Integration of supportive robots in R&D laboratories using the LAPP framework

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RAYA 2023 Finalist Event

Agenda

1. Robotized lab automation systems and their challenges
2. Problem statement and scope of our project
3. Simulations
4. On-site demo
5. The Laboratory Automation Plug & Play framework
   as a reference architecture model

Laboratory automation in R&D

High throughput

- Routine tests, repetitive workflows
- Highly customized purpose-made cells
- Set-up-and-leave / lights-out

High flexibility

- Dynamic workflows
- Stand-alone, often not robot-friendly devices
- Humans need to interface and connect these

Collaborative & mobile robotics

- Operate in human-designed (less-structured) environments
- Interface with modular and modular equipment
- Cooperative & collaborative operation

	Stationary robot	**MoMa***	**Human**
Throughput	High	Low	Middle
Availability	High	Middle	Low
Flexibility	Low	High	High

* Mobile manipulator robot

Mobile manipulators in laboratory automation

Usage
- Pick & place type sample transportation
- Standard objects
- Pre-defined hand-over positions

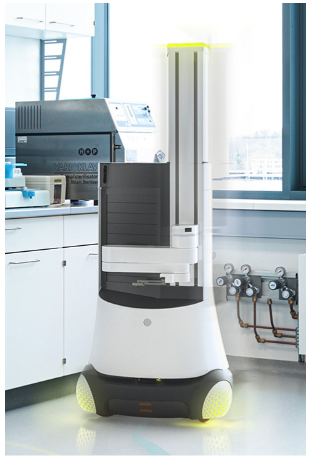
Anatomy
- Mobile base with simultaneous localization and mapping (SLAM)
  - cm accuracy
- Robot arm of 4-6 degrees-of-freedom (DoF)
- Fine-positioning system
  - Vision [13]
  - Mechanical probe
- Parallel gripper
  - Mostly for microplates [16]

Challenges
- Complex, multi-layer integration
- Many inter-connected components
- Many sources of errors

Omnidrive

Differential drive

Small circular footprint
4 DoF (SCARA)



KEVIN – Fraunhofer IPA

OMRON – Biosero

Bigger rectangular footprint
6-7 DoF articulated arm

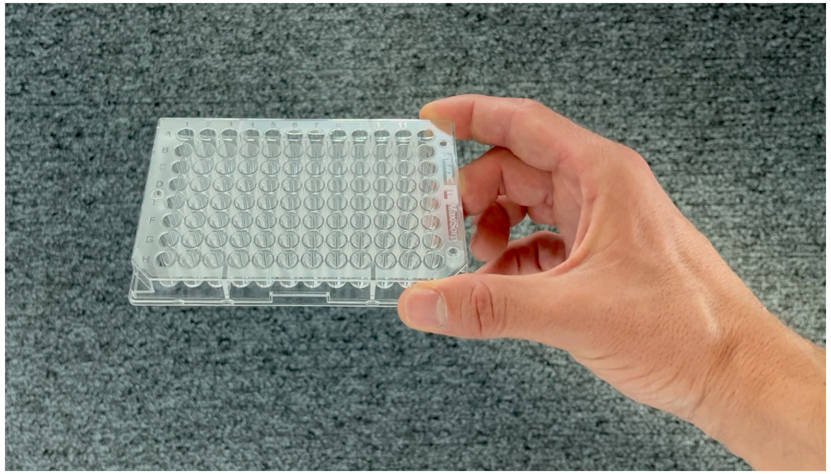
KUKA – Gearu

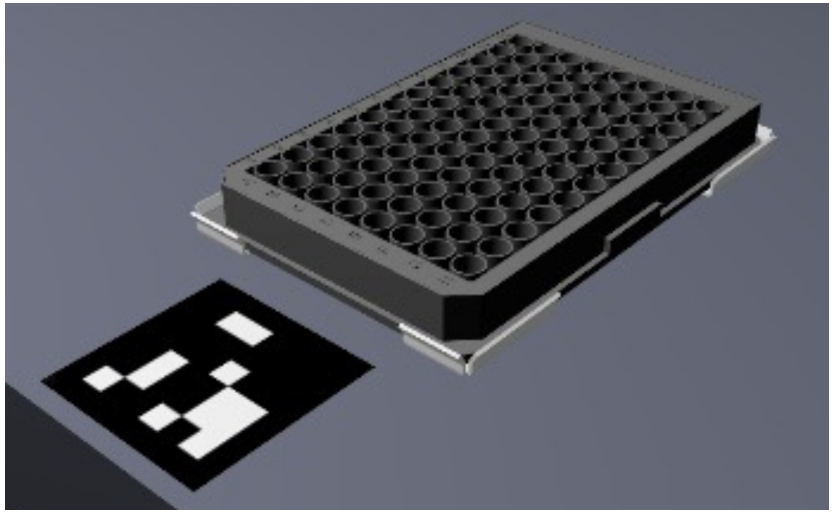
UniteLabs – Astech Projects

The use case

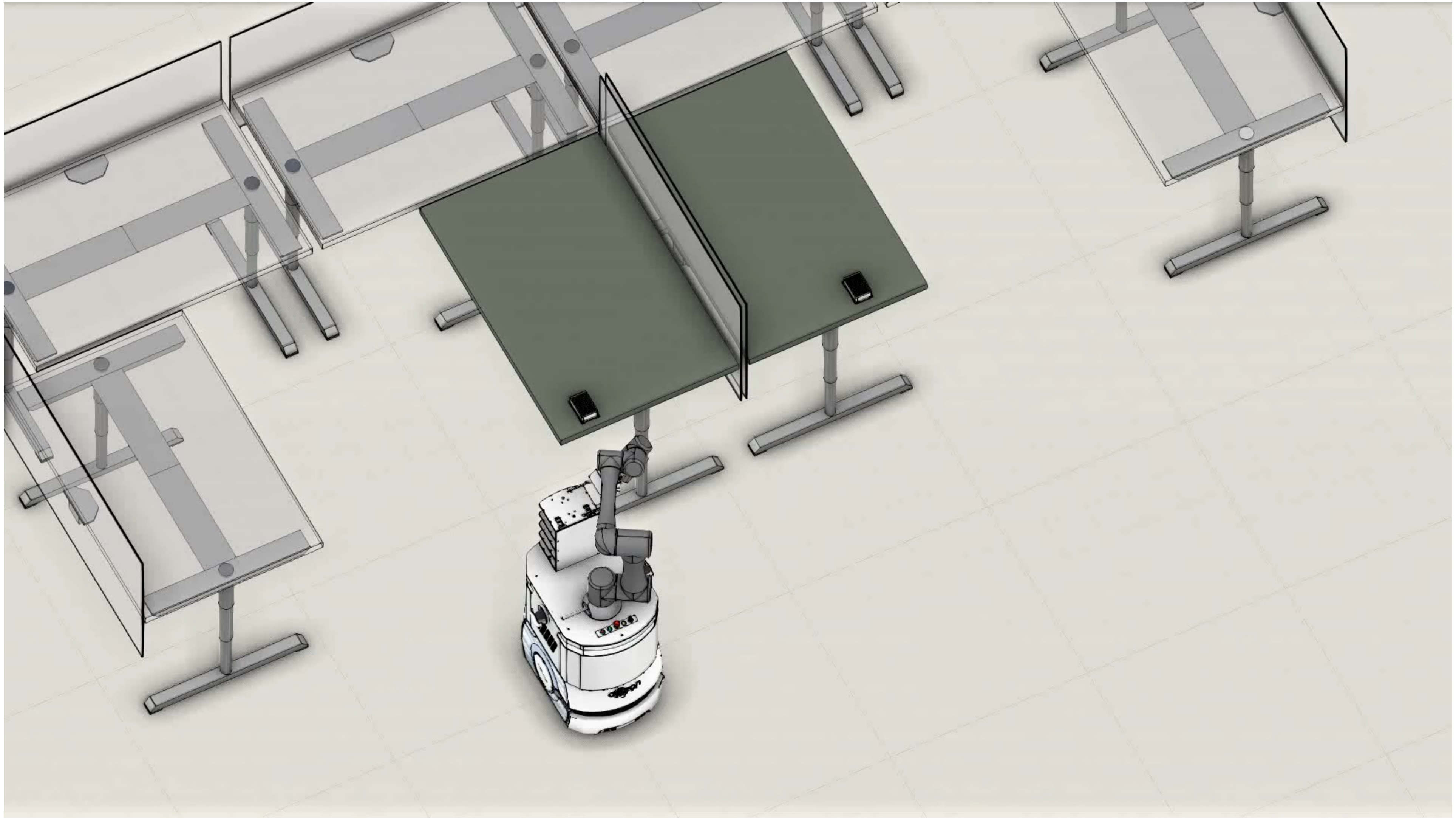
Pick-and-place transportation of standardized sample containers

- ANSI/SLAS-conform (aka. SBS) microplate[1]
- Fixed hand-over positions (aka. sites) within lab devices
- Fixtures (aka. nests) that allow < 1mm tolerance
- Landmarks (aka. fiducial markers) for position detection
- Pick-up (source) and drop-off (destination) positions selected via command parameter
- Source and destination can be located across the room
- Secondary scope: different rooms/floors → elevator access

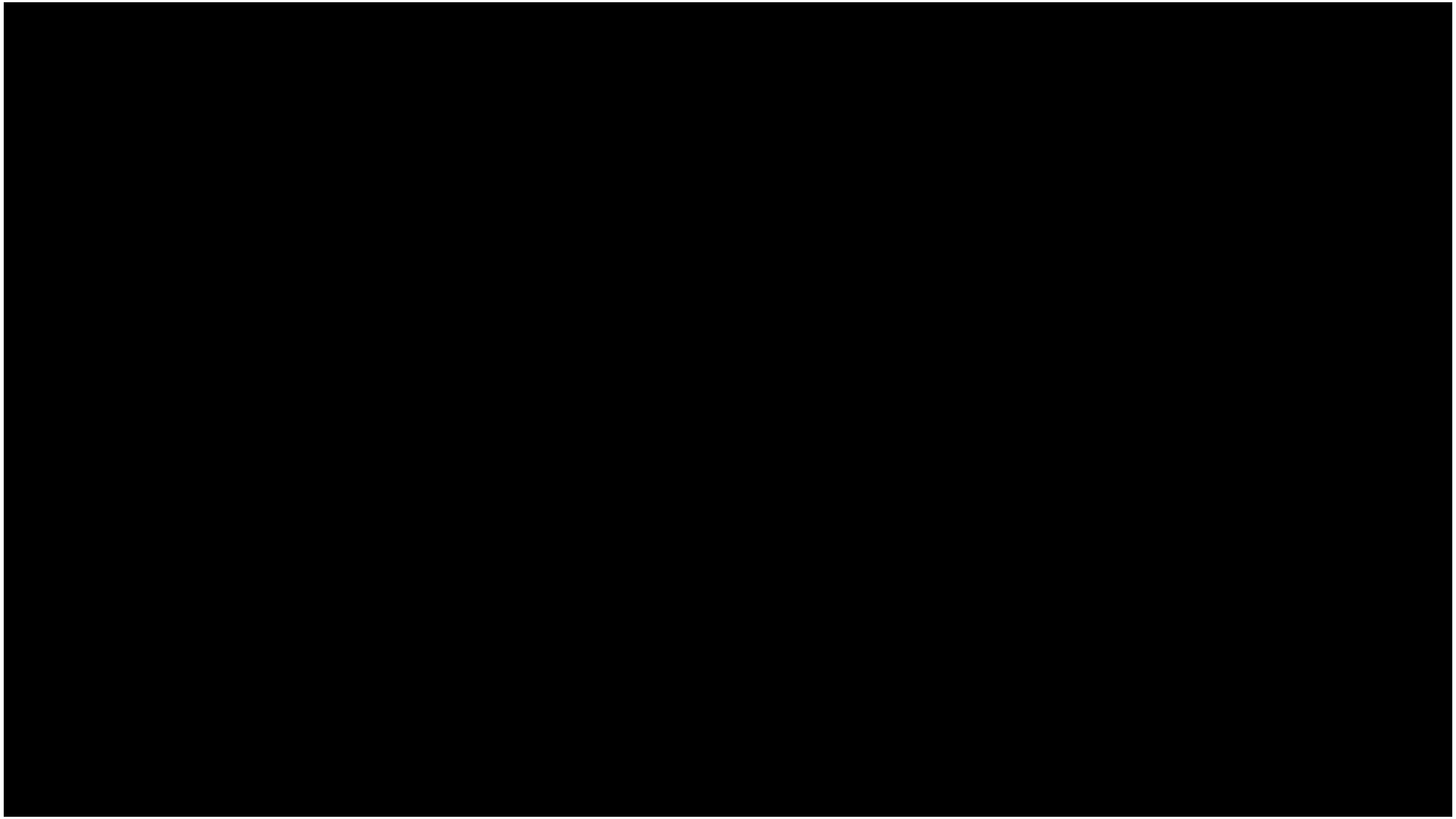




Pick-and-place simulation



MoMa interfacing with storage unit - Simulation



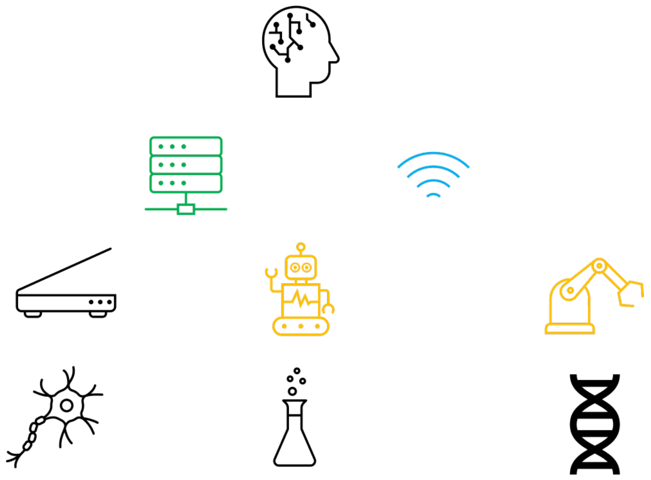
Pick-and-place SAT demo

Standardization and plug & play integration for lab robots

The Laboratory Automation Plug & Play (LAPP) framework

A reference architecture model to provide a comprehensive integration framework

- Hierarchical decomposition of robotized lab workflows
- Multi-layer control architecture
- Device-centric information representation in the digital twin
    - Teaching positions for robot motions, expressed in a device-attached coordinate frame
- Communication protocols
    - SiLA for communication and control (scheduler → device, scheduler → robot)



TRL*	Description	Form
1-2	Scientific conceptualization	Concept papers
3-4	Academical and collaborative PoC's	University collaboration
5-7	Implementation	Global MoMa PoC
	Standardization, communication	SiLA

Public project site

Thank you for your attention!