Notes on Thesis Project

Progress, Methodology, and Future Development

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Outline

Initial Setup and API Testing

Activities:

- **Hardware Assembly:** Robot commissioned.
- **Testing:** Verified Teach Pendant, C++ API, and Python API.

Identified Limitations:

- Native libraries allow only simple movements.
- **No support** for collision-aware trajectory generation.

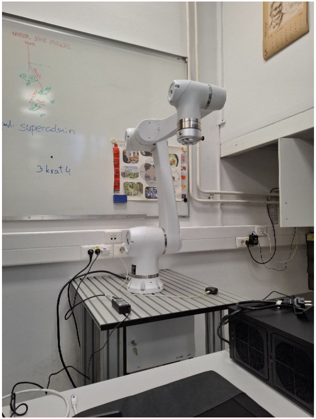


Figure: Hardware Setup

Transition to ROS2

Due to proprietary software limitations, we transitioned to **ROS2**.

- **Motivation:** Need for complex constraints handling and advanced planning.
- **Implementation:**
  - Configured a **MoveIt!** package for the dual-robot system.
- **Validation:**
  - Successfully tested MoveIt C++ API in simulation (RViz).
  - Verified on real hardware (single robot currently).

Visual Servoing Preparation

Simulation Environment:

- Integrated camera sensor into the simulation.
- Launched instance within **Gazebo**.

Video Demo:

[Click to play Simulation Video]

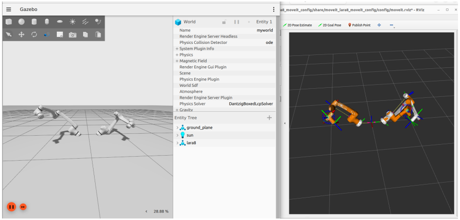


Figure: Gazebo Simulation

Methodology: Case Studies Overview

Analysis of previous results on dual-arm robots in agriculture.

1. **Bimanual Grape Manipulation** (Stavridis et al.)
2. **Robotic Aubergine Harvesting** (Sepulveda et al.)
3. **Vision-Based Dual Arm Harvesting** (Gursoy et al.)

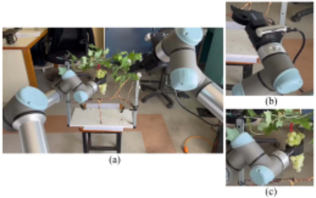
Case Study 1: Bimanual Grape Manipulation

Focus: Human-Inspired Robotic Harvesting

Role Division:

- **Arm 1 (Grasping):** Secures fruit via Force/Position parallel control.
- **Arm 2 (Camera/Cut):** Detects fruit and performs cutting.

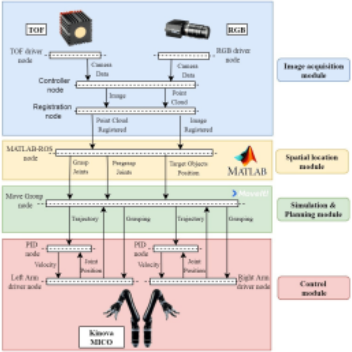
Key Strategy: A velocity-resolved control law keeps the fruit centered in the camera's Field of View (FoV) during the process.



Case Study 2: Robotic Aubergine Harvesting

Focus: Task Allocation and Efficiency
(Sepulveda et al.)

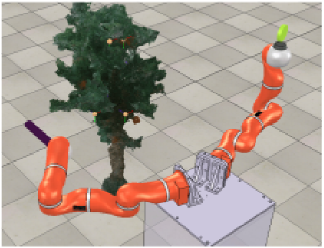
- **Detection:** SVM pixel-based classifier.
- **Planning:** Task allocation algorithm distributes grasping between arms. MoveIt generates waypoints for PID controllers.



Case Study 3: Vision-Based Dual Arm Harvesting

Focus: Hierarchical Control (Optimization)
(Gursoy et al.)

- **Control Strategy:** Hierarchical Quadratic Programming (HQP) to solve priority tasks.
- **Task Definition:** Absolute (cutting) vs Relative (grasping in cutter's frame).



Why not Reinforcement Learning (RL)?

Alternative solutions using RL were considered but **discarded**.

Reasoning

RL would require:

- Redesigning the entire setup.
- Rendering the current MoveIt implementation redundant (which already solves path planning with collision avoidance).

Future Development Steps

- **1. Hardware Completion:**
  - Assembly of the second robot.
- **2. Dual-Robot Integration:**
  - Test synchronous command transmission via ROS2.
  - Validate MoveIt integration for the complete dual-arm system.
- **3. Control Strategy Decision:**
  - *Option A:* Continue sending MoveIt-generated waypoints.
  - *Option B:* Transition to direct velocity control (`ros2_control` or **MoveIt Servo**).

Thank You

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