Open Master Thesis Topic: Combining Deep Reinforcement Learning and 3D Vision for Dual-arm Robotic Tasks

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1 Project Description

Recent breakthroughs in Deep Reinforcement Learning (RL) have led to an increased deployment of learning-based methods in robotics. Nevertheless, RL for robotics has been limited to simple setups that assume perfect knowledge about the robot's environment.

Recent work at the iRosa lab [1] (irosalab.com/rlmmbp) has successfully utilized Deep RL for performing mobile manipulation tasks (i.e. picking and placing objects using the robot arm while moving using the wheeled base of the robot). However, even in these experiments, the robot just used one out of its two arms, and the method assumed perfect perception of the environment (Fig. 1).

In this thesis, we aim to build on advances in 3D Vision [2] (stanford.edu/ rqi/pointnet) and combine them with Deep RL to learn using real-world, imperfect 3D information such as point-clouds or occupancy grids (Fig. 2). We also aim to solve the more challenging problem of dual-arm mobile manipulation instead of just using a single arm (Fig. 3).

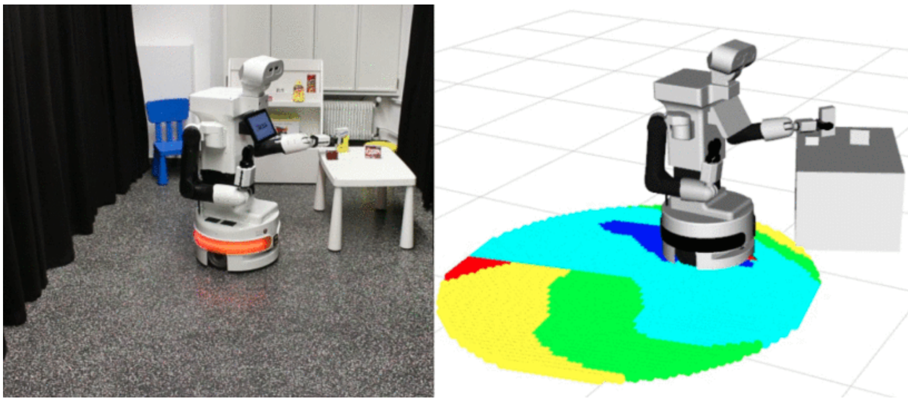

Figure 1: Recent work on learning to move the robot for single-arm object pick and place [1] (irosalab.com/rlmmbp). Perfect perception of the objects (grey boxes on the right) was assumed.

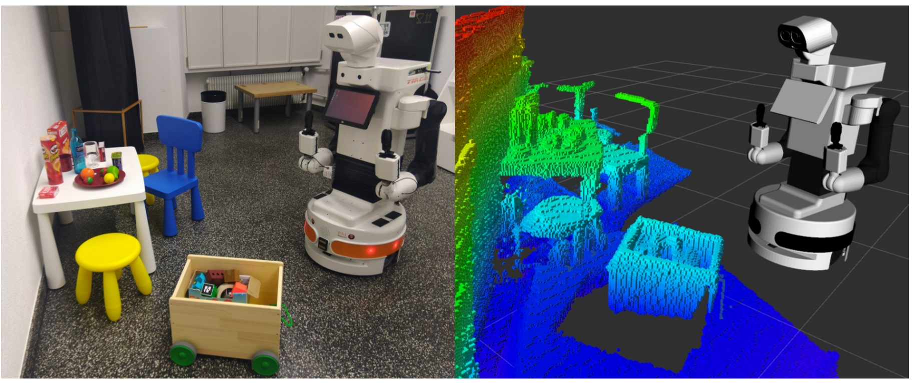

Figure 2: Learning from partial 3D information such as point-clouds or occupancy grids (shown above) is challenging and requires the effective combination of 3D Vision.

Figure 3: Dual-arm or bi-manual manipulation is essential in many cases but requires further learning and co-ordination [3].

2 Outline of Work Packages

Note: The following outline will be adjusted depending on the project's progress and insights. It is solely intended to give an idea of where the project might go and what we envisioned before starting to work on it.

WP 1
Duration: 1-2 months
The student has to perform a literature review of closely related methods in 3D vision and develop a good understanding of Deep RL for robotics. The student has to start getting familiar with the code and simulation environment of NVIDIA's Isaac Sim simulator (sufficient existing code will be provided to help kick-start the project).
WP 2
Duration: 1-2 months
The student has to evaluate 3D information processing neural networks such as PointNets [2] (among others) and integrate them into a Deep RL setting for learning mobile manipulation tasks as in [1].
WP 3
Duration: 4 months
The student has to explore dual-arm manipulation techniques and work towards applying RL to dual-arm mobile manipulation tasks. This can include: picking and placing two objects at the same time, grasping an object with two arms etc. Furthermore, the learnt behavior will be tested against comparable baselines in simulation as well as on a real-robot setup at the iRosa lab.
WP 4
Submit the research to a conference (for example, the Conference on Robot Learning: corl2022.org), and complete the thesis.

3 Requirements

Enthusiasm, ambition and a curious mind go a long way. There will be ample supervision provided to help the student understand basic as well as advanced concepts. However, prior knowledge about reinforcement learning, robotics and Python programming would be a plus.

4 Contact

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References

[1] S. Jauhri, J. Peters, and G. Chalvatzaki, "Robot learning of mobile manipulation with reachability behavior priors," *IEEE Robotics and Automation Letters*, vol. 7, no. 3, pp. 8399–8406, 2022.

[2] C. R. Qi, H. Su, K. Mo, and L. J. Guibas, "Pointnet: Deep learning on point sets for 3d classification and segmentation," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2017, pp. 652–660.

[3] K. S. Luck and H. B. Amor, "Extracting bimanual synergies with reinforcement learning," in *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE, 2017, pp. 4805–4812.