Humanoid Robots Lab
Introductory Meeting

Prof. Dr. Maren Bennewitz
11th October 2023

Course No.:
BA-INF 051 Projektgruppe
MA-INF 4213 Seminar
MA-INF 4214 Lab

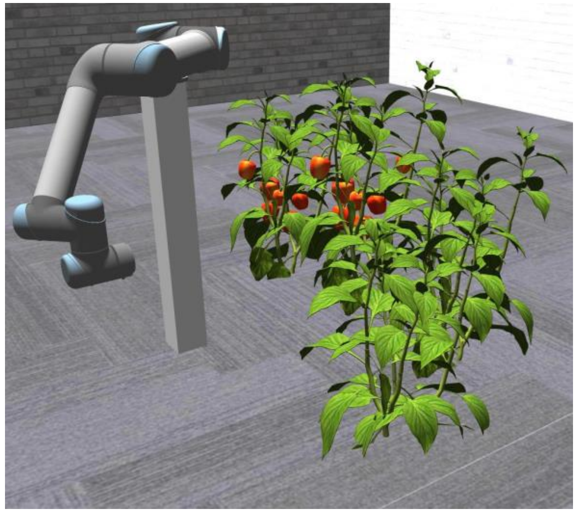
Humanoid Robots Lab

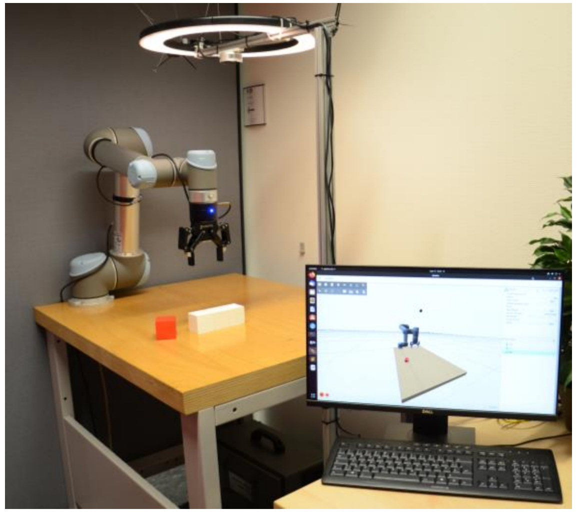
Group headed by
Prof. Dr. Maren Bennewitz

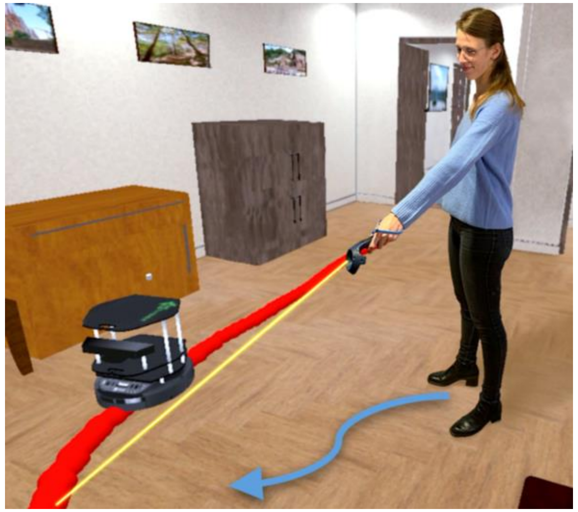
Our research topics:

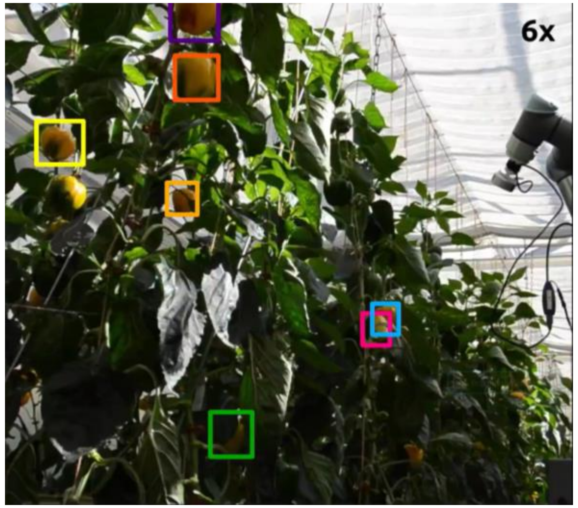
- Robotics & autonomous systems
- Robot navigation
- Manipulation
- Computer vision
- Machine learning
- Human-robot interaction

HRL Projects









Courses

	Bachelor PG			Master	Master
	Lab	+	Seminar	Lab	Seminar
ECTS points	6	+	3	9	4
Workload	180 h	+	90 h	270 h	120 h

- **Seminar:** Presentation and discussion of relevant scientific work
- **Lab:** Programming project on robot simulation software and on physical robots
- **Project Group:** Lab (2/3) + Seminar (1/3)

Course Deliverables

	Bachelor PG			Master	Master
	Lab	+	Seminar	Lab	Seminar
Presentation	X		X	X	X
Lab report	X			X	
Paper summary					X

Seminar

Seminar Overview

- **Presentation and discussion** of relevant scientific work (conference/journal papers)
- Aspects to cover
- Contribution of the work?
- Technique/Methodology used?
- Strengths & Weaknesses of the approach?
- Presentation: 20 minutes + 5 minutes Q&A
- Paper summary (MSc only): **Written summary and discussion** of the work (7 pages not counting figures, LaTeX template provided on web page)

Seminar Timeline

- **Prepare** during the semester
  - Understand the paper
  - Write paper summary (MSc only)
  - Prepare your presentation
- **Seminar Day** at the end of the semester
  - **Everybody has to be present**
  - It's a full day event! (depending on the number of participants)

Seminar Grade

- BSc Students:
  - Presentation: 100%

- MSc Students:
  - Presentation: 70%
  - Paper summary and discussion: 30%

Seminar Papers
(Only BA-INF 051 Projektgruppe)

BSc Students:
Paper will be assigned to you by your supervisor

Seminar Papers
(Only MA-INF 4213 Seminar)

MSc Students:
You can choose from the following selection

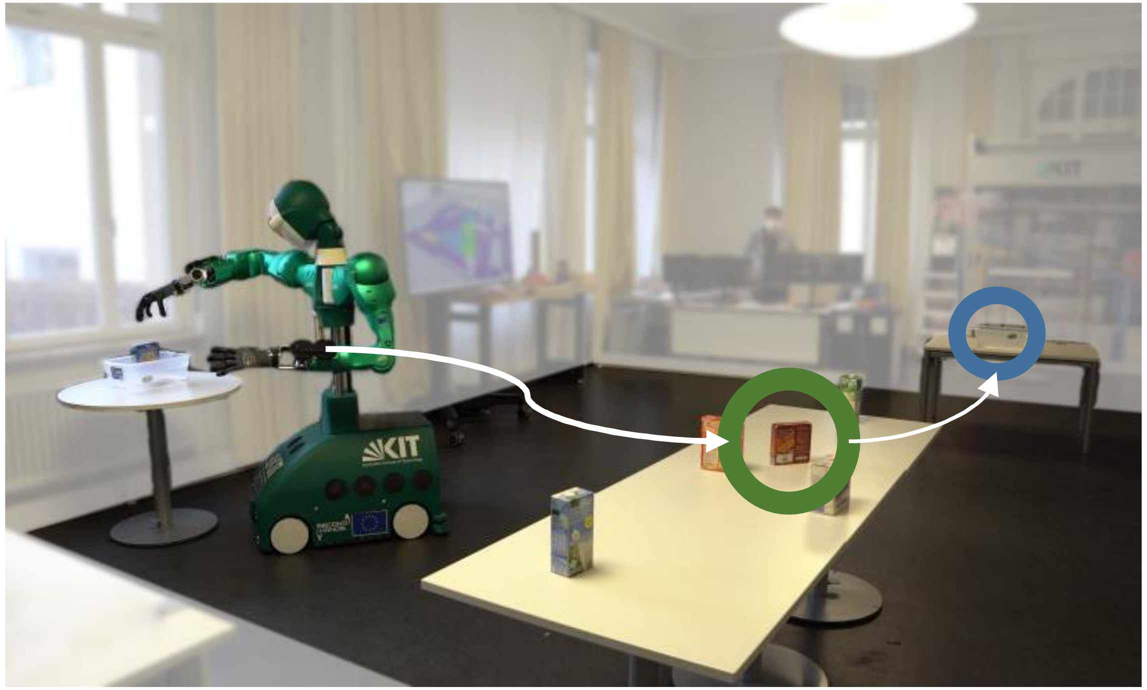
Combining Navigation and Manipulation Costs for Time-Efficient Robot Placement in Mobile Manipulation Tasks

Reister, Grotz, and Asfour

IROS 2022

Supervisor: Prof. Dr. Maren Bennewitz

- **Goal:** Find suitable robot placements to pick up and place objects for time-efficient task execution.
- **Problem:** Given a set of objects, select the optimal robot placement in conjunction with the best grasp candidate and corresponding arm configuration.
- **Approach:** Consider both, the navigation costs between consecutive robot placements and the manipulation costs.



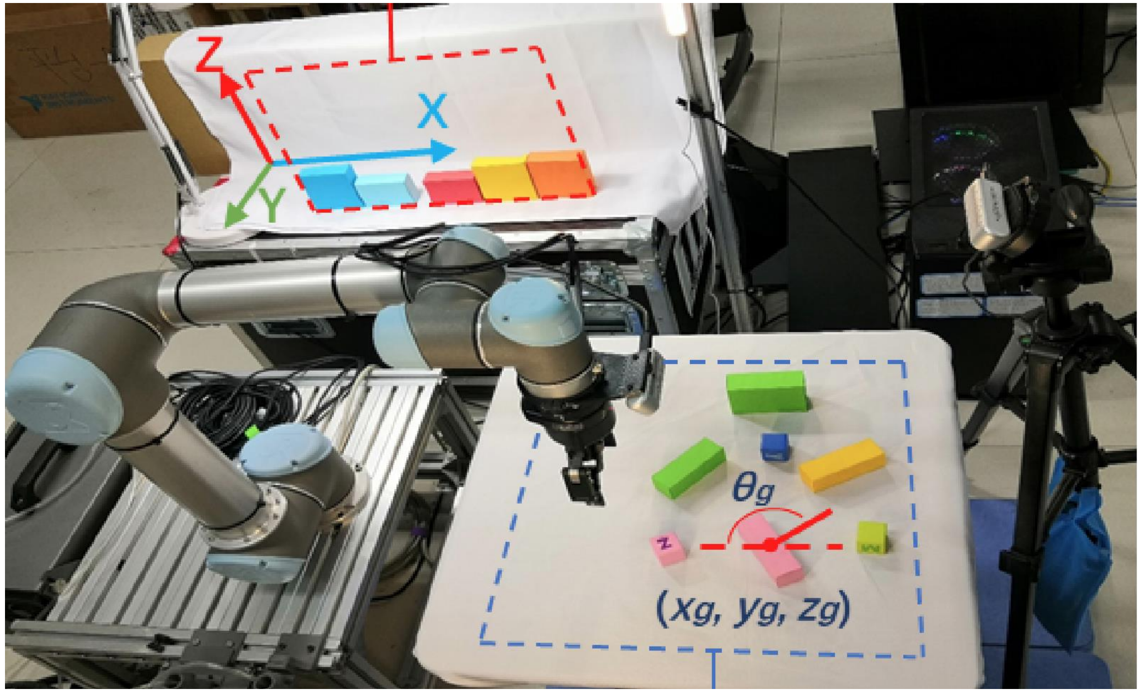
Grasp for Stacking via Deep Reinforcement Learning

Zhang et al.

ICRA 2020

Supervisor: Benedikt Kreis

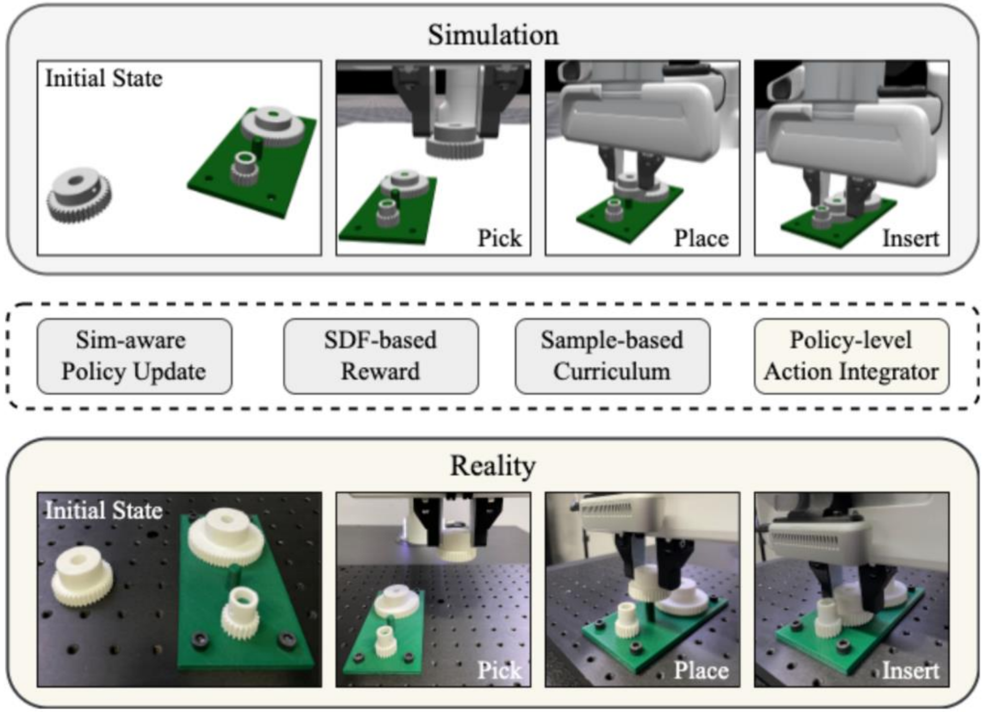
- **Goal:** Grasp objects in a way that they can be placed.
- **Problem:** The objects are randomly distributed on the table and they have different colors and sizes. Objects have to form a stack after placing them.
- **Approach:** Use a model-free Deep Q-Learning (Reinforcement Learning) method to learn an end-to-end grasping-stacking strategy.



IndustReal: Transferring Contact-Rich Assembly Tasks from Simulation to Reality

Tang et al.
RSS 2023
Supervisor: Benedikt Kreis

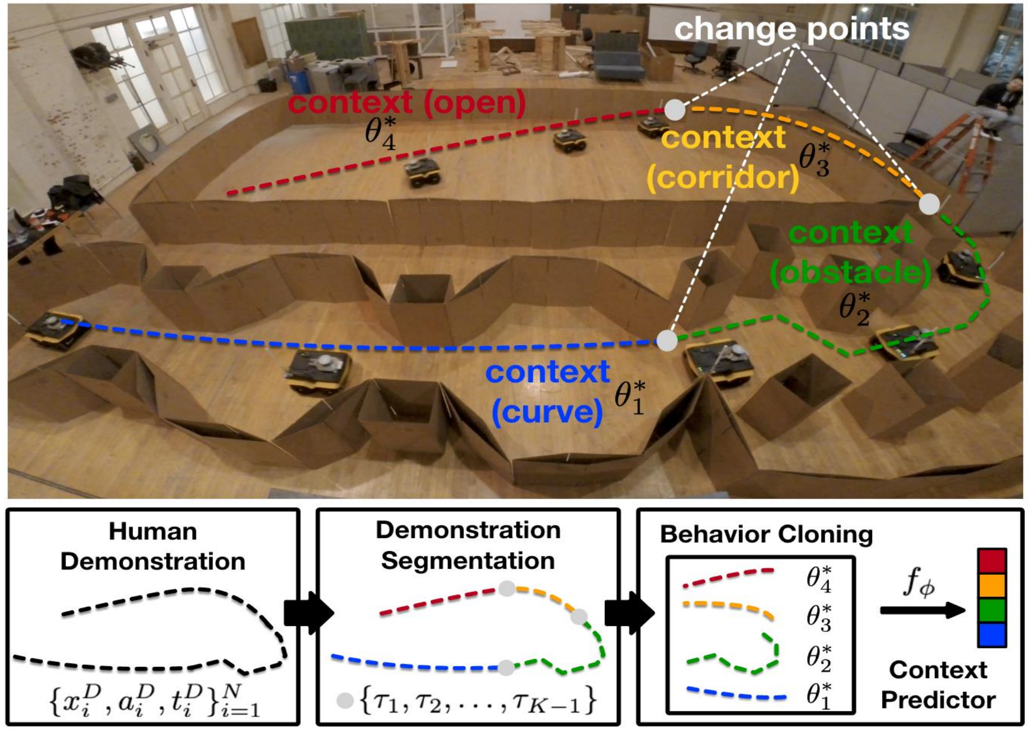
- **Goal:** Train Reinforcement Learning policies in simulation and transfer them to the real world.
- **Problem:** Contact-rich assembly tasks are hard to simulate. A simulation abstracts the real world so that a sim-to-real gap has to be overcome.
- **Approach:** Use different techniques to cope with the problem.

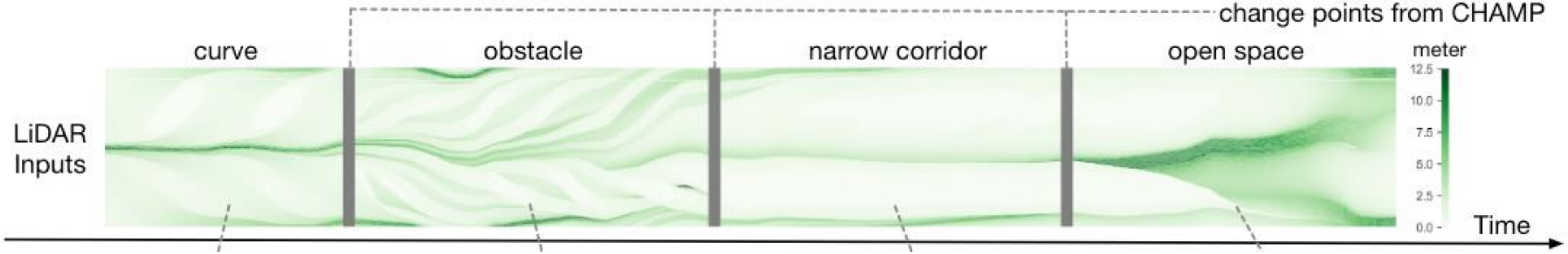


APPLD: Adaptive Planner Parameter Learning from Demonstration

Xiao et al.
RA-L 2020
Supervisor: Jorge de Heuvel

- **Goal:** Efficiently apply existing LIDAR-based navigation controllers to new environments.
- **Problem:** Robotic navigation systems need tedious re-tuning in new environments.
- **Approach:** Learn from user demonstrations and predict navigation context.



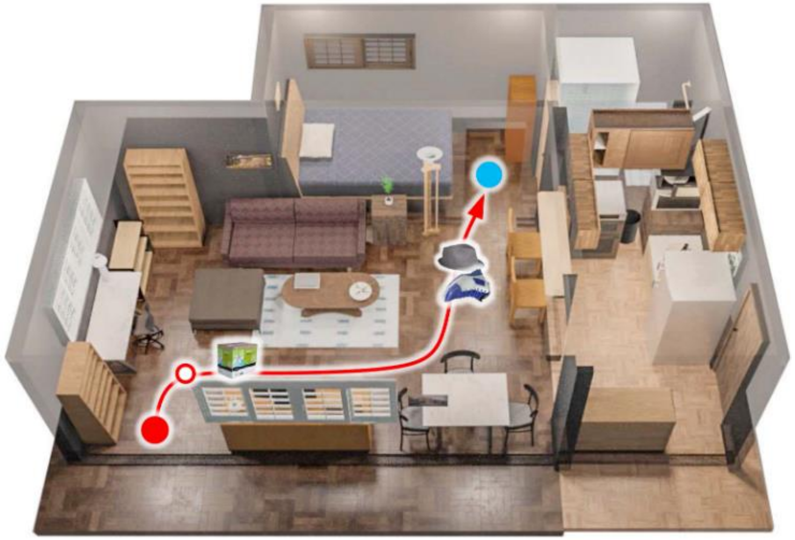


Transformer Memory for Interactive Visual Navigation in Cluttered Environments

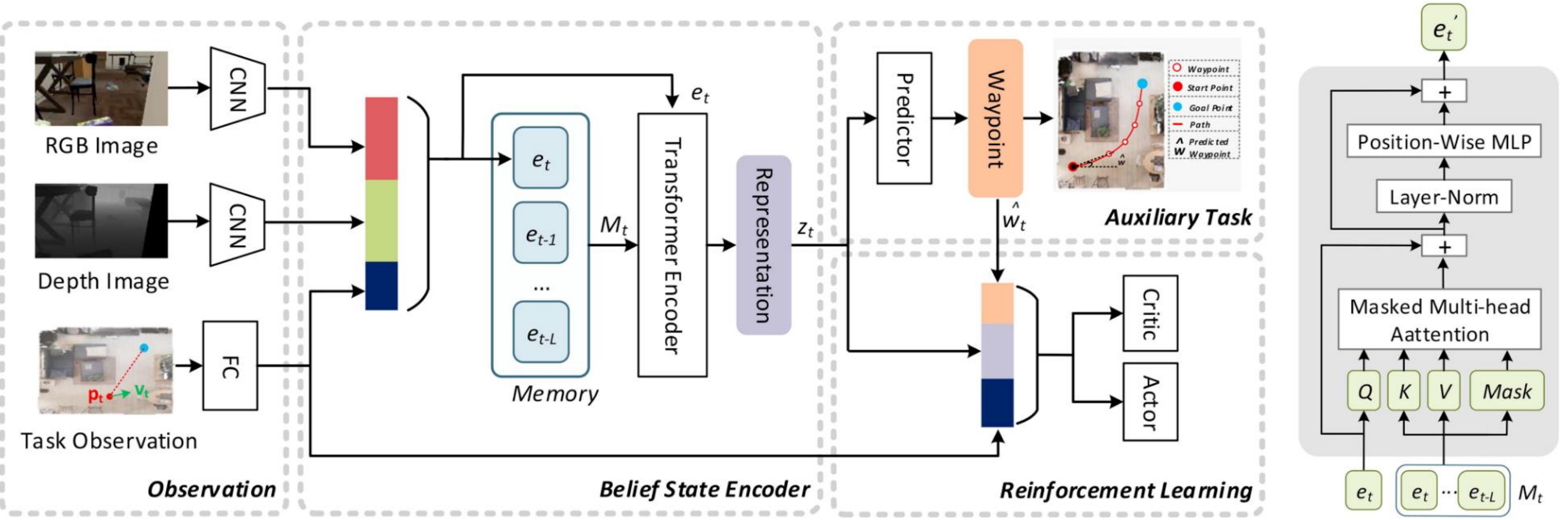
Li et al.

RA-L 2023

Supervisor: Jorge de Heuvel



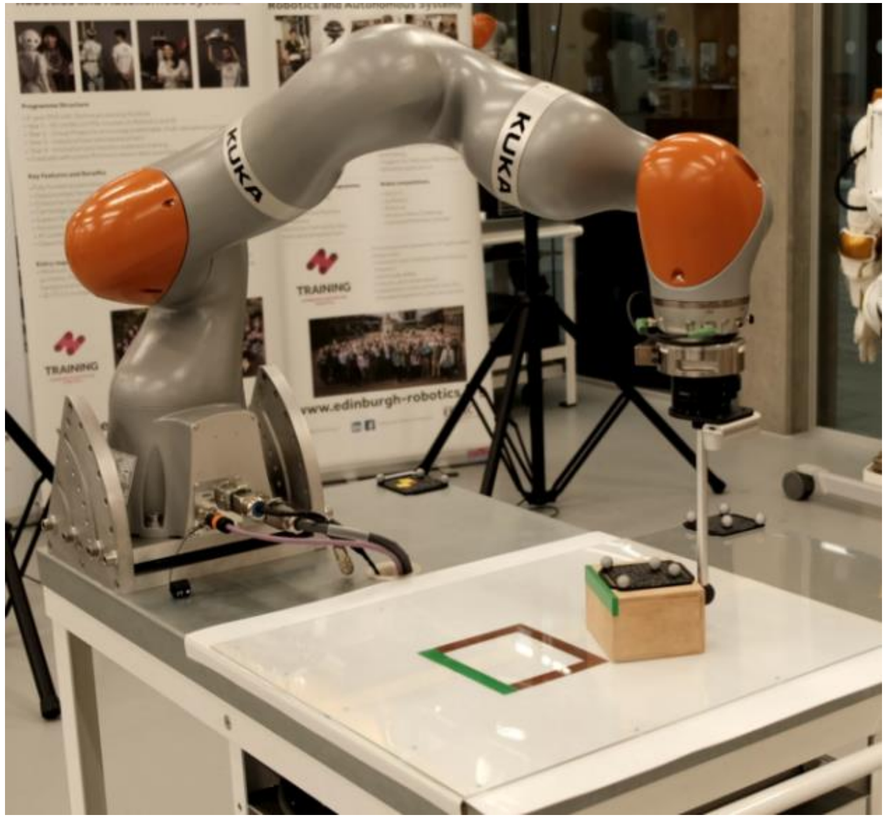
- **Goal:** Navigate cluttered environments based on vision.
- **Problem:** Learning from raw visual input is very hard.
- **Approach:** The attention mechanism enables an efficient reasoning about the robot's environment.



Nonprehensile Planar Manipulation through Reinforcement Learning with Multimodal Categorical Exploration

Del Aguila Ferrandis et al.
IROS 2023
Supervisor: Nils Dengler

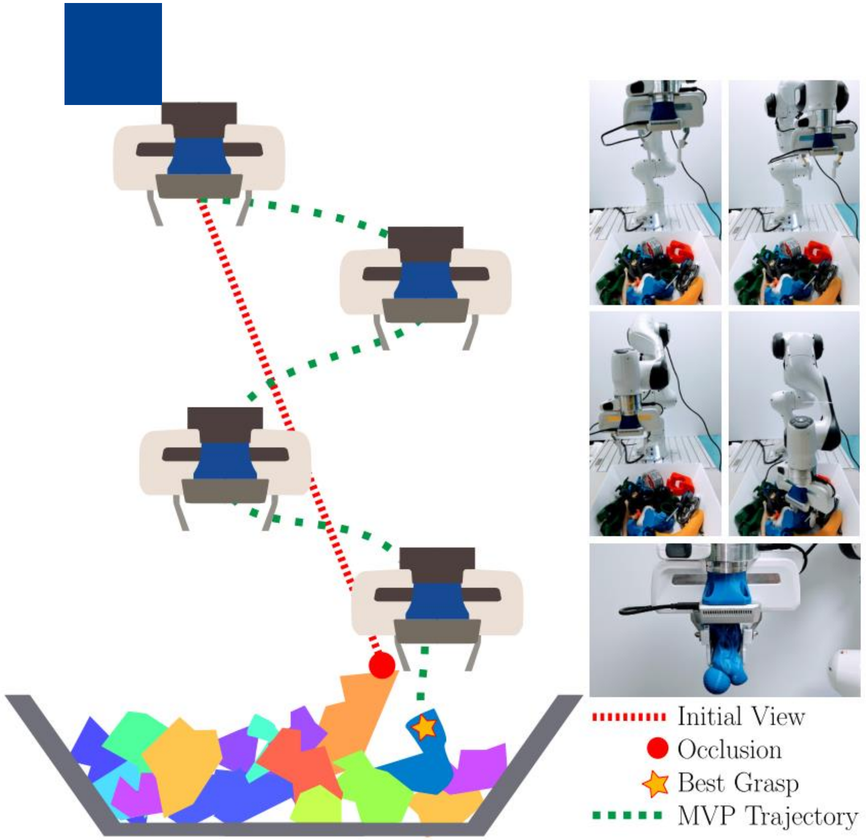
- **Goal:** Orientation aware planar object pushing.
- **Problem:** Unimodal exploration strategies fail to capture the inherent hybrid-dynamics of the task, arising from the different possible contact interaction modes between the robot and the object.
- **Approach:** Multimodal exploration approach through categorical distributions, which enables train of RL policies for arbitrary starting and target object poses.



Multi-View Picking: Next-best-view Reaching for Improved Grasping in Clutter

Douglas et al.
ICRA 2019
Supervisor: Rohit Menon

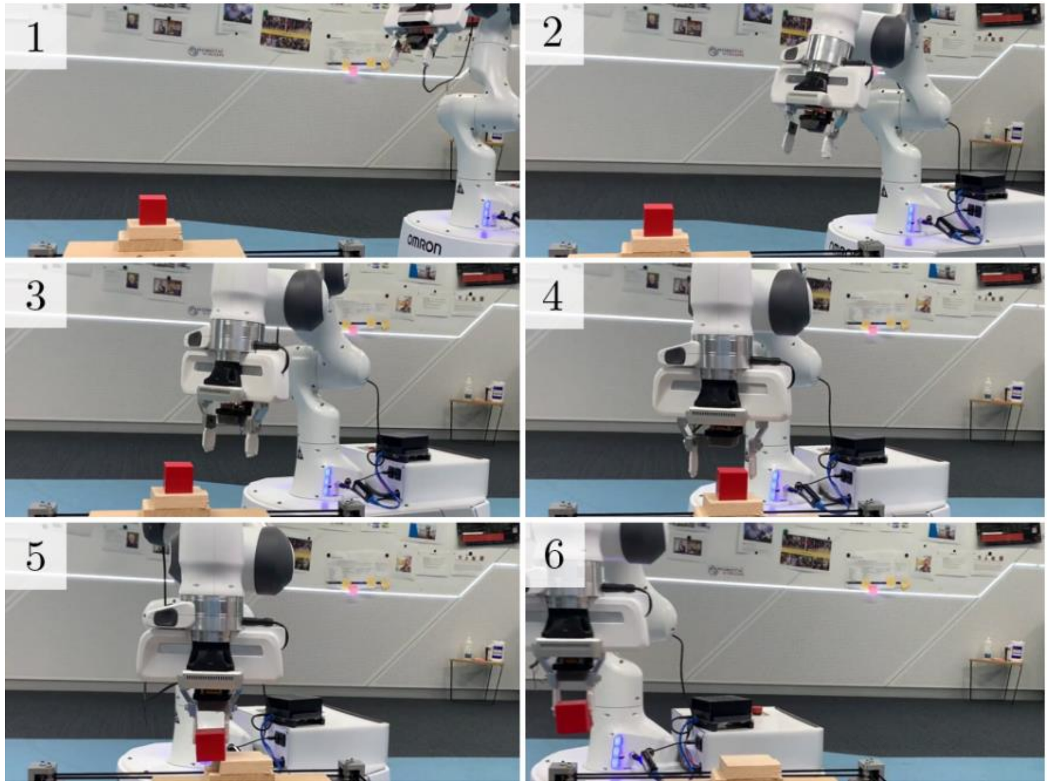
- **Goal:** Improve grasping in cluttered environments.
- **Problem:** Occlusions in cluttered environments and complexity of objects reduces visual grasp detection capability.
- **Approach:**
  - Select next best informative viewpoint based on quality of grasp estimate in real time to reduce grasp pose uncertainty.
  - Use the act of reaching towards a grasp as a method of data collection for grasping.



An Architecture for Reactive Mobile Manipulation On-the-move

Burgess-Limerick et al.
ICRA 2023
Supervisor: Rohit Menon

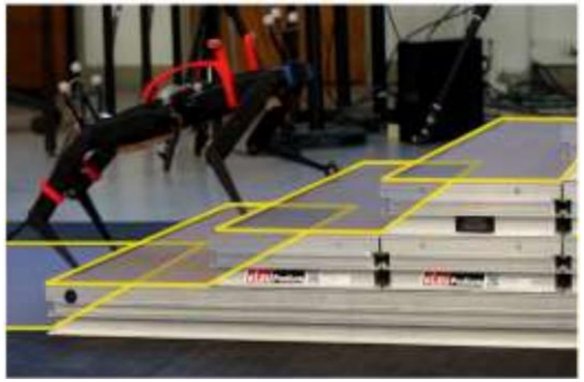
- **Goal:** Perform tasks on-the-move to reduce time lost in base motion pause.
- **Problem:** While on the move, mobile manipulation reduces cycle time, open loop approaches lead to grasp failure.
- **Approach:**
  - An architecture for mobile manipulation with continuous base motion that reacts to environmental change.
  - Reactive control of the manipulator robust to unexpected object motion, inaccurate perception, imprecise robot control.

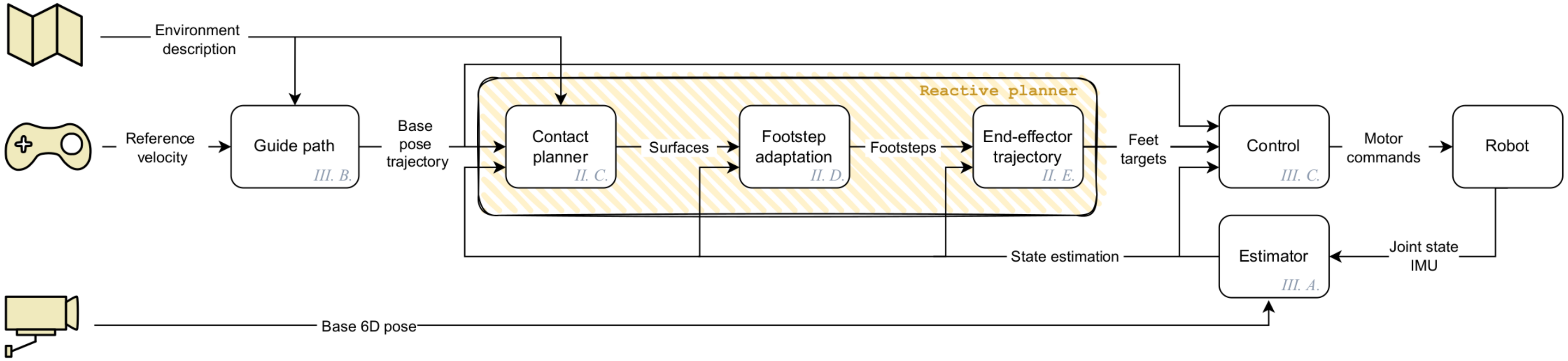


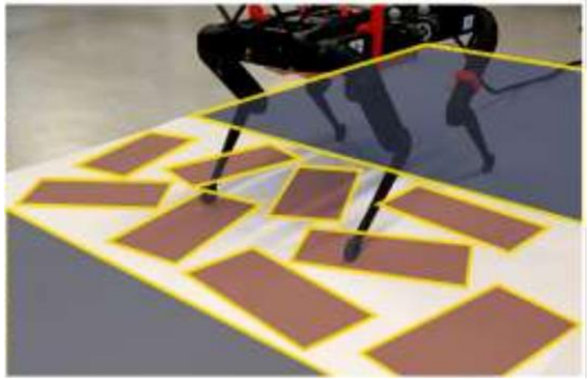
Real time footstep planning and control of the Solo quadruped robot in 3D environments

F.Risbourg, et al.
IROS 2022
Supervisor: Shahram Khorshidi

- **Goal:** Planning and controlling the locomotion of quadruped robots using 3D information about the surrounding obstacles.
- **Problem:** Complex environments require the planning of robot motions several steps ahead (within an established horizon).
- **Approach:** A contact planner formulated as a mixed-integer program, optimized on-line at each new robot step.

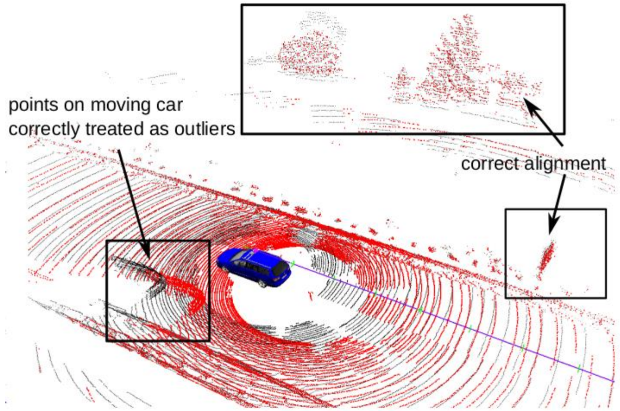




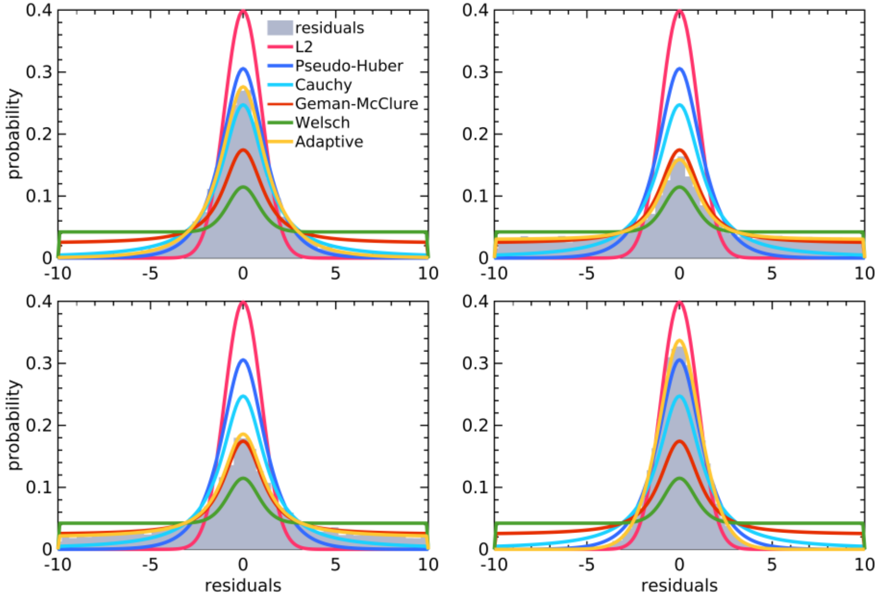


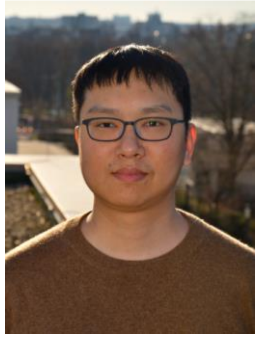
Adaptive Robust Kernels for Non-Linear Least Squares Problems

N.Chebrolu, et al.
RA-L 2021
Supervisor: Shahram Khorshidi



- **Goal:** Dealing with outliers within the data, in the least-squares error minimization.
- **Problem:** State estimation is a key ingredient in almost any robotic application, mainly formulated as an NLS problem.
- **Approach:** Using a generalized robust kernel family, which is automatically tuned based on the distribution of the residuals.

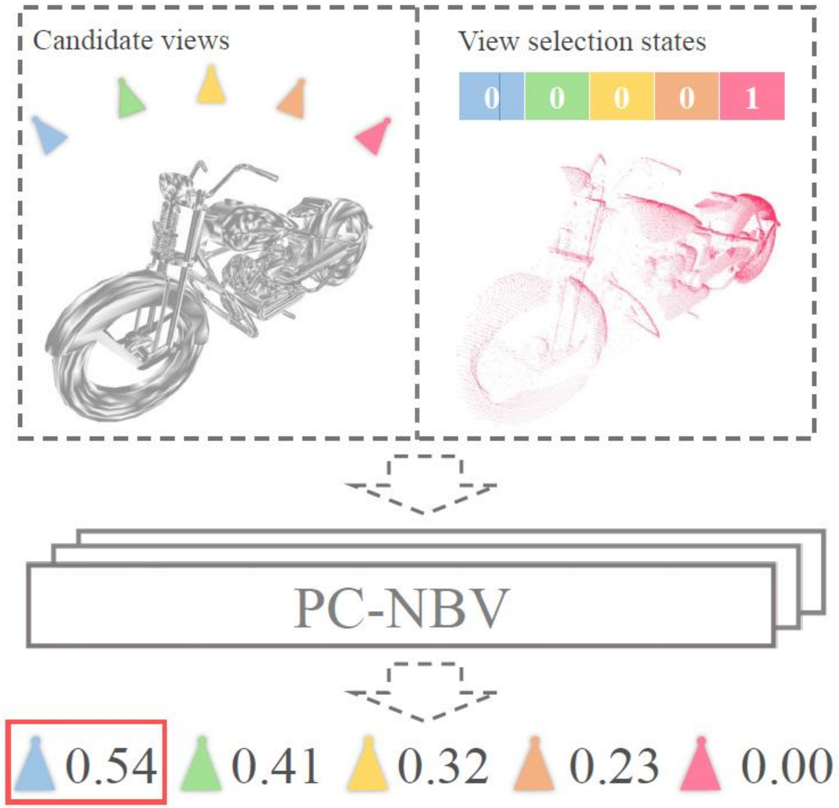


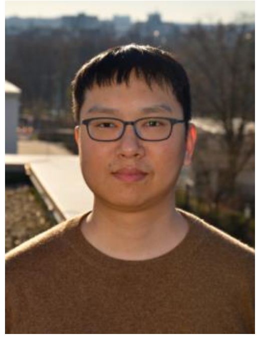


PC-NBV: A Point Cloud Based Deep Network for Efficient Next Best View Planning

Zeng et al.
IROS 2020
Supervisor: Sicong Pan

- **Goal:** Efficiently selecting a sequence of next-best views to reconstruct a 3D unknown object.
- **Problem:** Traditional view planning is based on voxel representation and time-consuming ray casting. How to directly use point cloud to score the views?
- **Approach:** Scoring next-best views via a point-cloud-based deep network.

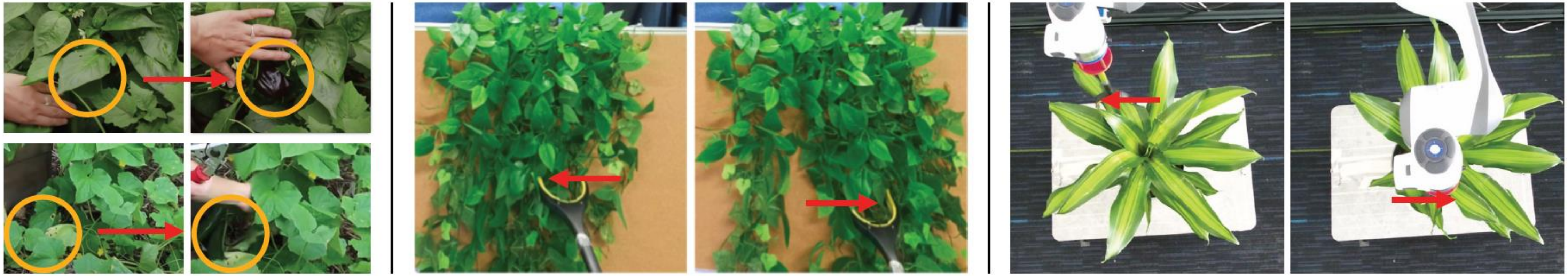




Push Past Green: Learning to Look Behind Plant Foliage by Moving It

Zhang and Gupta
CoRL 2023
Supervisor: Sicong Pan

- **Goal:** Manipulating the plant foliage to look behind leaves and branches.
- **Problem:** How to deal with partial visibility, extreme clutter, thin structures, and unknown geometry and dynamics for plants?
- **Approach:** Using deep network to predict actions that are effective at revealing space beneath plant foliage.



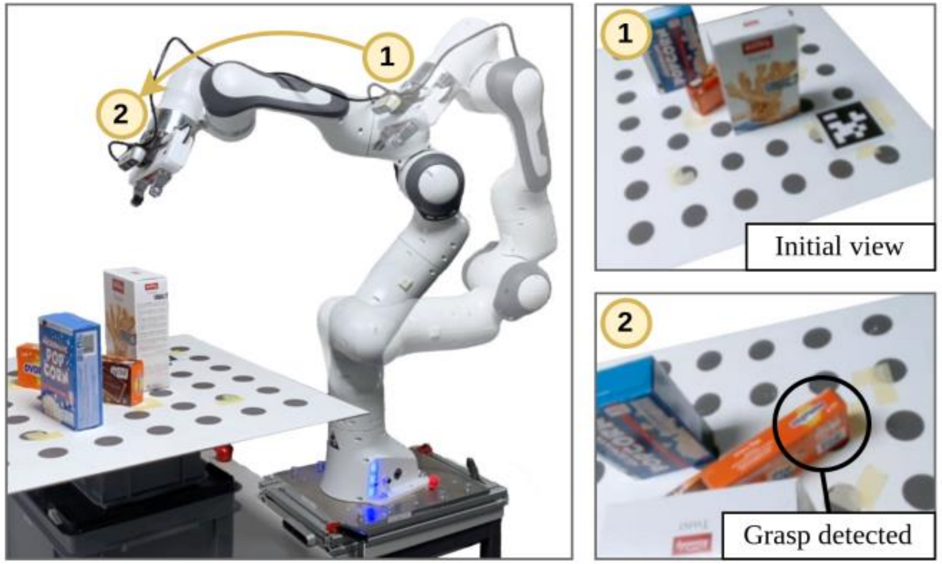
Closed-Loop Next-Best-View Planning for Target-Driven Grasping

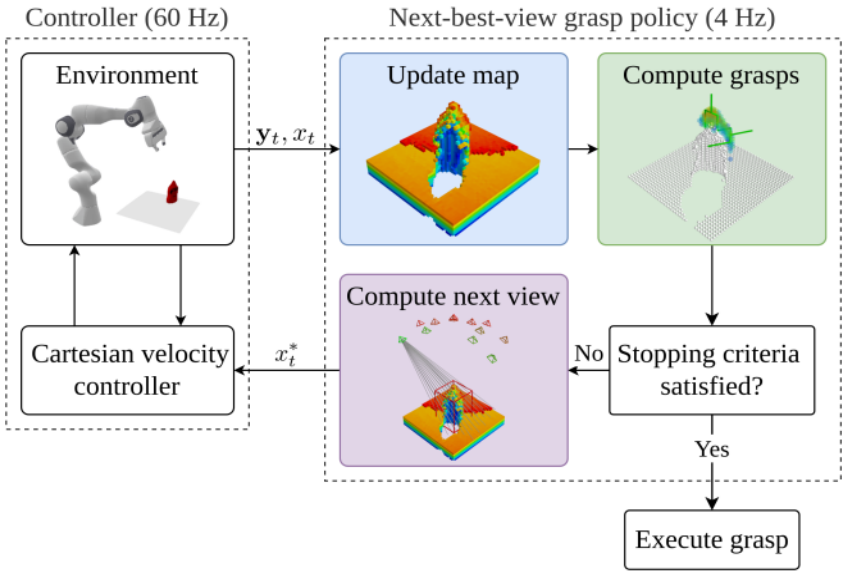
Breyer et al.

IROS 2022

Supervisor: Tobias Zaenker

- **Goal:** Grasp object in cluttered environment.
- **Problem:** Plan views to improve reconstruction until stable grasp is found.
- **Approach:** Create TSDF map from camera mounted on arm.

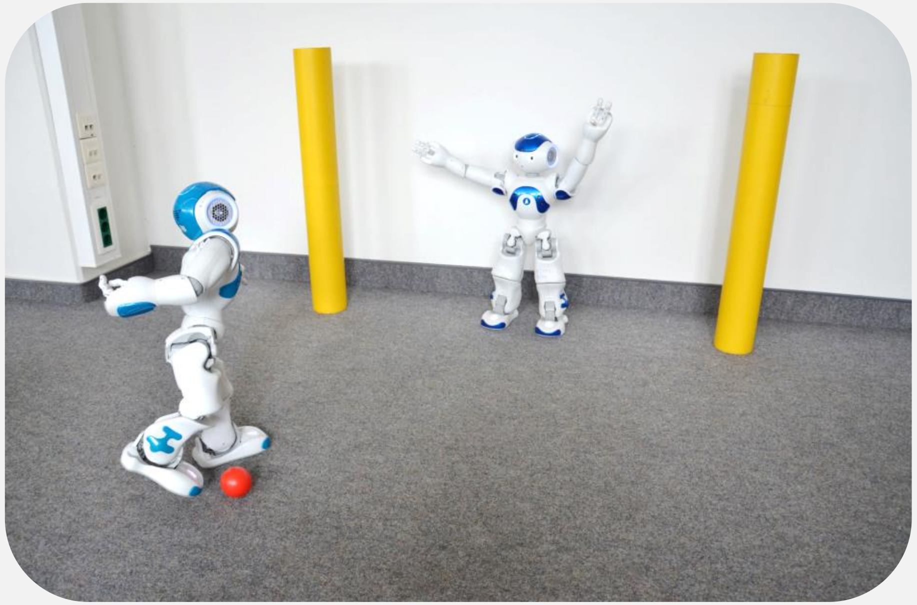


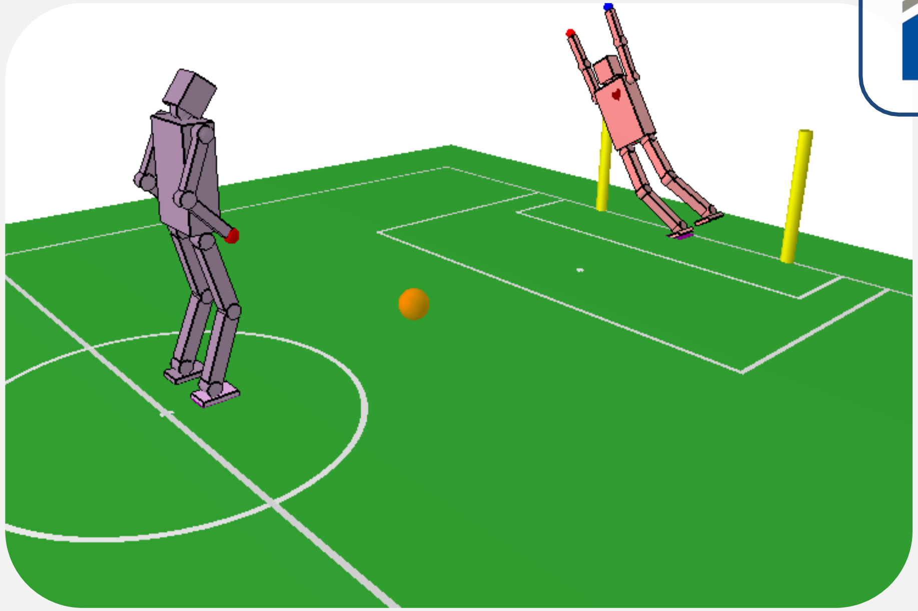


MA-INF 4214 Lab
&
BA-INF 051 Projektgruppe
(Lab Part)

Available Lab Projects

SOCCER

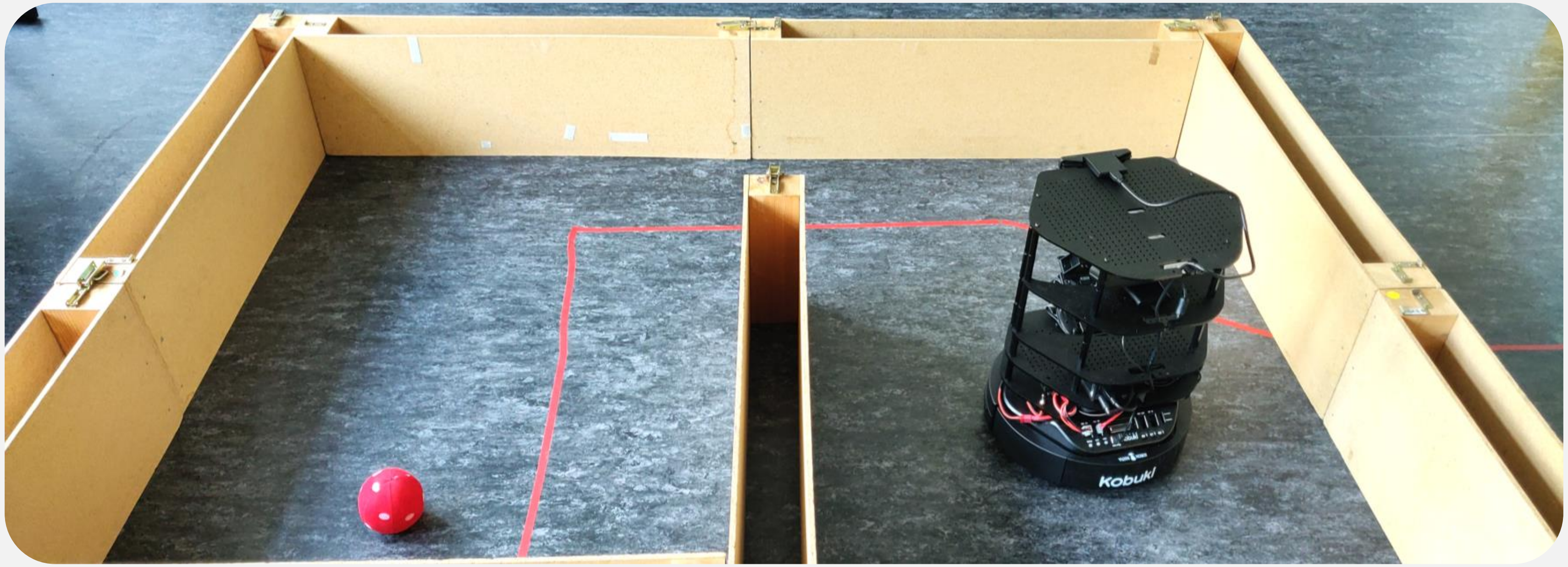




Goal: Score a goal, defend with the goalie

Challenge: Detect the goal and ball, walk up to the ball and kick the ball into the goal

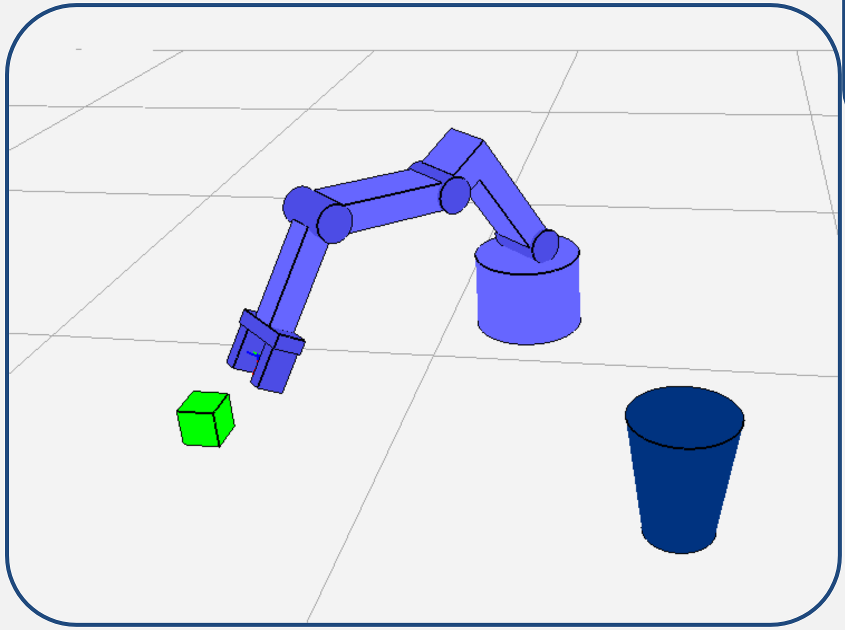
TURTLEBOT MAZE



Goal: Program a mobile robot to autonomously navigate

Challenge: Avoid collisions with the walls an solve the maze

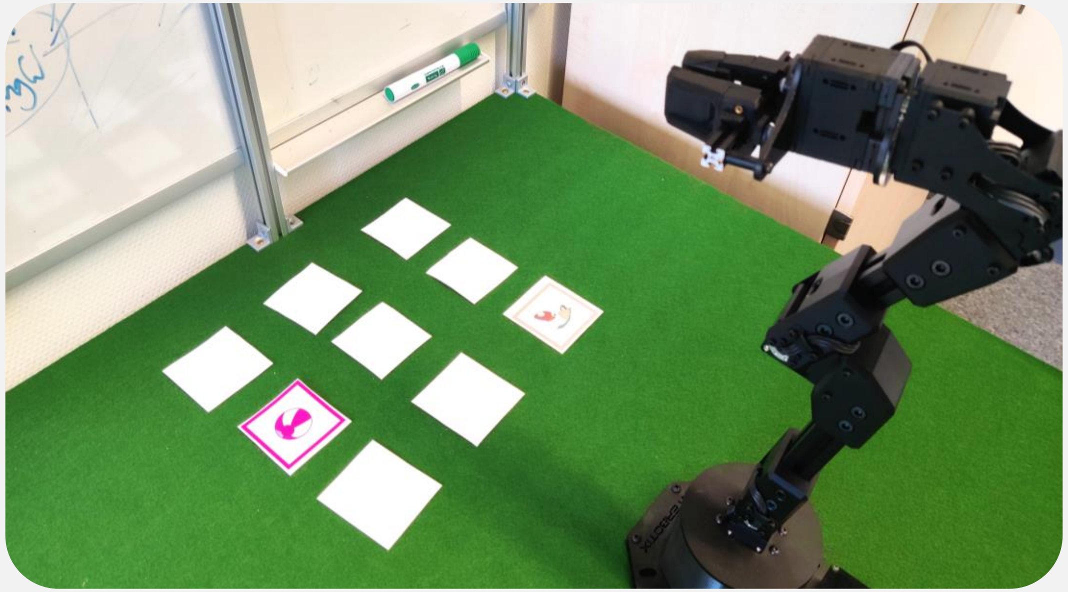
ROBOT ARM – PICK & PLACE



Goal: Program a robot arm to sort objects into a cup

Challenge: Use computer vision techniques to grasp objects

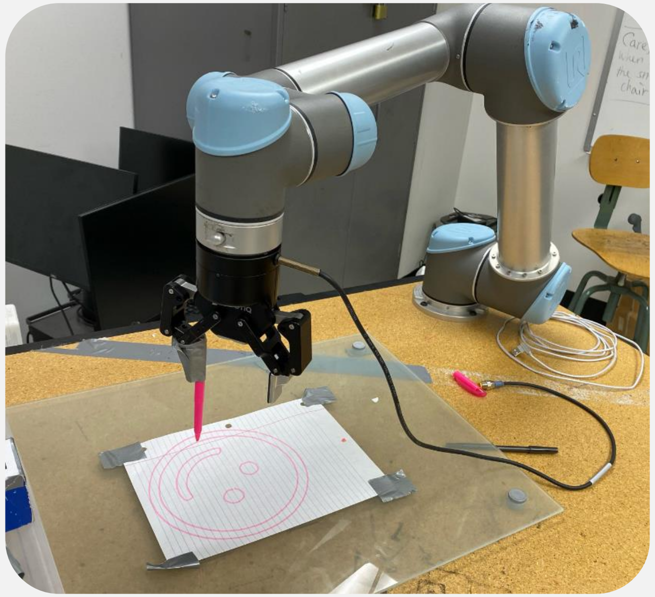
ROBOT ARM - MEMORY



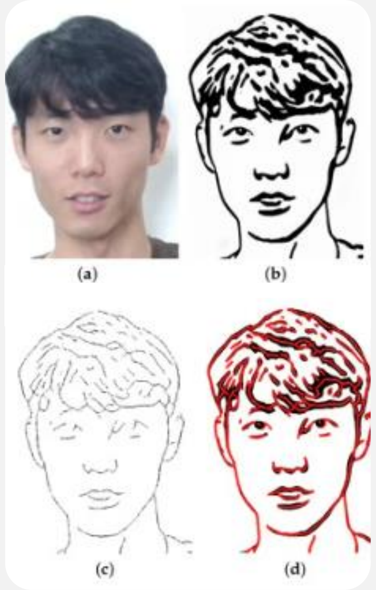
Goal: Program a robot arm to play the card game “Memory”

Challenge: Pick up the memory-cards, identify matching pairs, clear the field

SKETCH2DRAW



Source: mdpi.com



Source: hackaday.io

Goal: Program an industrial robot arm to draw pictures

Challenge: Generate the drawing contours from an RGB image and move the industrial robot arm accordingly

Lab Overview

- Small groups of 2-3 people
- A selection of projects involving perception and action generation for different robots
- Supporting C++ framework written by the lab ➡ **obligatory** (exception: Sketch2Draw is based on C++, Python, and ROS)
- Demonstration and written lab report at the end of the semester (Wednesday, 27.03.2024)

Lab Timeline

1) Work with robot simulation software

Transition ↓ Show working simulation model to your supervisor (**required** latest 2 weeks before demo day)

2) Move on to real robots in our lab

- **Demonstration Day** at the end of the semester
  - **Everybody has to be present**
  - Full day event! (depending on the number of participants)
  - 2 runs: 1) simulation 2) real robot
  - Prepare a video as backup

Lab Grade

- Individual grade for each group member
- Depends on participation during the semester and the performance of the system in the final demonstration
- Lab report is a precondition!
- **Written lab report** of the work (LaTeX template provided on web page)

Registration

Next Steps

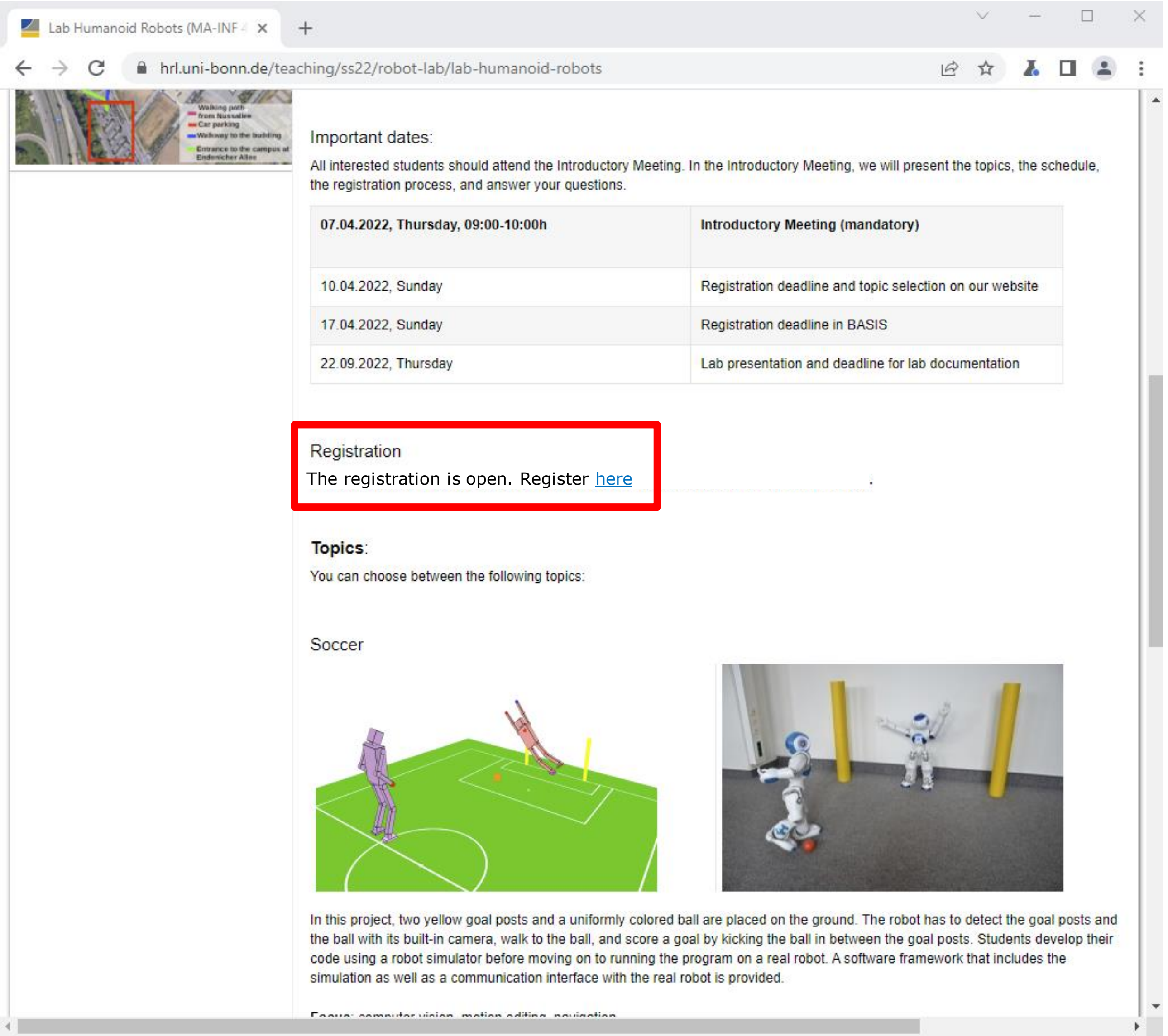
- **Two** separate registrations are necessary!

1) Registration on our web site (first-come-first-serve!) until Sunday, 15.10.

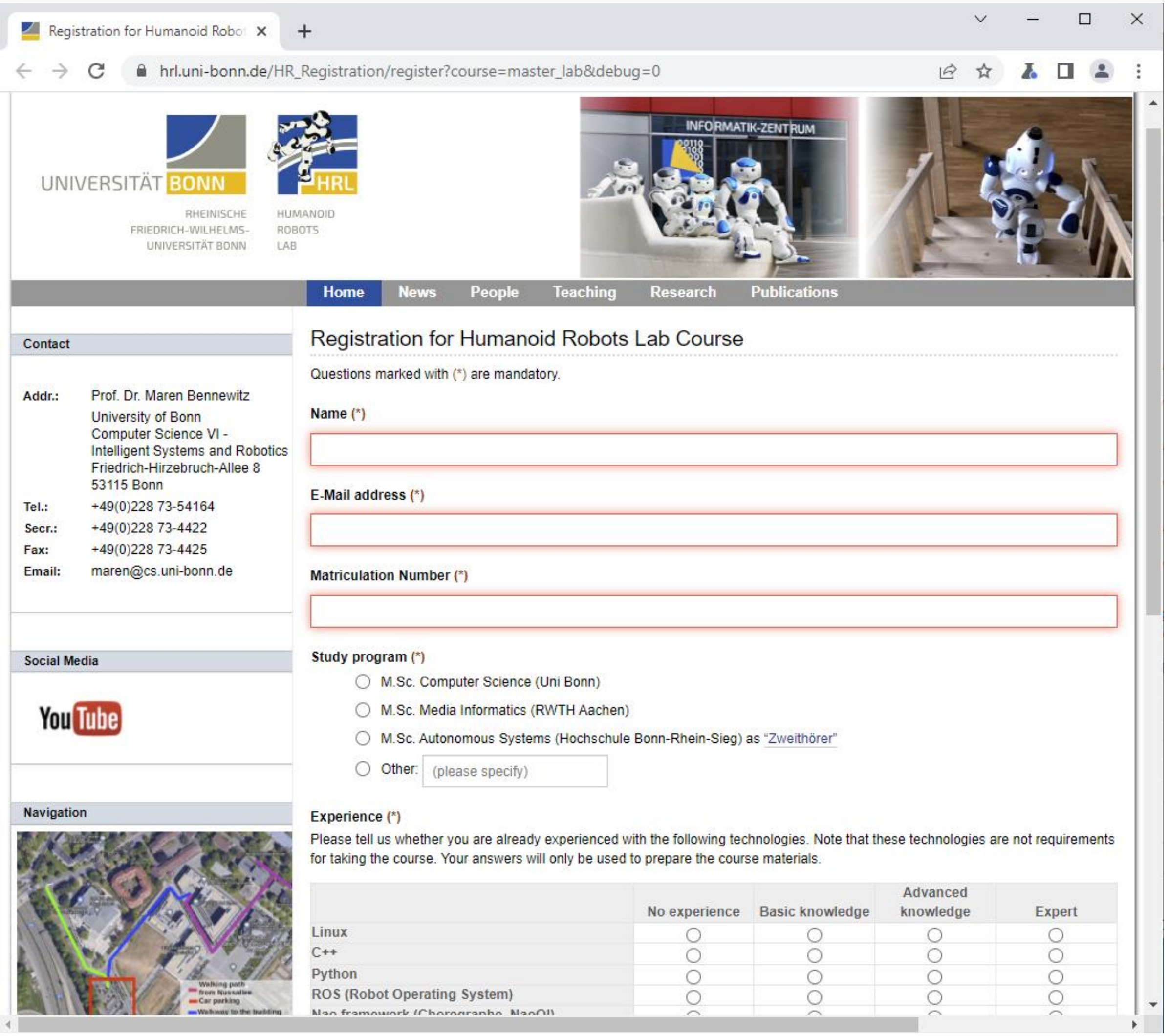
➡ Topic and group assignment (Hungarian algorithm) until Wednesday, 18.10. (notification via e-mail).

2) Registration in **BASIS until Sunday, 22.10.**

Website Registration



Website Registration



Schedule

Date	BSc Project Group	MSc Lab Course	MSc Seminar
Sun Oct 15	Registration deadline		
Wed Oct 18	Participation confirmation and topic assignment		
Sun Oct 22	BASIS registration deadline		
	Supervised lab course during the whole semester		Individual supervision
Thu Jan 25	Seminar presentation		• Seminar presentation • Deadline for the summary
Wed Mar 27	• Lab demonstration (in person) • Deadline for the lab report		

Thank you!

Questions ???