Autonomous UAV Takeoff and Landing on Moving Platforms

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PROJECT GUIDE: Dr. T S Chandar

MOTIVATION

- UAVs alone face limits in endurance, range, payload, and speed.
- Pairing drones with ground vehicles overcomes these limitations.
- This hybrid system boosts capability and supports time-critical missions.

IMPLEMENTATION

- The project is implemented entirely in a software-based simulation environment.
- The vehicle is modeled as a rover and the IRIS drone is used for the UAV.
- Integrates ArduPilot SITL, Gazebo, MAVSDK, MAVLink and OpenCV into a unified autonomous UAV pipeline.
- The UAV tracks the rover using an ArUco marker present on the rover.
- The rover sends its position odometry to the drone with a delay of 50ms.
- We simulate false negatives based on the attitude, and only give a few frames to the tracking algorithm.
- We combine the noisy odometry data with the vision data to track the rover.

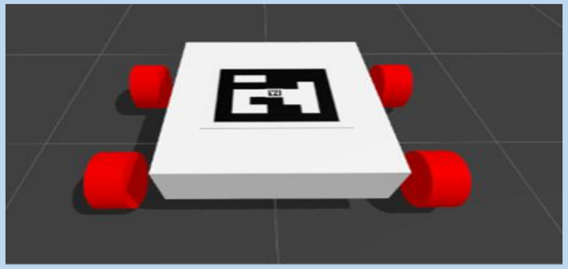

Figure 2: The Ground Rover With Aruco Marker

THEORY

- Nested ArUco marker is present on the rover which is used by the UAV use to find their relative pose using a Perspective-n-Point algorithm.
- Pose from vision is fused with relative odometry data from rover and UAV for stable, drift-free localization, even during vibrations or brief marker loss.
- The UAV is modeled and a Second order plus delay system and used to tune the PIDs.
- Rate of decent is a function of lateral error from rover and altitude of drone to enable smooth landing

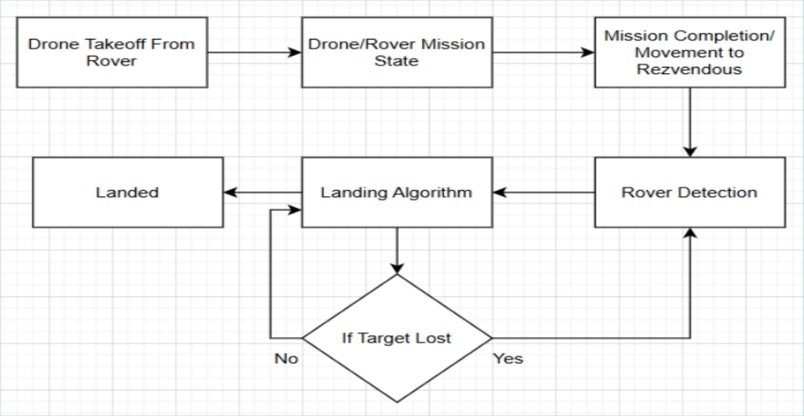

Figure 1:Flowchart of Mission plan

ANALYSIS AND RESULTS

- The UAV completed a waypoint mission and then tracked the rover, achieving precise landing with 2.73 cm lateral error while the rover moved at 2 m/s.
- During circular rover motion, the UAV overcame initial tracking oscillations and achieved landing with a 7.82 cm lateral error after 32 s from first detection.
- The system maintained tracking evenwhen there was a jump of speed at low altitudes (3 m) and successfully landed at rover speeds up to 5 m/s, with a final accuracy of 10.16 cm.

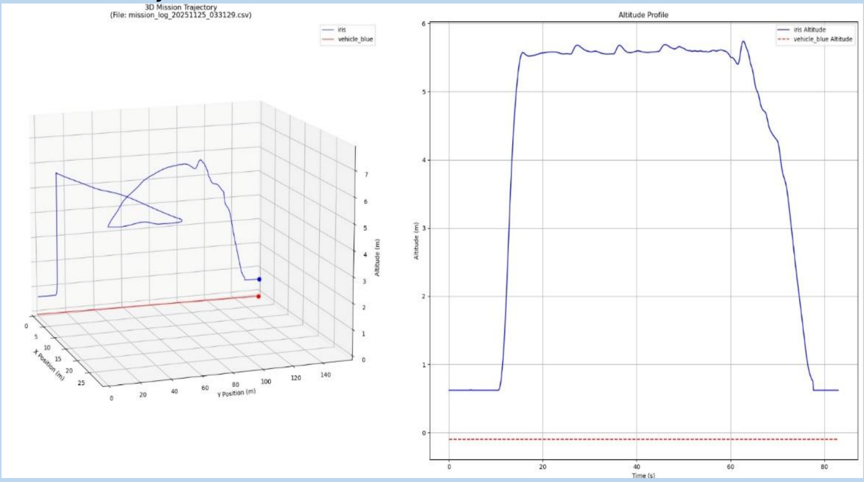

Figure 3: 3D mission trajectory and altitude plot

CONCLUSION

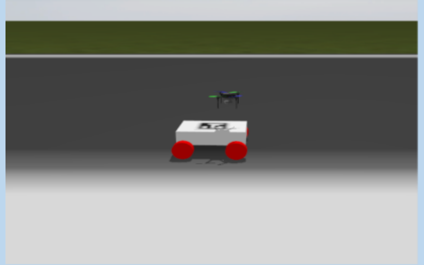

Figure 4:Drone attempts to land on the moving platform

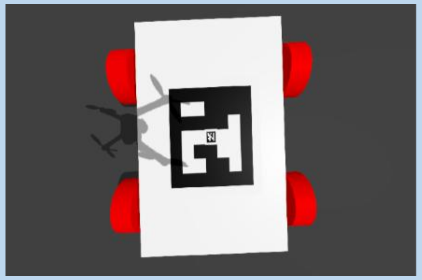

Figure 5: Drone Camera View Just Before Landing

The work presents a complete simulation-based framework for autonomous UAV takeoff, tracking and landing on a moving rover using a combined vision and odometry guided architecture.

We were able to successfully show that a UAV-Vehicle system can be used to complete mission and the UAV can takeoff and land autonomously on the vehicle without needing it to stop