Opening Doors: Teaching Robots to Work Like We Do

Popular Science Summary of the Master Thesis [1] at the RobotLab LTH, Lund University

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In this thesis, a control and estimation framework was developed for mobile manipulators to interact with everyday one-degree-of-freedom mechanisms such as doors and drawers. The framework combines navigation, whole-body coordination, and online learning, enabling robots to reposition, adapt, and execute manipulation tasks in real-world scenarios. The approach was tested in both simulation and on a real robot, demonstrating robust and flexible performance.

Many robots today are able to perform a single task well if they remain stationary. However, the challenge becomes much greater once they are required to move while interacting with the environment. Earlier research therefore focused on fixed-base manipulators, which simplified the problem but limited their usefulness in real-world settings. This thesis extends a control strategy originally developed for stationary systems to mobile robots, making it possible for them to drive, turn, and manipulate simultaneously. In this way, the robot can autonomously navigate to the correct location, coordinate the movements of its wheels and arm as one system, and learn the way a door or drawer moves while interacting with it.

Rather than treating the wheels and the arm as separate components, the robot is guided by a unified control system that enables smooth and well-balanced motion. On top of this, a planning layer ensures that the body of the robot remains clear of obstacles and that its heading is aligned with the direction of the hand's movement. By combining these elements, the system achieves fluid and coordinated whole-body behaviour. An additional online estimator allows the robot to adapt to mechanisms it has not encountered before, gradually learning their motion characteristics during the task.

The proposed framework was evaluated both in simulation and on a real mobile manipulator consisting of a UR5e robotic arm mounted on a MiR base. Through these tests, the robot successfully learned to open a wide variety of everyday mechanisms, including conventional doors, oven-style flip-down doors, sliding doors, and pull-out drawers.

Figure: Heron Robot [2]

The results demonstrate a step towards service robots that can operate effectively in human environments. Future applications may include supporting elderly people in their homes, carrying out work in hazardous environments, or delivering supplies in busy hospitals. By making robots more intelligent about how they move and interact with the world, this thesis brings us closer to reliable robotic assistants that can serve as genuine partners in everyday life.

The work presented here builds upon and extends earlier research on adaptive control for fixed-base manipulators, applying it to mobile robot platforms and demonstrating its applicability in realistic scenarios.

[1] Yuyao Liu. 2025. Mobile Robot Manipulator Control for Interacting with 1-DoF Mechanisms. Master's thesis. Dept. of Automatic Control, LTH, Lund University, Lund, Sweden. Available at: `https://lup.lub.lu.se/student-papers/`.

[2] Heron Robot. 2023. Available at: `https://robotics.lth.se/infrastructure/`.