AER1217: Development of Unmanned Aerial Vehicles
Lab 3: Georeferencing Using UAV Payload Data

1 Introduction

This is the third lab in a series designed to complement the lecture material and help you with the course project. In this lab, you will be using the Parrot AR.Drone 2.0 bottom-facing camera (64° diagonal FOV, 640px $\times$ 360px) to detect and locate circular targets of interest on the ground. The bottom camera's intrinsic matrix and distortion coefficients are the following:

$$K = \begin{bmatrix} 698.86 & 0.0 & 306.91 \\ 0.0 & 699.13 & 150.34 \\ 0.0 & 0.0 & 1.0 \end{bmatrix}$$

$$d = \begin{bmatrix} 0.191887 & -0.563680 & -0.003676 & -0.002037 & 0.000000 \end{bmatrix},$$

where more details can be found in Lecture Notes.

The data from the Vicon motion capture system and the images from the quadrotor will be used to find each target's location on the ground within the inertial Vicon fixed reference frame. The extrinsic transformation matrix from the vehicle body frame to the camera frame is assumed to be

$$T_{CB} = \begin{bmatrix} 0.0 & -1.0 & 0.0 & 0.0 \\ -1.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & -1.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 1.0 \end{bmatrix}.$$

1.1 Lab Objectives

A dataset has been provided to you, which includes the state of the ARDrone measured by the Vicon system and the bottom camera images in corresponding timestamps. This lab requires you to design an image processing algorithm that will assign georeferenced coordinates to pixels of an image based on quadrotor position and attitude. It is encouraged for you to conduct image processing in real-time, but this is not necessary to complete this lab. You may find the OpenCV library useful for this task.

2 Lab Components

2.1 Requirements

For this lab, you are required to locate the centroid of targets of interest in the Vicon space using the quadrotor. There will be a **six targets** on the ground for which you are required to provide the Vicon position coordinates based on the ARDrone pose and the images it captures. The targets, as shown in Figure 1 will be within an area on the ground bounded by $x \in [-2.0, 2.0]$ m and $y \in [-2.0, 2.0]$ m.

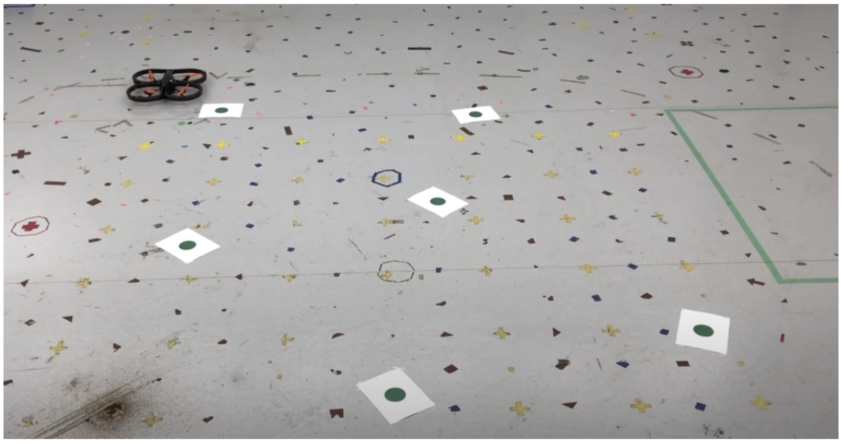

Figure 1: Example of landmarks on the ground

3 Deliverable and Grading

Your deliverable for this lab includes (1) a short report of **maximum four pages** documenting your results, and (2) the source code that your team wrote or modified. You are encouraged to write code in a modular way.

This lab is worth 15%. Please submit the following in a .zip format, to Quercus, latest by **11:59 PM, March** 20, 2025:

- **Code** (7%):
  - Image (post)-processing (3%).
  - Target localization (4%)

  Please comment your code properly and provide a `readme.txt` with proper explanation of the code structure.
- **PDF report** (8%) containing the following:
  - Overview of the algorithm used to locate targets, including the equations used. (4%)
    Hint: You should use more than one image per target to improve your estimation.
  - Summary of the targets found and their estimated positions. (4%)
    The grading for the target position accuracy follows the formula:

$$\text{Score} = \sum_{i=1}^{N} \frac{4}{N} \min\left\{1, \frac{0.25}{R_i}\right\}$$

    where N is the total number of targets, and R_i is the distance between the identified position and actual position of the target in meters.