INDOOR DRONE PHOTOGRAMMETRY AND NAVIGATION

By: Hannah Poon, Claire Mah, and Mabel Heffring
Department of Geomatics Engineering
Schulich School of Engineering, University of Calgary

BACKGROUND

Problem Statement:

To explore the functionality of the Parrot Mambo Fly drone to demonstrate principles and applications of Geomatics engineering to be used by future students.

Objectives:

1. Utilize second- and third- year geomatics curriculum
2. Utilize previous research to build a new solution
3. Create an open-source geospatial tool

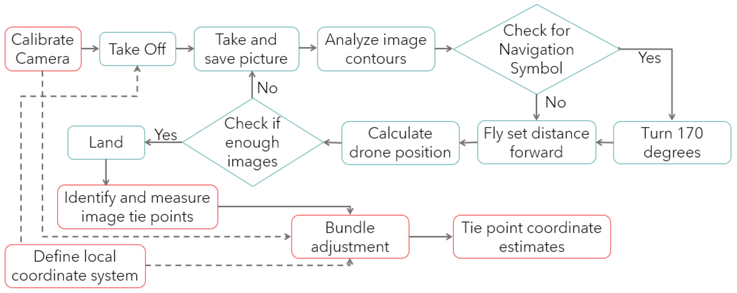

Figure 1. Process overview flowchart

NAVIGATION & FLIGHT

Purpose:

Autonomous navigation and exterior orientation parameter (EOP) estimates for each image.

- Drone is flown and operated over a Wi-Fi connection using a Python script
- Star shaped flight path to minimize error propagation effects
- On-board IMU provides heading
- Drone coordinates estimated at each image location
- Python script performs symbol detection, similar to photogrammetry tie points

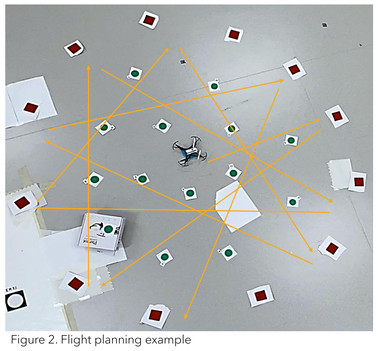

Figure 2. Flight planning example

```
There is a red square in this picture

heading:  -120.15797241826091
New length is 18
Mambo_2018-10-08T140833+0000_2B04A5.jpg
c:\Users\clair\Documents\ENGO Year 4\engo500\git\Capstone
Your Mambo groundcam files will be stored here c:\Users\cl
```

Figure 3. Python script sample outputs

PHOTOGRAMMETRY – TIE POINT DETECTION

Purpose:

Autonomously identify and measure the position of tie points in image space for the bundle adjustment.

- Gaussian blur is applied to reduce image noise
- Image mask is created using RGB range for colour green
- Edge detection is applied to the image mask to find circular contours
- Centroid is measured for each detected circle

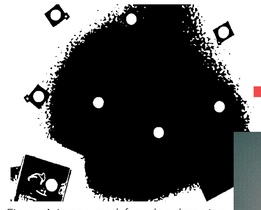

Figure 4. Image mask for edge detection

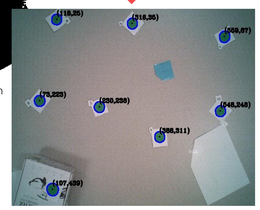

Figure 5. Tie point detection results

PHOTOGRAMMETRY – CAMERA CALIBRATION

Purpose:

Determine the interior orientation parameters (IOP) for each drone camera to accurately relate the image space measurements to the 3D real-world coordinates.

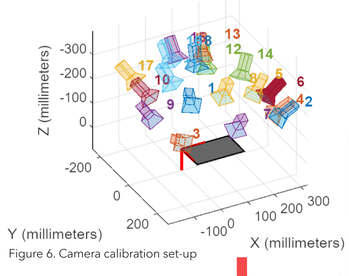

Figure 6. Camera calibration set-up

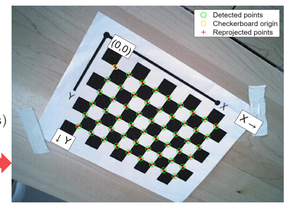

Figure 7. Example calibration image

- Camera calibration performed using MATLAB calibrator function
- Tested before and after time passed and drone had crashed
- Tested with 10 to 20 images

PHOTOGRAMMETRY – BUNDLE ADJUSTMENT

Purpose:

Estimate the 3D real-world coordinates of each tie point using image space measurements.

- Iterative Least Squares Adjustment
- 8 images and 10 tie points, n=106, u = 78
- Zero Order Design: Datum defined by assuming ground control points
- First Order Design: Limited camera angle due to flight pattern and tie point placement
- Second Order Design: Automatic tie point detection

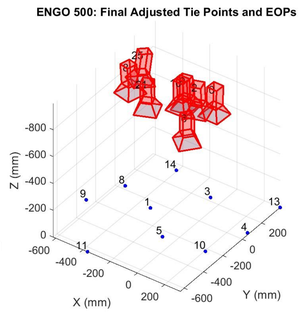

Figure 8. Final adjusted tie points and EOPs

Table 1. Final Adjusted Tie Points and Precisions

Point	# of Images	X (mm)	Y (mm)	Z (mm)	sd X (mm)	sd Y (mm)	sd Z (mm)
1	7	-313.400	-63.307	-0.366	1.391	1.321	1.942
3	6	-81.388	231.213	0.041	1.486	1.433	1.977
4	1	304.480	69.558	-0.460	1.745	1.763	1.970
5	7	-87.886	-256.683	-0.129	1.475	1.508	1.924
8	4	-565.376	31.154	0.644	1.680	1.628	1.981
9	1	-584.217	-344.362	-113.911	1.824	1.959	1.981
10	5	205.986	-225.733	0.650	1.681	1.727	1.960
11	1	-365.781	-638.497	0.251	1.885	1.994	1.998
13	1	315.593	390.200	0.087	1.919	1.880	1.988
14	5	-406.011	334.457	0.194	1.645	1.720	1.977

LIMITATIONS

- Drone flight limited by battery, weight, and environment
- Requires control points to be set out and measured for accuracy
- Inertial position estimation - Integration of GNSS technology for georeferencing can improve the precision and reliability of inertial position estimation in real-life applications
- Tedious post-processing steps – Work on finding ways to perform photogrammetry preparation in real-time

IMPROVEMENTS

- Automatic EOP collection
- Estimate biases in system
- Batch script to call tie point identification and bundle adjustment
- Automate tie point ID assignment
- Increase quantity and density of tie points
- Better control of drone height

APPLICATIONS

- Incorporate drone in geomatics engineering courses to be used as a learning tool for coding in Python
- Surveying of remote areas with no access or connection to GNSS or Wi-Fi
- Indoor mapping can be used for architectural design and emergency response planning
- Remote sensing and photogrammetry can create accurate 3D models of building interiors and aid in search and rescue operations

Figure 9. Example drone flight path

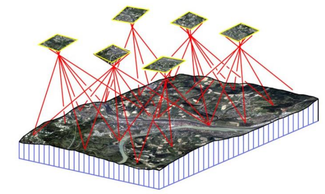

Figure 10. Real-world bundle adjustment

Project on GitHub

Watch our drone in flight!