A Flexible Mobile Laboratory Robot for Adaptable Assistance

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Background

Motivation

- **Automation** has become essential in many laboratories, but **stationary systems** (e.g. Liquid Handling Stations) **are costly**
- **Mobile robots** (mostly for transporting MTPs) are implemented in various research facilities, but are **limited in functionality** and require fiducial markers and automation-friendly devices (Fig. 1, left)
- Robots need to interact with present **large range of sample vessels** and **manual** (i.e. not digitalized) **devices** (Fig. 1, right)

Figure 1: Standardized MTP transport vs. real-world conditions in laboratories.

Solution

- A **flexible and universal robot assistant** for laboratory logistics tasks
- With **advancements in hardware and AI based perception**, robots can adapt to variable everyday environments
- Robots **especially adopt dangerous or routine tasks**, improving job quality, safety and efficiency and enabling 24/7 operation
- Our focus: Development of intelligent, hardware-independent software modules

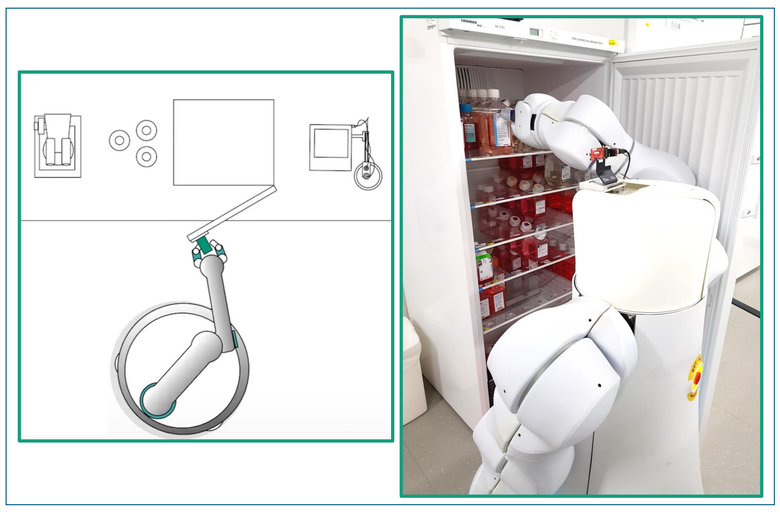

Figure 2: Mobile robots need to be able to interact with every type of object and manual device in the laboratory.

Main Challenges

- Diverse process-relevant (non-standardized) objects need to be **localized in a chaotic environment**
- Omnipresent **transparent/metallic objects** are challenging to existing depth sensors
- **Fine and complex** manipulation sequences needed for interaction with the environment

Methodology and Progress

Concept

- By detecting the rectangular image region (**detection**) and pixels belonging to relevant object(s)/-parts (**segmentation**), **points of interaction can be located** without the need for alteration of the environment
- Using **discriminative patches** (e.g. logos, labels, barcodes, …) the **correct object can be identified** from many similar ones
- By using **3D sensors** (RGB-D cameras), these points can be located in 3D and **motions for interaction** can be planned

Figure 3: Detection of door handles in a challenging every day environment.

Object Localization

- Using AI methods, modules for **localizing metallic handles** were developed and tested at a partners facility (Fig. 3)
- For shelf situations, chaotically placed objects can be localized using the **large-scale retail dataset "IPA-3D1K"**
- By **detecting relevant object parts (e.g. text, barcodes, logos or color)**, similar looking objects can be distinguished, such that the robot can detect and pick the correct object

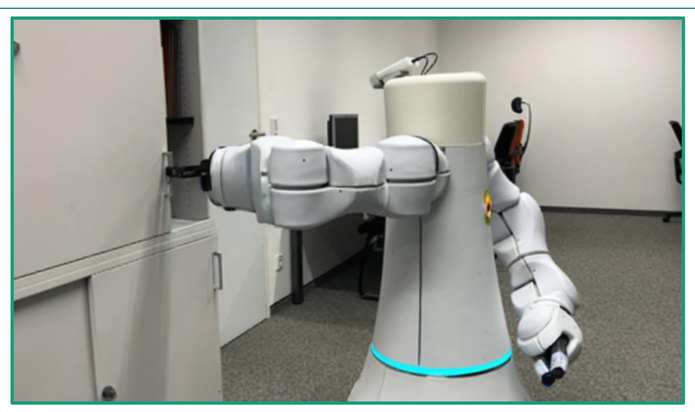

Figure 4: Robot autonomously opening a sliding door.

Door / Drawer Operation

- Utilizing handle detection and predefined movement templates, **door and drawer opening skills were implemented** (Fig. 4)
- **Both swing and sliding doors** can be operated by our mobile manipulators
- **Force measurement / control** were included to prevent any damage of the environment or the robot

Outlook

- Initiative currently in the **stage of collecting data** for the laboratory use cases
- Once finished, **AI systems to locate and grasp non-standardized objects** from chaotic scenes will be trained
- After grasping, the **consumables / samples can be delivered to the workplaces**
- Afterwards, **dexterous robot skills** like container opening, extraction and mixing of samples / chemicals and device loading will be set up as well
- Each module / skill **will be tested at interested partner facilities**, to ensure practicality and transferability

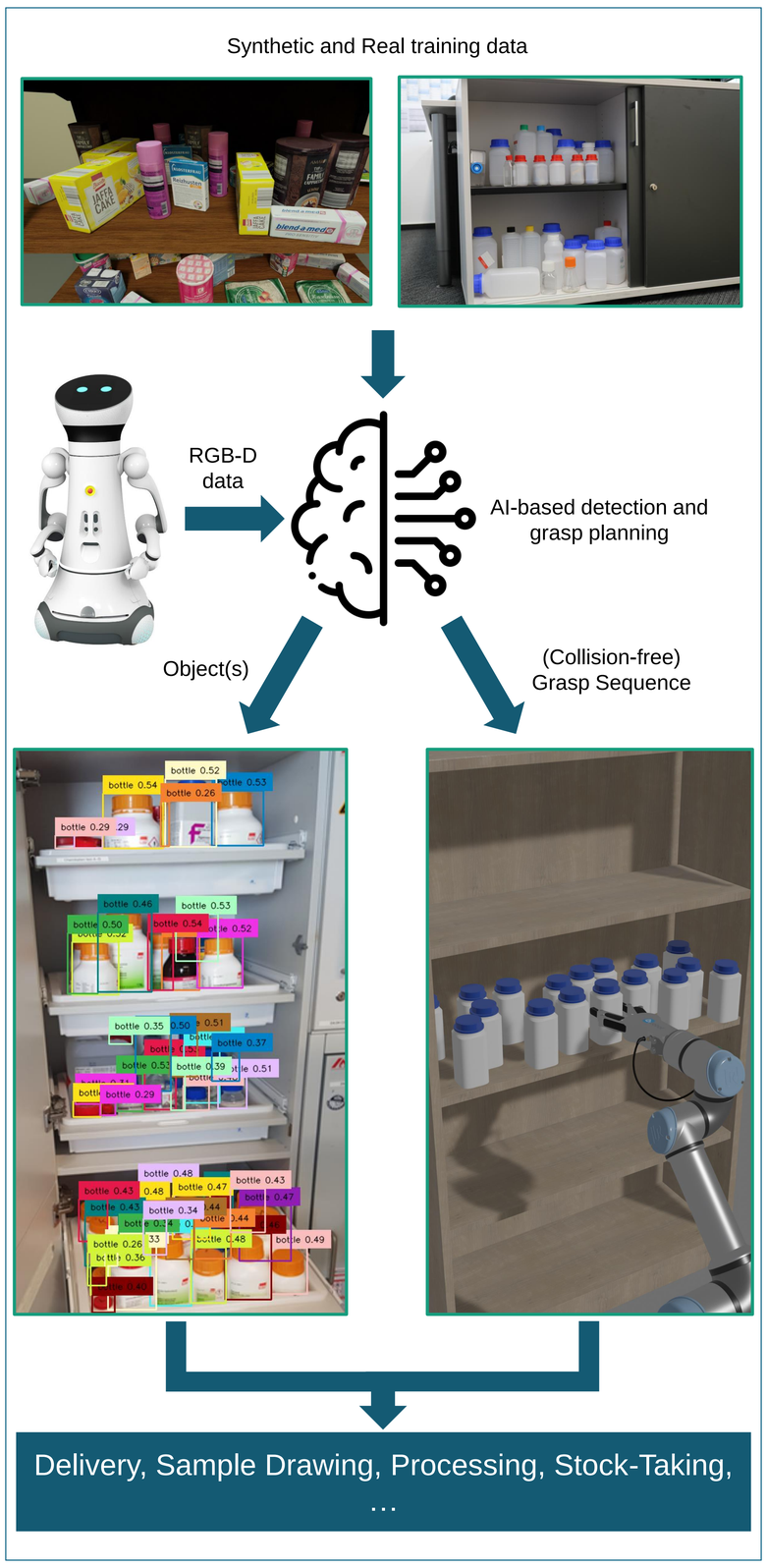

Figure 5: Connectional overview of aspired mobile robot system for flexible assistance.

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