Documentation of remote archaeological sites

A comparison between long-range laser scanning and UAV-photogrammetry

Anden-Transekt-Project

In cooperation with German archaeological institute (DAI)

http://maps.google.com
http://www.dainst.org
Geodetic tasks within the Anden-Transekt-Project

Geodetic documentation of remote archaeological sites

- Generation of digital terrain models
  - visualisation
  - further analysis

- Detailed acquisition of objects of interest

Sites to be mapped

**Cutamalla** (3300 m.a.s.l, 0.5 km²)
Visible from below (highest peak)
Low and sparse vegetation

**Santa Maria** (2800 m.a.s.l, 0.2 km²)
Visible from above (valley’s slope)
Denser vegetation
Applied methods

UAV-photogrammetry

- Flying altitude 60 meters above ground
- Ground sampling distance 2.5 cm
- Ground control points measured with D-GNSS
- DSM and orthophoto with rastersize of 5 cm (re-rasterized to 10cm for comparison)

Terrestrial LR-LS

- Max measurement distance of 1.2 km (counter slope)
- Resolution at largest distance ~5 cm (orthogonal)
- (Some) scan stations measured with D-GNSS
- DSM with rastersize of 10 cm

Model generation – UAV-photogrammetry

Image Orientation & Camera Calibration → Dense Matching → DTM Generation → Orthophoto Generation

Cutamalla: 790 images, 20 GCPs
Santa Maria: 240 images, 12 GCPs
Model generation – LRLS

- Cropping to region scan positions (8 with D-GNSS)
- Single Scan Filtering
- Combining Scans & 2nd Filtering
- Rasterization & Interpolation

- Initial solution from internal sensors
- Merging of single scans
- Terrain filter (vegetation)

Model comparison

Differences in meters
Model comparison

Deviations: UAV – LRLS

Differences arise mostly at the edges of man-made structures and at dense vegetation

- Missing LRLS data (occlusion)
- Different filtering strategies
- Different observation angle

Quantitative comparison

<table>
<thead>
<tr>
<th></th>
<th>Santa Maria</th>
<th>Cutamalla</th>
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</thead>
<tbody>
<tr>
<td>No. compared raster cells</td>
<td>12.8 Mio</td>
<td>19.8 Mio</td>
</tr>
<tr>
<td>Mean* in m</td>
<td>- 0.11</td>
<td>- 0.03</td>
</tr>
<tr>
<td>StdDev* in m</td>
<td>0.22</td>
<td>0.18</td>
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<tr>
<td>Outlier &gt; 0.5 m</td>
<td>4.6%</td>
<td>1.8%</td>
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*Mean height differences (Mean) and the corresponding 1σ standard deviations (StdDev) include the outliers.
### Method comparison

<table>
<thead>
<tr>
<th>UAV-photogrammetry</th>
<th>Terrestrial LRLS</th>
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<tbody>
<tr>
<td>+ homogenous point density over entire area</td>
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<tr>
<td>+ fast acquisition of large areas</td>
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<tr>
<td>+ bird's-eye view, thus well-suited for flat areas</td>
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<tr>
<td>+ robust with respect to meteorological conditions</td>
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<tr>
<td>+ little or no obstacles (except overhanging objects)</td>
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<tr>
<td>+ well-suited for sites with large vertical extension</td>
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<tr>
<td>- suited only for smaller areas (&lt;1 km$^2$)</td>
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<tr>
<td>- susceptibility to obstacles within line-of-sight</td>
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<td>- limited by meteorological conditions (i.e. wind and rain)</td>
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<td>- decreasing resolution with distance to the scanner</td>
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### Conclusion

- Both methods are **suited** to generate high resolution digital terrain models

- Archaeological surveying **demands** were fulfilled: visualization of complete site and basis for further analysis (e.g. man made structures are visible)

- Internal **quality checks** of the single models state accuracies of a **few cm**, but the comparison showed model differences up to **some dm**
  - Problems mainly in steep areas, and close to structures (vegetation, walls)
  - Further analysis would require independent field measurements of **control objects**

- Investigated methods are **complementary** if area consists of nearly vertical and horizontal parts **combination** makes sense and should be investigated
Thank you for your attention