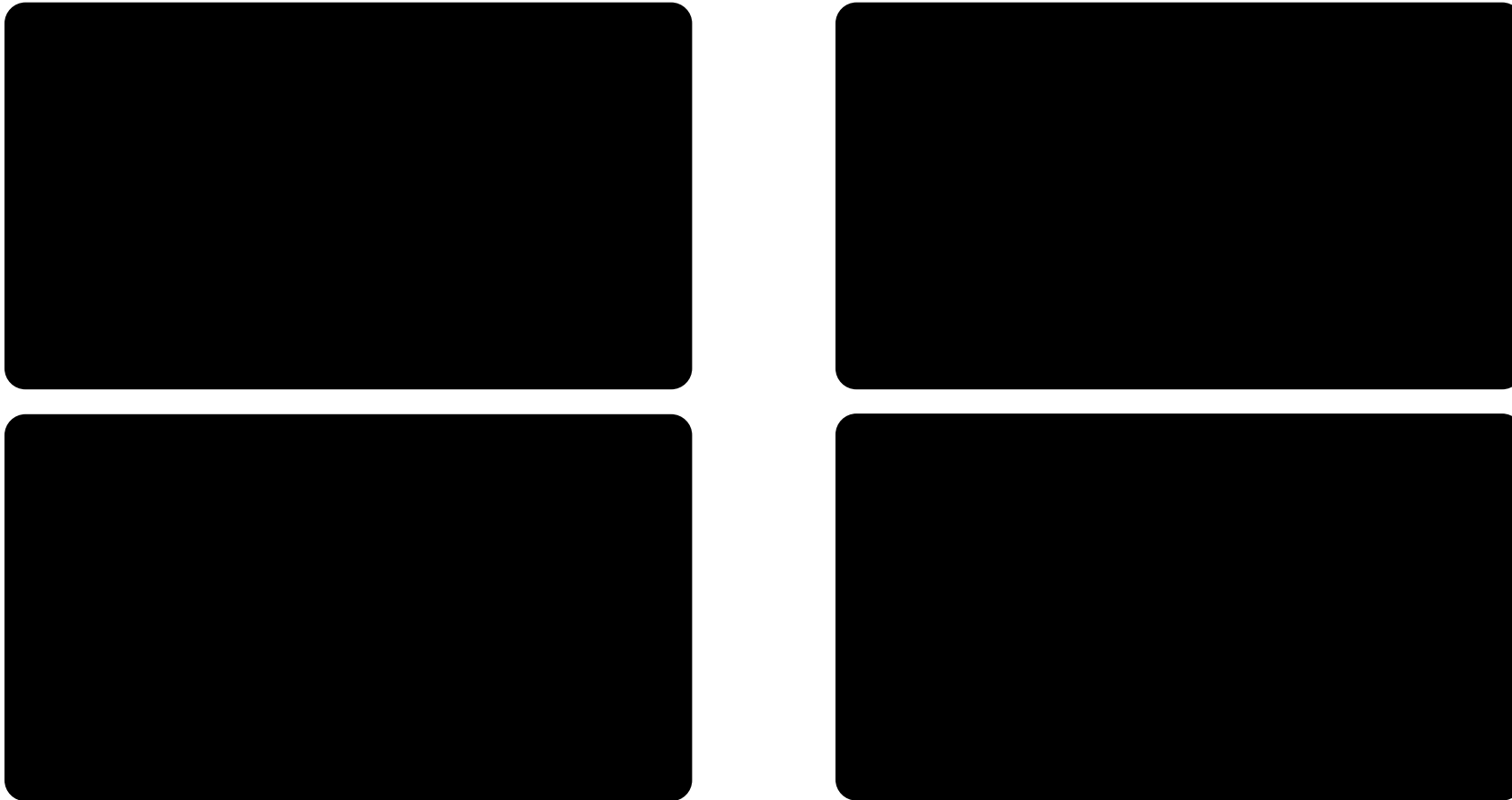
Illustration of the verifiers

TraceBot highlights – Reasoning for verification
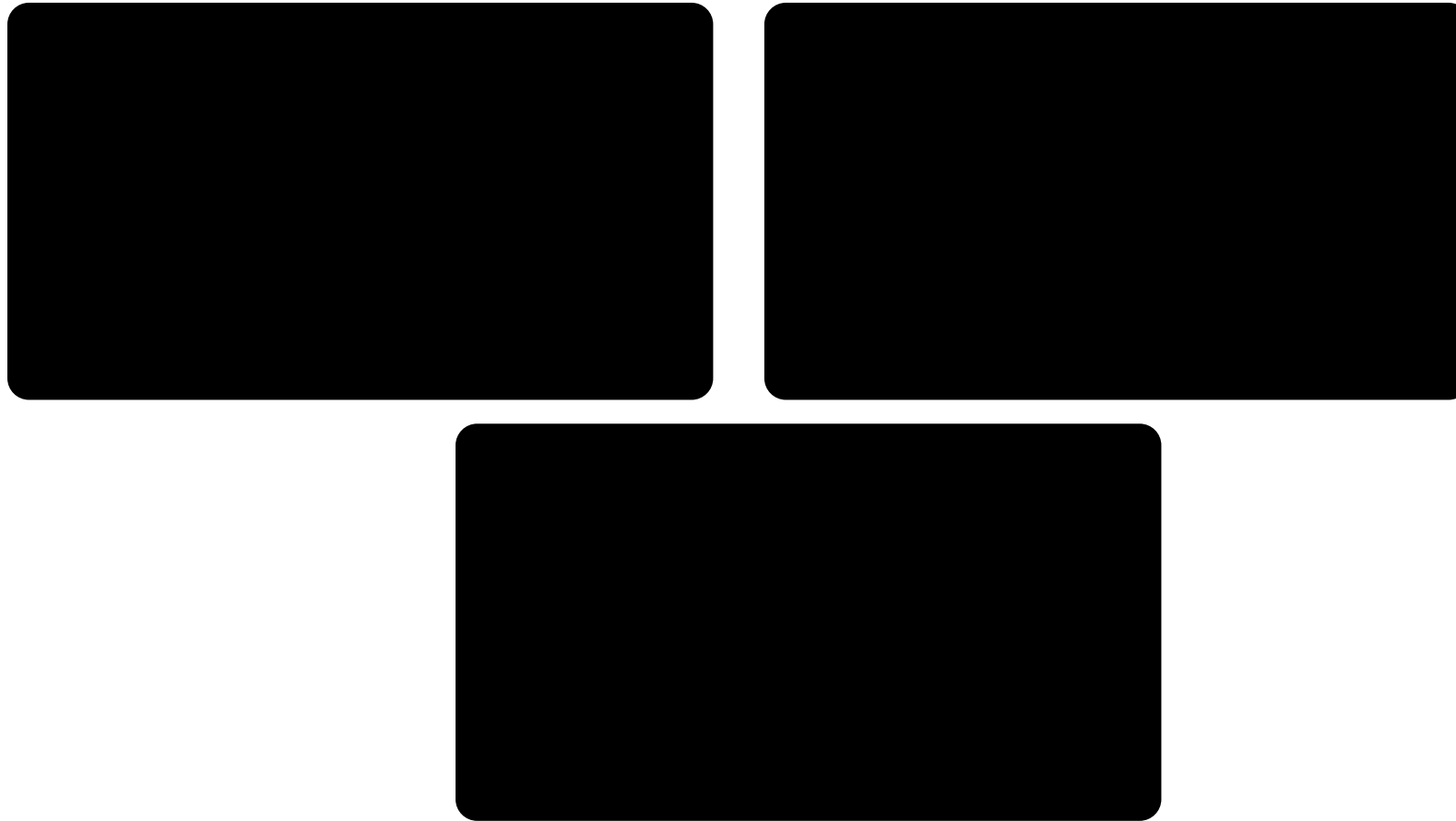
Illustration of the verifiers

TraceBot highlights - Reasoning

How to understand and control what is going on - Audit Trail with verification and traces

Summary

Semantics

Verification

Action Tree

Conclusions

Several progresses towards sterility testing automation

Dexterity, perception, robot control, tracing & verification, reasoning

Programming interface, programing by demonstration, integration

Combining several steps into unique demonstration

Conducting acceptance test to check progress

Concepts applicable to other processes

Looking for more use cases to confirm technique validity

Pending / challenging steps

Small object manipulation

Deformable consumable management

Object affordances management

Thank you

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