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VISION-BASED RELATIVE POSITION ESTIMATION AND INTERCEPT TRAJECTORY PLANNING FOR SMALL UNMANNED AIRCRAFT SYSTEMS

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Objectives

This thesis examines the use of commercial-off-the-shelf (COTS) monocular camera to visually estimate the relative range and angular offset in azimuth and elevation of a nominal drone target from the optical axis of the camera. A computer vision (CV) algorithm is developed to detect and localize the position of the target within the camera's field of view (FOV). A simple flight guidance algorithm is subsequently developed to use information from the CV algorithm to generate motion command signals to allow the observing drone platform to autonomously pursue and intercept the target. Implementing these functionalities would form the foundation for a practical counter-UAS capability.

Research Idea

The CV algorithm uses color-space segmentation approach to detect and localize the target position within the video image frames. The baseline scenario considers only the detection of a single airborne target against a sky background of largely homogeneous color. These simplifying assumptions allow the thesis to focus on the range and angular performance of a COTS-based camera.

Table 1. Range Measurements at Impossible City

Waypoint	Planned distance from waypoint to camera (meters)	Angular size (degrees)	GPS estimated range (meters)	Width of bounding box (pixels)*	CV estimated range (meters)	Estimate error (%)
R1	10	1.89	9.5	34	5.2	48%
R2	20	0.95	19.4	16	10.8	46%
R3	30	0.63	29.8	-	-	-
R4	40	0.47	40.1	-	-	-
R5	50	0.38	48.9	-	-	-
R6	60	0.32	59.2	-	-	-

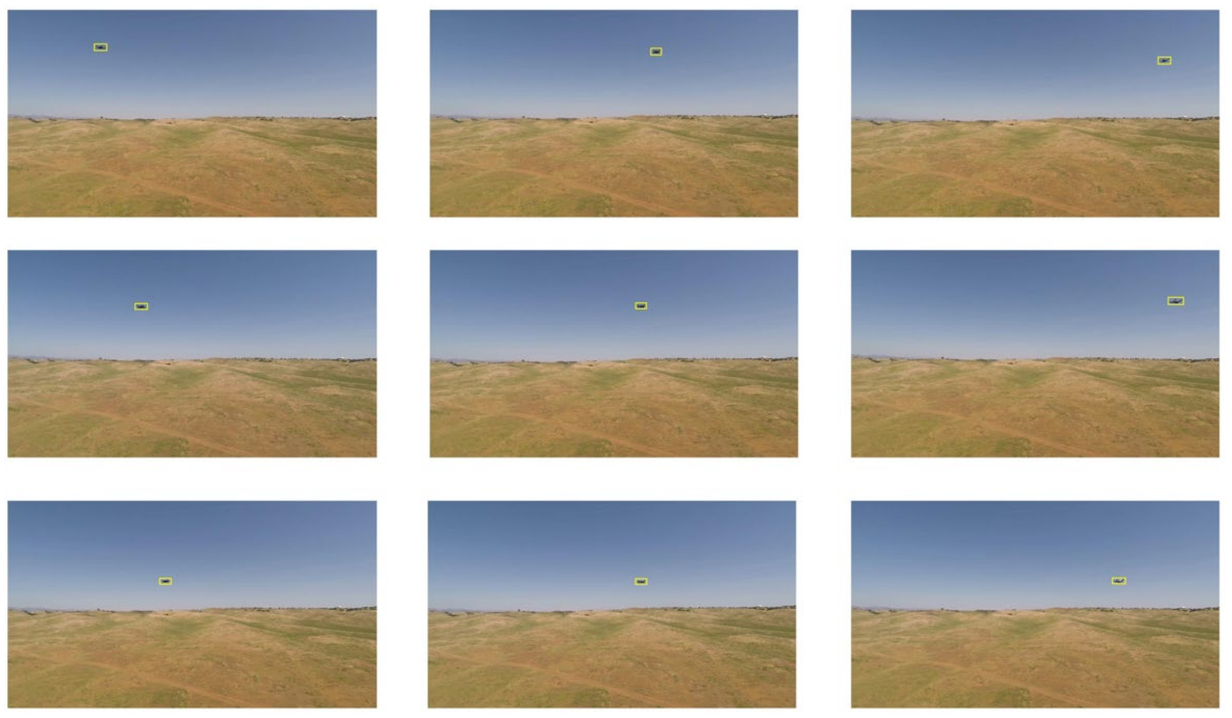
*based on 960 x 540 resolution image frame

Table 2. Range Measurements at Camp Roberts

Waypoint	Planned distance from waypoint to camera (meters)	Angular size (degrees)	GPS estimated range (meters)	Width of bounding box (pixels)*	CV estimated range (meters)	Estimate error (%)
RR1	4	4.7	-	70	5.1	-27%
RR2	8	2.4	-	50	7.1	11%
RR3	12	1.6	-	44	8.1	33%
RR4	16	1.2	-	35	10.2	36%
RR5	20	1.0	-	22	16.1	20%
RR6	30	0.6	-	-	-	-
RR7	40	0.5	-	-	-	-
RR8	50	0.4	-	-	-	-
RR9	60	0.3	-	-	-	-

*Based on 1920 x 1080 resolution image frame

Figure 1. Montage of Waypoints at Camp Roberts (10m)



Results

The upper bound of the range estimation was established to be 20m for a small-size UAS target (33cm in width). For the waypoints observed at 20m away from the camera, the azimuth errors range from 1.5°–18.4°, while the elevation errors range from 0.1°–5.6°. At 10m away, the azimuth errors range from 3.9°–11.4°, while the elevation errors range from 0.3°–4.9°. The results of the angular estimation did not reveal any dependency in the estimation error.

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