Drohne für ein hoch genaues Korridor-Mapping

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Ahorn 2015, Wildhaus
Motivation

- Flussverlauf
- Autobahn
- Pipelines
- ...

[Images of pipelines and highways]
What’s on the menu

- Corridor Mapping
- MAV Platform
- Methodology & testing
  - Calibration fields
  - System calibration
- Mapping & “orientation” performance
- Conclusion
Details on corridor mapping

- ground control point
- time, 3D position/attitude
- Image with photo measurements
- No typical block structure
- Small lateral overlap
- Texture (snow, vegetation)
- GCPs take time to set up

a – indirect SO
b – direct/integrated SO
TOPO plane - Structure

- Characteristics

- Custom built
- 150 Euro frame (the same as MAVinci UAV)
- Off-the-shelf components
- 1630 x 1170 mm
- Operational weight 2800g
- Endurance 40 min with 600 g of payload
- Flying speed 16-20 m/s
- Pixhawk (ETHZ) autopilot
TOPO Plane – Photogrammetry Payload

- **Redundant-IMU (A)**
  - FPGA board
  - 1-4 x MEMS IMU
  - 250 – 500 Hz

- **Camera (B)**
  - Sony NEX 5T camera (16 Mpx)
  - 16 mm lens (used in test)
  - synchronization module (flash)

- **GNSS**
  - multi freq., PPS, Event
  - GPS/GLonass L1/L2 antenna
System & Sensor Calibration

- **Camera calibration**
  - Self calibration during a separate flight

- **IMU calibration**
  - LSQ method for estimating “constant” elements (e.g. biases)
  - GMWM for estimating sensor noise characteristics

- **Bore-sight**
  - Camera – Body frame (IMU)

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System & Sensor Calibration

- Lever-arms
  - GNSS antenna – body frame (IMU)
  - Camera – body frame
  - “Pseudo-measurement” technique
System & Sensor Calibration
Flights

- Total Calibration field
  - 100 ha
  - 26 control/check points
  - ~30 m height differences

- Calibration block
  - Strips: A-E + H-J
  - Two heights: 120 and 150 m
  - 17 control points

- Corridor
  - Strips F+G
  - 1200 x 180 m long
  - 9 check points

- Statistics
  - 520 images
    - 459 used for calibration
    - 61 for corridor evaluation
  - Average GSD 3.8 cm
Processing Steps

- Image measurements – auto & manual (GCP) via Pix4D
- GNSS antenna positions – GrafNav (10 Hz)
- IMU position & attitude – custom filter/smooother
- Camera position & attitude transfer/adapt. – CAMEO

1. Calibration block
   - Camera self calibration + bore-sight estimation

2. Corridor
   - Bundle adjustment with POS and POS/ATT, no GCPs
   - Pix4D, several processing approaches
## Mapping Accuracy – Corridor

- No GCPs in the adjustment
- Fixed IO parameters, bores-sight and lever-arm
- Evaluated at 9 check points
- Angular observation plays a role

### EO parameters

<table>
<thead>
<tr>
<th>Residual</th>
<th>Position [m]</th>
<th>Height [m]</th>
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</thead>
<tbody>
<tr>
<td>MAX</td>
<td>0.147</td>
<td>0.114</td>
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<td><strong>Position only</strong></td>
<td><strong>MEAN</strong></td>
<td><strong>0.037</strong></td>
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<tr>
<td>RMS</td>
<td><strong>0.070</strong></td>
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<tr>
<td>MAX</td>
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<td>0.136</td>
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<tr>
<td><strong>Position + Attitude</strong></td>
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<tr>
<td>RMS</td>
<td><strong>0.029</strong></td>
<td><strong>0.070</strong></td>
</tr>
</tbody>
</table>
DTM Mapping Accuracy – Corridor

- Processed in Pix4D
  - Recalibrated IO

- **Block:** Complete set of images + all GCPs = reference

- **Corridor:** 3 different processing scenarios
  a) 9 GCPs – indirect
  b) 4 close GCPs - indirect
  c) NO GCPs - integrated
Conclusion

- MAV: hobby-grade plane + open source autopilot + correct instruments = **an affordable MAV mapping tool**

- **Sensor calibration**
  - One-time workflow for constant parameters
  - Good system calibration is needed.
  - Time varying parameters (IO) can be recalibrated in-flight.

- Achieved **accuracy in corridor** with POS/ATT: **1.5 GSD** in position and **2 GSD** in height **without GCPs**.
Conclusion

- One step closer to accurate direct sensor orientation with MAVs

- Requirements
  - Redundant-IMU with higher accuracy is needed.
  - Fault Detection and Identification (FDI) algorithm should be applied.
  - ...

- Déjà vu in aerial photography with manned aircraft?
Questions
Thank you for your attention!

To find more about the specific topic of sensor orientation on MAVs (and other platforms)

http://www.eurocow2016.org/
Feb. 10-12, 2016
EPFL campus
Reference