VTT Technical Research Centre of Finland

Intuitive Adaptive Robotics

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Intuitive Adaptive Robotics

"I will take care of it!"

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PHASE 1: Task description | Robot & physical environment | CAD-model | Simulation environment

PHASE 2: RL algorithm | Training | Simulated task validation

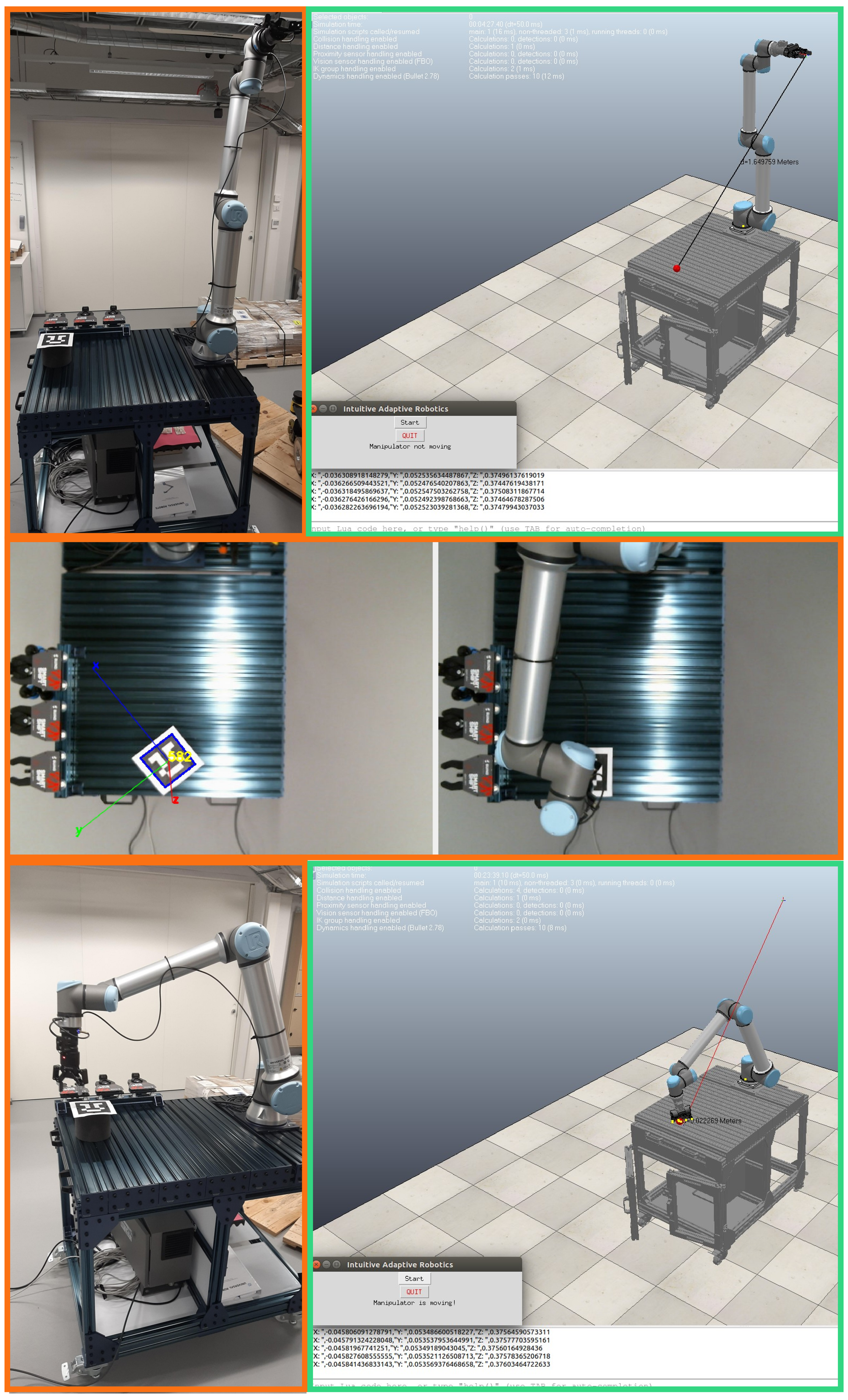
PHASE 3: ROS communication | Machine vision | Real-time feedback | Physical task validation

Problem

Human way of independent learning is often trial and error. If in the future we want industrial robots/ manipulators to become independent and to be able to quickly adapt to scenarios unforeseen by their creators, it is essential that they learn similar skills.

Solution

Safe and fast way of doing this is with the help of simulation. We let the robots simulate their scenario, environment and actions to learn a way to accomplish the task, without external guidance from their designers or operators. We wanted to do it in way that is **intuitive** (understandable) and **adaptive** (scalable) in nature.



UR10e manipulator controlled by DDPG RL-algorithm from CoppeliaSim simulator with target tracing via camera.

Phase 1 – Building the environment

Task description is to simply reach a target. Robot and the physical environment is transferred into a CAD model, and imported to a simulator. Because of intuitive APIs, CoppeliaSim is chosen as the environment to combine simulation with Reinforcement Learning (RL) methodologies.

Phase 2 – Reinforcement Learning, Training

For the robot to learn by trial and error a RL paradigm was chosen. An agent tries to accomplish a given task with a reward function guiding its actions, while controlling a robot with 6-degrees of freedom. The chosen algorithm is Deep Deterministic Policy Gradient (DDPG), because of its proficiency with continuous action spaces and intelligibility with exploration and exploitation. Eventually, after 2000 episodes with 300 steps simulated robot learned to reach a target within the restricted area (table surface). Training phase is visually approved in simulated task validation by approving the learned trajectories of the robot.

Phase 3 – Simulation and reality, Validation

Simulation environment controls the physical robot UR10e with DDPG-algorithm via Robot Operating System (ROS). ROS network was build with multi-machine discipline in mind, having a specific pc for simulation with RL and control scripts, communication with the robot, and for machine vision. Machine vision is utilized in the validation for updating the location of the target. Camera tracks a QR tag in the physical world and provides feedback by updating the pose of the target within the simulation. Physical task validation consists of giving a feedback to the user whether the robot has reached the target.

Conclusion

- With DDPG, ROS and open simulation environment transferring knowledge from simulation to physical environment was accomplished
- Built pipeline provides means for testing and validation of AI algorithms in robotic domain
- Simulation environment can be made more realistic by improving the dynamics, inertia of objects and mass forces. Current implementation is responsive with objects, but does not utilize actual dynamics

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beyond the obvious