Assessment of different GNSS and IMU observation weights on photogrammetry aerial triangulation
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Introduction

Geospatial and Temporal data

http://www.imo.org/en/MediaCentre/PressBriefings/Pages/41-SDGS.aspx
Study Purpose

Applications:
- City Planning
- 3D modeling
- Disaster Management
- Deforestation
- ...

Quality check
Systematic errors optimization
Aerial triangulation

Data:
- Image data
- Ground Control Points
- Tie Points
- Check Points
- GNSS data
- INS data

Applications:
- City Planning
- 3D modeling
- Disaster Management
- Deforestation
- ...

High Quality Data

Output

DSM
DTM
Orthophoto
Mesh
Introduction [photogrammetry]

Photo = Light
Gram = Recording
Metry = Measurement
**Introduction [LiDAR]**

LiDAR stands for Light Detection and Ranging, commonly known as Laser Radar.

**Aerial LiDAR System Components:**

- Aircraft
- Scanning laser emitter-receiver unit
- Differentially-corrected GPS
- Inertial measurement unit (IMU)
- Computer

![LiDAR System Components Diagram](Source: internet)
Introduction [GNSS]

Global Navigation Satellite System

- Europe’s Galileo
- The USA’s NAVSTAR Global Positioning System (GPS)
- Russia’s Global’naya Navigatsionnaya Sputnikovaya Sistema (GLONASS)
- China’s BeiDou Navigation Satellite System

GNSS/GPS applications include:

- Tracking/Mapping Devices
- Industrial Machinery
- Sea vessels
- Air Navigation
- Automobiles
Combination of GNSS and INS will give continuous position, time and velocity information, even in difficult environments where there is limited GPS satellites in view.
Introduction [Aerial Triangulation Vs. Direct Georeferencing]

Calibrate some parameters:

- lever arm,
- boresight misalignment,
- camera interior orientation,
- some other sensor noise and errors

**GNSS shift and drift errors**


https://doi.org/10.1117/1.JRS.10.014002
Introduction [Aerial Triangulation Vs. Direct Georeferencing]

Aerial Triangulation

- More accurate
- Faster

Direct Georeferencing

Position and orientation estimated by AT

Position and orientation from GNSS/IMU

Direct measurements on Ground without GCP

Measurements on Ground using results of AT

Source: internet
Study Background

**Schmitz and Wübbena 2001**
- The rigorous GPS modeling in the combined GPS/block adjustment
- Compared it with shift and drift approach
- Better accuracy-IMU beside GPS-supported AT

**Mostafa and Hutton 2001**
- POS/Av 510
- DG in conjunction with standard stereo model + a single photo
- Accuracy of DG meets the theoretical admissible accuracy for map production

**Kruck 2002**
- Applanix V.s. IGI in two different photo scale considering GNSS shift and drift effect
- Applanix had lower RMS (better accuracy)

**Cramer 2006**
- Imaging sensor + Continuous GPS/INS data
- Kalman filter (strip-wise integration approach)
- Accuracy: Horizontal = 10-20 cm, Vertical = 20-30 cm

**Blázquez and Colomina 2012**
- Introduced functional models using relative aerial control instead of absolute position
- Removed completely GNSS shift and drift error besides IMU-to-camera boresight misalignment angle

**Kersten and Haering 1998; Heipke 1999**
- Tie points extraction in lake, forest and mountain area is hard.
- GNSS/IMU data collection during project

**Mostafa et al. 2001**
- Independent photogrammetrically derived reference trajectory V.s. US National Geodetic Survey (NGS) Continuously Operating Reference Station (CORS)
Purpose and Data

Purpose:
- To finding best GNSS/IMU weight in aerial triangulation process

Study area and data:
- Gothenburg, Sweden – July, 08, 2019
- Lantmäteriet, the Swedish mapping, cadastral and land registration authority
- 0.25 m ground sample distance (GSD)
- The test field size is approximately 75 × 90 km²
- 25 strips, 1198 images
- 60% forward overlap 25% lateral overlap

- Applanix POS AV 510 – GNSS/IMU Equipment
- Ultracam Eagle digital camera with an 80 mm lens
Method

GNSS shift and drift errors

- GNSS antenna-eccentricity
- GNSS reference stations are far away from the project area
- Incorrect On The Fly (OTF) integer ambiguities in GNSS kinematic observations

\[
\begin{align*}
    f_x &= (x'_0 + d_{x_0}) - (f + d_f) \times \left[ \frac{r_{11}(X - X_0) + r_{21}(Y - Y_0) + r_{31}(Z - Z_0)}{r_{13}(X - X_0) + r_{23}(Y - Y_0) + r_{33}(Z - Z_0)} \right] + \delta_{\text{shift}} + (t - t_0)\delta_{\text{drift}}, \\
    f_y &= (y'_0 + d_{y_0}) - (f + d_f) \times \left[ \frac{r_{12}(X - X_0) + r_{22}(Y - Y_0) + r_{32}(Z - Z_0)}{r_{13}(X - X_0) + r_{23}(Y - Y_0) + r_{33}(Z - Z_0)} \right] + \delta_{\text{shift}} + (t - t_0)\delta_{\text{drift}},
\end{align*}
\]
### Result

<table>
<thead>
<tr>
<th>Observation uncertainty</th>
<th>IMU (°)</th>
<th>Numbers of image rejection</th>
<th>RMS Residual check Points (m)</th>
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<tbody>
<tr>
<td>GNSS (meter)</td>
<td></td>
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<tr>
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<td>N</td>
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</tbody>
</table>

The number of image rejection and checkpoints RMS of some best case, worst case and Lantmäteriet default (*) for observations uncertainties.

![T-test evaluation of Images with higher errors](image-url)
Result

![Graph showing RMS Residuals of Check points and Total Image Rejection](image_url)

RMS Residuals of Check points (m)

Total Image Rejection (m)

GNSS (cm) and IMU (degree/1000) uncertainties
Thank you for your attention