TALLINN UNIVERSITY OF TECHNOLOGY
School of Information Technologies

Kalev Miljan 185891 IACB

Scene-Steering Capability for Unmanned Aerial Vehicle Camera Platform

Bachelor's thesis

Supervisor: Assoc. Prof. Dr.-Eng.
Jeffrey A. Tuhtan

Tallinn 2022

TALLINNA TEHNIKAÜLIKOOL
Infotehnoloogia teaduskond

Kalev Miljan 185891 IACB

Stseeni jälgimise võimekus mehitamata õhusõiduki kaameraplatvormile

Bakalaureusetöö

Juhendaja: Assoc. Prof. Dr.-Eng.
Jeffrey A. Tuhtan

Tallinn 2022

Summary

One of the unmanned aerial vehicle (UAV) camera payload operators' tasks is to observe specific locations, or *scenes* for periods of time on the order of tens of minutes. Since the UAV is in constant motion, the camera's field of view drifts away from the scene. Operators must either continuously manually track the area or use an autonomous system to maintain a fixed field of view under motion and orientation changes of the UAV camera. Commercial solutions for this problem exist, but lack in adaptability.

This thesis describes the development of such an autonomous system. Using only image processing methods, a solution for calculating corrective commands for a stabilized, motor-driven 2-axis gimbal is designed.

A simulation environment was built to test the solution's performance. The resulting solution can track scenes for long periods of time (tests were ran for up to 10 minutes). In tests, the solution demonstrated robustness to zooming in and out 16x and partial scene occlusion by moving vehicles.

Tests and results

The purpose of the tests was an evaluation of end-to-end performance: the solution's ability to keep the camera pointed at a target scene.

Within the simulation framework, a target scene at point R was specified. Two lines were constructed: OF, representing the optical axis of the camera and OR, connecting the target and the camera. The distance $|FR|$, taken on the plane p (to which line OF is normal) was used as the linear measure of error (Figure 1).

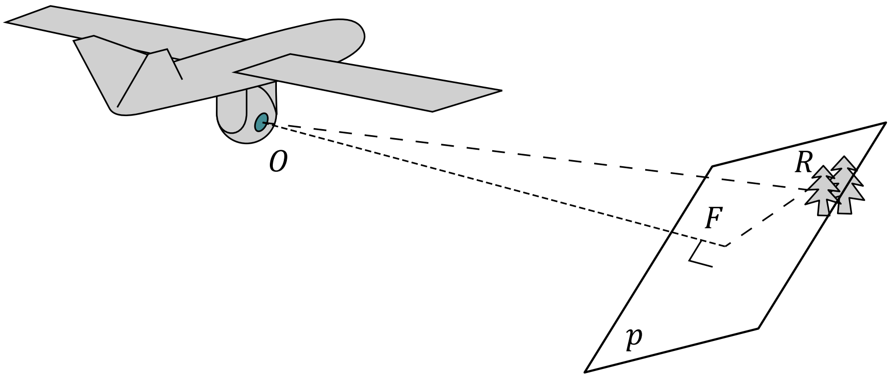

Figure 1. Error measure visualisation.

Drift is then defined as the cumulative average of the linear measure of error. 2 tests (Table 1) were set up with common parameters listed in Table 2.

Table 1. Test scenarios.

Parameter	**Scenario 1**	**Scenario 2**
Description	Circle around target with distracting vehicles. After the first 5 minutes, zooming the FOV out to 16x and back in 5 seconds was repeated 5 times.	Harsh conditions and a distant target. Flight path not centred around target.
Test duration	10 minutes	4 minutes
Simulated camera sensor	Visible light	MWIR
Simulated weather	Fair weather	Fog, heavy rain (rain droplets visible on camera feed)
UAV distance from scene	1100 meters	1550 to 2400 meters
Distracting moving vehicles	2 aircraft flying repeatedly through the field of view, taking up max 1/3 of frame area. 3 moving small ground vehicles.	None

Table 2. Parameters common to tests.

Parameter	**Value**
UAV airspeed	120 km/h
Flight path	Approximate circular (8 waypoints), 1 km diameter.
Altitude (above ground level)	1000 m
Simulated vibration amplitude	0.1 m
Simulated vibration spectrum	White noise up to 15 Hz
Sampling rate for error measurement	60 Hz
Scene steering working frequency	30 Hz
Scene-steering activation method	Manual (incurs some error)

The results in Table 3 indicate an expected cumulative average of scene tracking error of less than 10% of scene width over 10 minutes.

Table 3. Simulation test results.

	Approximate scene width during activation (meters)	**Cumulative average of linear error measure (meters)**	**Percentage of linear error measure relative to scene width.**
Scenario 1	77	5.9	7.7%
Scenario 2	84 (Activated at furthest point in the flight path)	3.0	3.6% (8.9% when extrapolated to 10 minutes)