COMPARISON OF GEOMETRIC AND RADIOMETRIC INFORMATION FROM PHOTOGRAMMETRY AND COLOR-ENRICHED LASER SCANNING

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Project

- Terrestrial Laserscanning (TLS)
  + detailed geometric representation
  - no detailed image with realistic colors
- Terrestrial Photogrammetry (TP)
  + detailed radiometric representation
  - very time-consuming restitution

Research question: Does “TLS+HR photo” deliver comparable results to those of the classical photogrammetry (geometrically and radiometrically)?

Get the best of both techniques: TLS + HR photo

Study Area

*Porte de Landelies at the Abbaye d’Aulne*
Thuin, Belgium (ca. 50 km at the South of Brussels)
Study Area

Porte de Landelies at the Abbaye d’Aulne

- Cistercians Abbey, built between 657 and 879
- Since 15th century: plundered and destroyed by respectively Burgundians, Beggars, French Royal Army
- 18th century: partly restored
- 19th century: partly destroyed in the French Revolution aftermath
- 20th century: partly rebuilt as rest home, a new church and the “Porte de Landelies” gate was reconstructed
Virtual 3D reconstruction of the “la Porte de Landelies” based on photogrammetry
La Porte de Landelies
(horizontal projection)
Terrestrial photogrammetry

Acquisition (2007) with analog metric Rolleiflex 6008 (40 mm lens – photoscale 1/150) and high resolution scanning of the negatives
Photogrammetric restitution

End products:
- Orthophoto
- DTM generation
- 3D Model

End result: orthophoto

Porte de Landelies at the Abbaye d'Aulne
Methodology for the comparison of the TLS image (2011) and the orthophoto (2007)

1. Acquire the laser point cloud
2. Take a photograph from exactly the same point as the laserscanner
3. “Texture” or “Fit” both images to the point cloud (e.g. using Cyclone software)
4. “Normalise” the colors of both the “draped photo” and the photogrammetrically produced “orthophoto”.
5. Compute for every pixel the “color difference”
6. Select all pixels with significant “color difference”

1. Acquisition of the Terrestrial laser scanning (with phase-based Leica HDS 6100)

<table>
<thead>
<tr>
<th>Laser Scanner System</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Phase-based</td>
</tr>
<tr>
<td><strong>System Performance</strong></td>
<td></td>
</tr>
<tr>
<td>Accuracy of single measurement</td>
<td></td>
</tr>
<tr>
<td>Position *</td>
<td>5 mm, 1 m to 25 m range; 9 mm to 50 m range</td>
</tr>
<tr>
<td>Angle (horizontal and vertical)</td>
<td>125 μrad/125 μrad, one sigma</td>
</tr>
<tr>
<td>Range</td>
<td>79 m ambiguity interval</td>
</tr>
<tr>
<td></td>
<td>79 m @90%; 50 m @18% albedo</td>
</tr>
<tr>
<td>Scan rate</td>
<td>Up to 508,000 points/sec, maximum instantaneous rate</td>
</tr>
<tr>
<td>Scan resolution</td>
<td></td>
</tr>
<tr>
<td>Spot size</td>
<td>3 mm at exit [based on Gaussian definition] + 0.22 mrad divergence; 8 mm @25 m, 14 mm @50 m</td>
</tr>
</tbody>
</table>

* At 127,000 pts/sec scan rate, one sigma.
2. Photo acquisition
with DSLR Canon 450D (12 Mp) and Nodal Ninja 3II

Forced convergence of center of the scanner and ‘optical midpoint or point of no parallax’ of the camera, taking into account the offsets of the camera body and mounted lens (e.g. [http://wiki.panotools.org](http://wiki.panotools.org))

3. Point set texturing (Leica Cyclone software)

Intensity values, measured by the scanner
RGB values, based on image draping
4. Color normalization (same mean and SD RGB intensities)

<table>
<thead>
<tr>
<th>Descriptives</th>
<th>Mean</th>
<th>St. Dev.</th>
<th>Median</th>
<th>EOM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>132,56</td>
<td>40,533</td>
<td>143,00</td>
<td>0,129</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,59</td>
<td>74,007</td>
<td>128,20</td>
<td>0,236</td>
</tr>
<tr>
<td>Green</td>
<td>130,13</td>
<td>42,485</td>
<td>141,00</td>
<td>0,136</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,53</td>
<td>73,982</td>
<td>129,55</td>
<td>0,236</td>
</tr>
<tr>
<td>Blue</td>
<td>122,51</td>
<td>42,112</td>
<td>132,00</td>
<td>0,134</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,50</td>
<td>73,952</td>
<td>129,09</td>
<td>0,236</td>
</tr>
<tr>
<td><strong>Ortho</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>157,60</td>
<td>50,023</td>
<td>173,00</td>
<td>0,160</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,57</td>
<td>74,114</td>
<td>127,76</td>
<td>0,237</td>
</tr>
<tr>
<td>Green</td>
<td>147,66</td>
<td>51,948</td>
<td>164,00</td>
<td>0,166</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,52</td>
<td>74,062</td>
<td>127,76</td>
<td>0,236</td>
</tr>
<tr>
<td>Blue</td>
<td>140,31</td>
<td>52,617</td>
<td>157,00</td>
<td>0,168</td>
</tr>
<tr>
<td>Corrected</td>
<td>128,42</td>
<td>74,093</td>
<td>129,34</td>
<td>0,237</td>
</tr>
</tbody>
</table>
5. Compute local color distance between both sets by computation of “color cube distances”

\[
\sqrt{(\text{red color difference})^2 + (\text{green color difference})^2 + (\text{blue color difference})^2}
\]

6. Select pixels with “significant color difference”
   a. by applying t-test to log(distances) in color cube?

<table>
<thead>
<tr>
<th>Test Value</th>
<th>1</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logarithmic color distance</td>
<td>366.609</td>
<td>98115</td>
<td>0.000</td>
<td>0.573</td>
<td>Lower: 0.570, Upper: 0.576</td>
</tr>
</tbody>
</table>

LOG(Δ(R,G,B))

local differences for some RGB-value are significant
6. Select pixels with “significant color difference”
b. by “user-driven” color change trigger value (=>
distance limit in color cube)?

- Red+Yellow = Noise on the façade;
- Good radiometric matching of window frames and the door;
- Below the windows, clusters with high errors are visible: absence of flowers in image draped point set (2011).

Conclusion

A methodology was given for comparing orthophotos resulting from photogrammetry with color-enriched laser scanning clouds.

This methodology enables “change detection” based on a mathematical or user-driven “color change trigger value”.

Draping images on a point set, acquired by TLS, seems to give results at least comparable in quality to conventional photogrammetry.
Thank you for your attention

Questions?

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