Medium-format cameras and their use in topographic mapping

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Disposition

1. Introduction
2. General characteristics of Medium-Format Cameras (MFCs)
3. Two examples of new MFCs
4. Performance parameters of the two selected MFCs
5. Use of a selected MFC in topographic mapping tasks
6. Conclusions
Progress in camera design

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New large-format cameras

- DMCII-250

New medium-format cameras

- TAC-80
- UC-Eagle
- RCD30

The new cameras

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Features of aerial frame cameras

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At the same image scale (GSD) the medium-format camera has a much smaller swath width and area coverage (footprint).

<table>
<thead>
<tr>
<th>features</th>
<th>LFC UC-E (f=80 mm)</th>
<th>MFC RCD30 (f=50mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>flying height</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>swath width</td>
<td>2.2</td>
<td>1.0</td>
</tr>
<tr>
<td>footprint</td>
<td>4.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Comparison between large-format and medium-format cameras
### Elevation accuracy of digital aerial cameras

<table>
<thead>
<tr>
<th>Camera</th>
<th>Relative accuracy ((\sigma_h/h)) [% of flying height]</th>
<th>Absolute accuracy ((\sigma_h)) [GSD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC 80MP (f=50mm)</td>
<td>0.16</td>
<td>1.55</td>
</tr>
<tr>
<td>RCD30 (f=50mm)</td>
<td>0.19</td>
<td>1.55</td>
</tr>
<tr>
<td>DMC</td>
<td>0.16</td>
<td>1.63</td>
</tr>
<tr>
<td>DMCII-250</td>
<td>0.09</td>
<td>1.71</td>
</tr>
</tbody>
</table>

\[
\frac{\sigma_h}{h} = \frac{\sigma_{px'}}{b'} \quad \text{relative accuracy}
\]

\[
\sigma_h = \frac{f}{b'} \frac{\sigma_{px'}}{pel} \cdot GSD \quad \text{absolute accuracy}
\]

where
- \(\sigma_h\) = elevation accuracy
- \(h\) = (mean) flying height above ground
- \(f\) = calibrated focal length
- \(b'\) = image base
- \(pel\) = side of the pixel
- \(\sigma_{px'}\) = parallax accuracy related to the image

at forward overlap=60% and parallax accuracy of \(\sigma_{px'}=0.5\) pixels
Results of tests:

- At objects of high contrast the position of edges can be displaced by 0.65 pel
- The intensity differs from centre to the edge up to 3 DN

**Image quality of digital cameras**
Results of tests:

- At objects of high contrast the position of edges can be displaced by \( c = 0.5 \) pel.
- The intensity differs from centre of edge to the edge up to 28 DN.

### Image quality of digital cameras

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Mapping products and their generation

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Matching of overlapping images leads to very dense point clouds which can be processed to accurate Digital Surface Models (DSMs). The DSM is the prerequisite for several new applications.

Removal of blunders may need some manual editing.

Application: Generation of Digital Surface Model
Application: Generation of Digital Building Models
The true ortho-image does not have displacements and facades.

Application: Generation of true ortho-images
Application: Generation of land cover maps
Application: Generation of land cover maps

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Application: Generation of classified point clouds

Eastings Northing Z dZ class
537129.20 5228938.57 486.46 0.24 grass
537129.23 5228938.68 488.46 2.26 trees&hedges
537144.46 5228987.38 486.35 0.01 roads&parking lots
537128.03 5228938.32 490.75 4.16 buildings
Reference values are determined for randomly determined sample points using colour images and stereo-vision.

<table>
<thead>
<tr>
<th>Error matrix</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 buildings</td>
<td>64</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>2 roads&amp;parking lots</td>
<td>1</td>
<td>84</td>
<td>3</td>
<td>3</td>
<td>91</td>
</tr>
<tr>
<td>3 trees&amp;hedges</td>
<td>21</td>
<td>5</td>
<td>37</td>
<td>28</td>
<td>91</td>
</tr>
<tr>
<td>4 grass</td>
<td>8</td>
<td>24</td>
<td>3</td>
<td>56</td>
<td>91</td>
</tr>
<tr>
<td>Σ</td>
<td>94</td>
<td>125</td>
<td>58</td>
<td>87</td>
<td>364</td>
</tr>
</tbody>
</table>

Application: Assessment of classification accuracy

Accuracy of classification:
- 70% (buildings)
- 92% (roads&buildings)
- 41% (trees&hedges)
- 62% (grass)
Conclusions

• MFCs have less area coverage than LFCs
• Both new MFCs may produce colour images of high quality
• The absolute elevation accuracy can match LFCs at same GSD
• Light weight and compactness enable the use of MFCs in small airplanes, helicopters and high-end UAVs
• MFCs may be applied in corridor mapping, automated generation of DSMs, urban true orthoimages, and in updating of topographic databases and DTMs
• RCD30 camera is also prepared for production of land cover maps, remote sensing tasks and combination with lidar
• Advanced MFCs will play an important role in mapping
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