

Sim-to-Real of a Mobile Robot Manipulator in ROS 2

Student



Jonas Scholz

Definition of Task: This project investigates ROS 2 and Gazebo, an open source framework, for accelerating laboratory automation, focusing on sim-to-real transfer. The core question is whether a use case can be implemented in simulation and transferred directly to hardware. To assess this, a ROS 2 digital twin of the Mobile Manipulator (MoMa) was developed. The objective was to solve a repetitive ampule rack pick-and-place task in simulation and transfer it to the physical robot to evaluate the framework.

Result: To examine ROS 2's advanced capabilities, the MoveIt Task Constructor (MTC) was used. MTC enables robust task definitions by specifying positions of interest and trajectory conditions rather than fixed paths, facilitating fallback strategies for obstacle handling. The developed program was successfully transferred to the MoMa hardware with only one minor adjustment, replicating the simulation's performance and achieving sufficient accuracy. While the simulation-based approach was not faster than proprietary software (TM Flow) for this simple task, the results demonstrate ROS 2's potential to accelerate complex use cases. MTC's collision avoidance and planning capabilities are critical for developing robust solutions in dynamic environments, particularly those involving mobile robotics.

Conclusion: Transitioning to conditional automation (Level 3), which demands handling dynamic environments and sequential tasks, requires a framework beyond hardware-specific software. This project confirms that ROS 2 can effectively integrate diverse industrial components with open-source tools for perception and trajectory generation. By prioritising goal-based definitions, ROS 2 provides the robustness necessary to handle unexpected obstacles. However, this flexibility entails greater complexity and a steeper learning curve compared to industrial solutions. Tools like MTC are essential for managing this complexity in "intelligent" applications. While Gazebo suffices for validating smaller setups, advanced scenarios involving perception or large-scale parallel simulations necessitate more powerful tools like NVIDIA's Isaac Sim.

Advisor

Prof. Dr. Agathe Koller

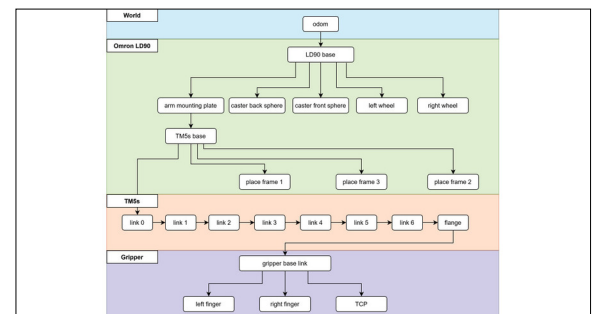
Subject Area

Mechatronics and Automation

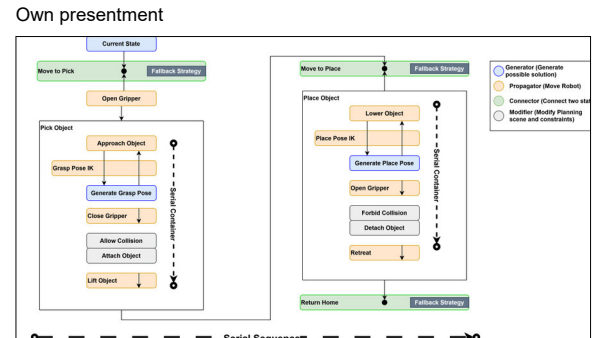
Project Partner

Roche Diagnostics International AG, Rotkreuz, Zug

This figure shows the planned kinematic chains starting with the odometry frame in the world frame. Own presentation



This flowchart shows the structure of the pick and place task with MTC. Own presentation



The image shows the same state in the pick and place process between simulation and reality. Own presentation

