Terrawarden Drone Cleanup

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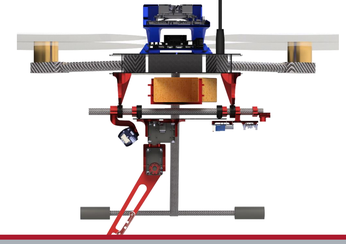


Search → Navigate → Track → Grasp → Deposit

Abstract

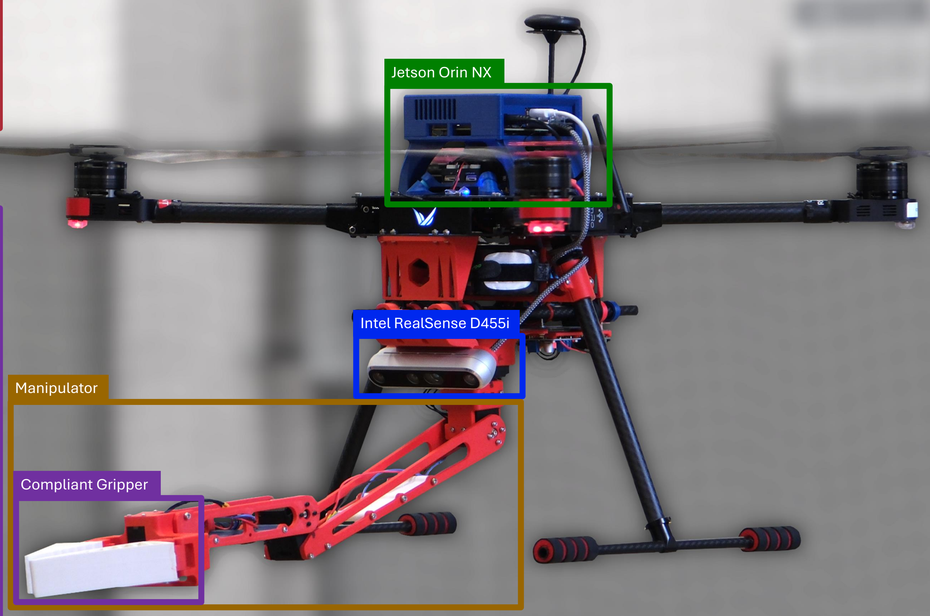
Roadside trash, a serious environmental and economic issue, is difficult, dangerous, and expensive to remove. **The Terrawarden drone, a one-meter-wide quadrotor with a 3-DOF manipulator and compliant gripper, addresses the challenges associated with collecting trash** on the inaccessible and uneven terrain of highway medians by autonomously detecting and retrieving trash using on-board perception.

Manipulator Design

- 3-DOF, ZYY joint config arm
- **Compliant** and **lightweight**
- Dynamixel XM430 actuators
- **3D printed** using ABS-GF

Gripper Design

- **Fin Ray inspired** compliant finger design printed in TPU
- Driven by symmetrical four-bar
- Total weight ~150 g



Drone Hardware

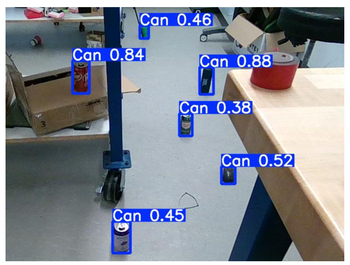
- **Jetson Orin NX** companion computer
- Pixhawk 6X autopilot flight computer
- 38 cm propellers
- **MicoAir optical flow** and distance sensor
- ELRS 2.4GHz remote control receiver
- **Intel RealSense D455i** depth camera
- Dynamixel OpenRB-150 servo controller

Results

- **Autonomous** flight and trash pickup
- Flight **hold within 10 cm** of setpoint
- Manipulator **within 2 cm** of setpoint
- Gripper holds **350 g payload**
- Trash **detection 83.2% accurate**
  - 39.1% of real-world cans missed
- Detection accurate up to 4 m
- Vision feedback in **under 40 ms**

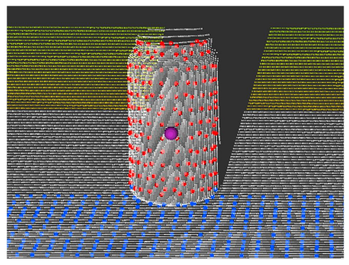
Trash Detection

- **Custom dataset** of trash, **CaNET**, generated with Blender
- Convolutional neural network, **YOLOv11**, to detect trash



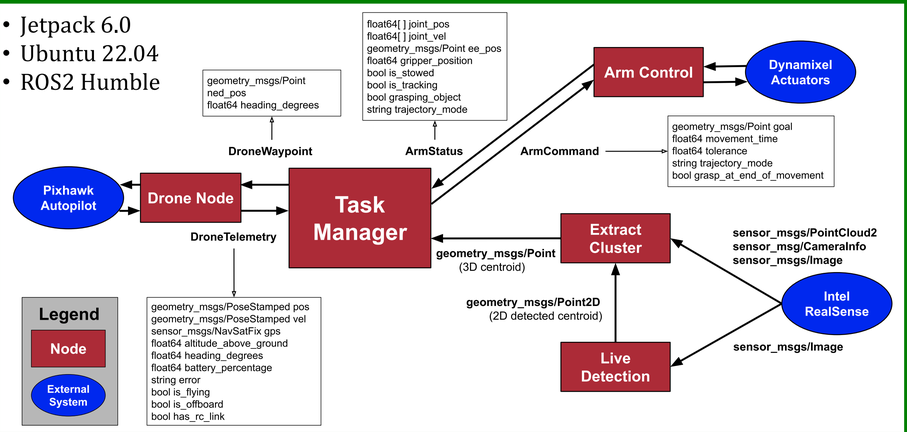
Vision-Based Manipulation

- **Stereo depth vision** converts a 2D point to 3D
- **Point Cloud Library** extracts the object cluster



Software Architecture

- Jetpack 6.0
- Ubuntu 22.04
- ROS2 Humble



Future Work

- Switch to **model predictive control**
- Implement collision avoidance
- Add robust outdoor search pattern
- More **durable manipulator** control
- Improve vision **accuracy and speed**
- Expand vision object dataset

Acknowledgements

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More Info

Image icons: flaticon.com