UAV Landing on General Moving Platforms Without Markers*

Sagar Dalai[1 [0000−0001−7195−9831]], Kanishk Vishwakarma[2 [0000−0001−8673−9440]], Kaushal Kishore[1 [0000−0001−8751−3009]], and Samarth Singh[1 [0000−0002−7745−7477]]

[1] CSIR-Central Electronics Engineering Research Institute Pilani, India
[2] Birla Institute of Technology and Science, Pilani Campus, India
kaushal@ceeri.res.in

Abstract. Multirotor UAVs and their ability to hover and maneuver in air makes them the best vehicle for applications where quick package deliveries are required. Our assumed example system is a collaboration of a UAV and a land vehicle capable of storing multiple packages and charging the UAV's batteries. Another example is in quickly exploring some unknown region where the UAV scans the unexplored region and returns to the moving vehicle when required knowledge is gathered. An active research problem in such systems is about takeoff and landing the UAV on the moving vehicle. Taking off the UAV from the moving platform and stabilizing it is easily implementable using extrinsic sensors for observing relative speed and minimizing it. The landing problem, however, is quite challenging without special markers like visual tags, hard-coded trajectory targets, etc. We present a marker-less program that uses only computer vision and calculates the optimum trajectory to land on the moving platform without collision.

1 Introduction

The increasing interest of delivery companies like Swiggy[4] and Amazon towards autonomous robotic deliveries using UAVs, it is inevitable that the UAVs have to land on moving platforms in some cases, for instance for charging batteries via a land vehicle during mission or when collecting more packages from the land vehicle without requiring to go back to original workstation. Either case, landing a UAV on a moving platform certainly is a tricky problem with unpredictable target trajectories, occlusions, controls without collision, and ambient noise such as wind or bad visuals due to smoke or rain. Currently a lot has been done but using visual markers, which is impractical in real-life scenarios where the target landing site will most of the times not have markers, or anything that can be vaguely considered a marker. Because of the generalization of the problem, deep neural networks need to be employed to detect the target landing platform.

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2 Related work

The work done by Samir et al.[1] demonstrated autonomous landing with an error of less than 37 cm from the center of a mobile platform traveling at a speed of up to 12 m/s under the condition of noisy measurements and wind disturbances. Borowczyk et al.[3] made use of AprilTags, a visual fiducial dictionary based system, together with an IMU and GPS receiver integrated on a moving target travelling at a speed of up to 50 km/h.

3 Our Approach

The overview of our approach consists of three stages:

1. Locating and classifying the moving target and the landing platform, respectively
   - The computer vision stack uses semantic segmentation to find the vehicle having the landing platform. Optical flow contours can also be used to segment the moving objects and select the target vehicle using semantic segmentation.
2. Trajectory generation and getting upto the platform's speed and orientation
   - Visual servoing is performed so that the UAV can follow the vehicle and starts following a safe target trajectory. An extension to research done by K M Krishna et al.[2] can be performed for visual servoing.
3. Calculating a safe, collision-free touchdown maneuver
   - Once the target viewpoint is reached and the UAV is following the vehicle on the target trajectory, a landing maneuver is performed using an MPC similar to what Samir et al.[1] calculated.

References

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