

Lab Project Proposal: Whole-Body Control for Furniture Opening

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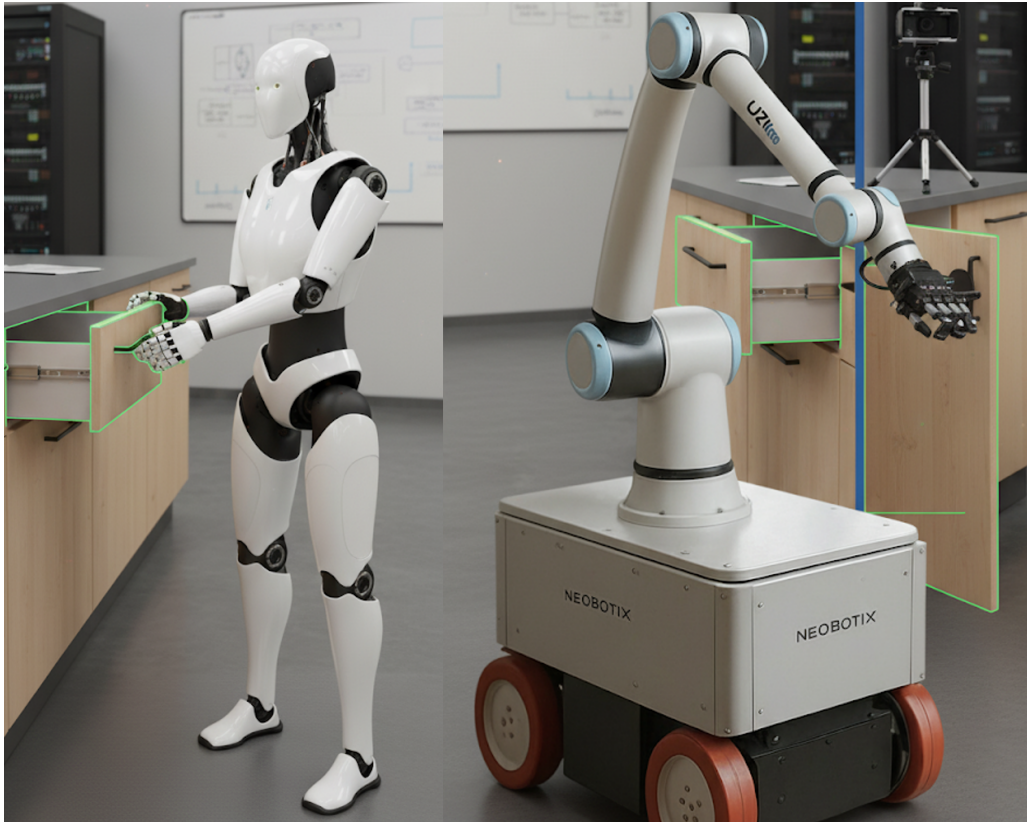


Figure 1: Caption

Goal

Enable the **Unitree G1 humanoid** and the **Neobotix MPO-700 with UR5e arm and Psyonic Ability Hand** to open furniture such as drawers and cabinet doors using whole-body control. The system should detect different types of handles with a vision-based pipeline and generate coordinated whole-body motions for safe and robust execution.

Motivation and Background

Furniture interaction is a critical step toward service robots that can operate in real homes and labs. Opening drawers and doors is challenging because it requires:

- **Reliable perception:** detecting varied handle types (horizontal, vertical, knob) in cluttered environments.

- **Whole-body control:** coordinating locomotion, arm reach, and end-effector forces.
- **Dexterous grasping:** leveraging advanced hands such as the Psyonic Ability Hand for robust interaction.

Recent methods such as *YOLO-Drawer* provide accurate handle detection. By combining this perception with whole-body control on the Unitree G1 humanoid and the omnidrive Neobotix platform, students will explore state-of-the-art strategies for embodied manipulation.

Approach and Work Packages

The project will be structured into work packages (WPs). Teams of 2–3 students (max. 4) will share responsibility for integration.

WP1 – Handle Detection: Integrate YOLO-Drawer into the ROS2 perception pipeline. Detect and classify different handle types. Estimate 3D handle poses with RGB-D data.

WP2 – Whole-Body Motion Planning: For Unitree G1: coordinate bipedal locomotion and arm trajectories to reach and manipulate handles while maintaining balance. For Neobotix + UR5e + Psyonic: use omnidrive base motions with arm trajectories to optimize reach and force application.

WP3 – Furniture Interaction: Design grasp strategies for different handle geometries. Use the Psyonic Ability Hand for robust pulling and pushing actions. Implement compliant control to handle uncertainties during drawer/door opening.

WP4 – Simulation and Deployment: First test in Isaac Sim / Gazebo for both platforms. Deploy on the Unitree G1 humanoid and Neobotix MPO-700 with UR5e + Psyonic Ability Hand. Evaluate success rates and robustness across different furniture types.

Available Resources

- **Software:** ROS2 (Humble), MoveIt2, Isaac Sim / Gazebo, YOLO-Drawer for handle detection.
- **Hardware:** Unitree G1 humanoid robot, Neobotix MPO-700 with UR5e arm and Psyonic Ability Hand.
- RGB-D cameras (Intel L515, D405) for perception.

Requirements

- Programming: Python (mandatory), Linux, shell scripting, and some C++.
- Packages: OpenCV, PyTorch, YOLO-based detection, MoveIt2, whole-body control frameworks.
- Interest in humanoid control, manipulation, and computer vision.

Expected Outcome

- A perception-to-action pipeline for furniture opening tasks.
- Robust handle detection with YOLO-Drawer and 3D pose estimation.
- Whole-body control strategies for humanoid and omnidrive manipulators.
- Demonstrations in simulation and on both real platforms (Unitree G1, Neobotix MPO-700 + UR5e + Psyonic Ability Hand).