Active Object Tracking on DuckieDrone

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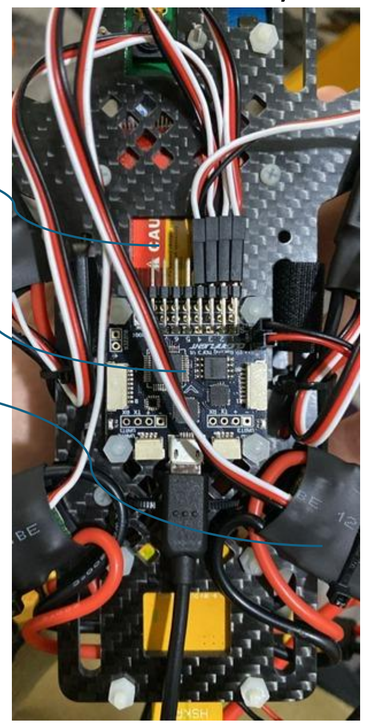
Introduction

- Autonomous aerial systems are essential in robotics for tasks requiring mobility and real-time perception. This project equips the Duckiedrone—a lightweight drone with RGB cameras and IMU sensors—with the ability to detect, track, and follow a target like a Duckiebot autonomously.
- Using ROS as the middleware, the system integrates flight control, sensor processing, and lightweight deep learning-based object detection on embedded hardware. This work highlights the successful integration of AI and embedded systems into a fully assembled aerial platform for adaptive real-time tracking.
- The image below shows the key components of the drone assembly with labeled parts, including top and bottom views of the drone.

1500mAh 3S 20C LiPo Battery

SP Racing F3 Acro

XXD 30A 2-4S ESC Brushless Motor Speed Controller



- The red arrows indicate the rotation direction of the propellers and the orientation of the drone.

Arducam 5mp 1080p OV5647 (The solution methodology includes images captured from the camera.)

Raspberry Pi 3B+ And Raspberry Pi Hat

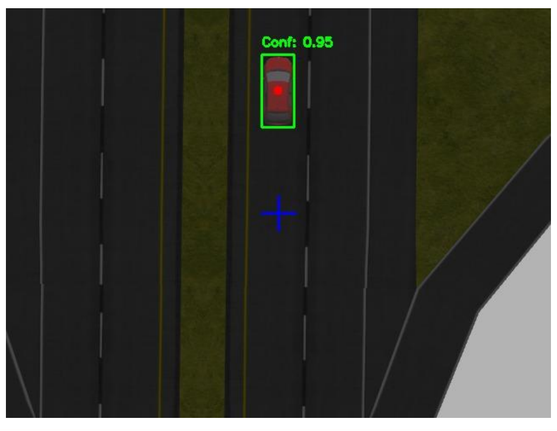
Hobbywing 5V 3A UBEC

Power Distribution Board (PDB-XT60)

Solution Methodology

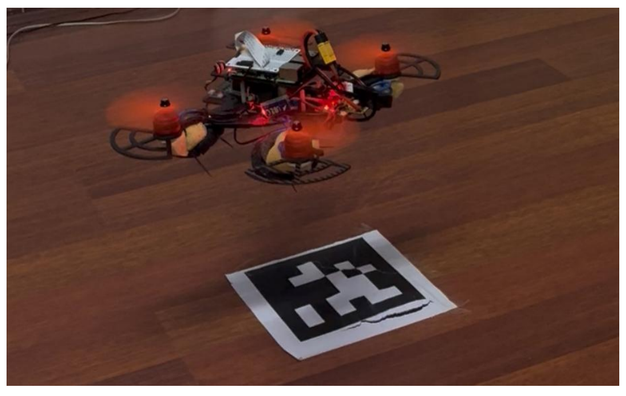
Simulation Part

- **Vehicle Tracking in ROS-Gazebo Environment**
- Platform: Iris ArduPilot quadcopter model in Gazebo simulator
- Detection: YOLOv5s lightweight model
- Control: PID controllers for autonomous drone movement commands
- Target: Real-time vehicle tracking with continuous following behavior
- Performance: Achieved robust tracking across various scenarios including static, moving, and occluded situations
- Validation: Comprehensive testing in controlled virtual environments with realistic physics simulation



DuckieDrone dd21 Part

- **Hardware Assembly and Autonomous Flight System**
- Platform: Custom-built Duckiedrone DD21 with Raspberry Pi 3B
- Components: Brushless motors, ESCs, IMU sensors, Pi Camera module
- Navigation: AprilTag-based visual positioning system using apriltag_ros
- Assembly: Complete hardware integration from discrete components
- Calibration: ESC calibration, motor balancing, and sensor alignment
- Control: Custom PID parameter tuning for stable flight characteristics
- Challenges: Hardware assembly complexity, power management, and flight stability



Results and Discussion

- **Simulation Results**
- Successfully tested real-time tracking with YOLOv5n in ROS-Gazebo.
- Maintained consistent performance in various scenarios (static, moving, occluded targets).
- Tracking algorithms and PID controllers validated in simulation.
- **Real-World Results**
- Fully assembled the Duckiedrone DD21 from scratch.
- Achieved motor control and ESC calibration, but faced challenges with autonomous flight.
- **Overall Assessment**
- Simulation confirmed the effectiveness of the algorithms.
- Real-world tests highlighted a significant gap between simulation and deployment.

Acknowledgements

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