DIRECT ORTHOPHOTO GENERATION FROM COLOR POINT CLOUDS OF COMPLEX SCENES

D Skarlatos & S Kiparissi,
Cyprus University of Technology
S Theodoridou
GeoAnalysis SA
Sources of color point cloud data acquisition

- Laser scanners
- IBM (SfM+MVS), which can provide depth maps for every pixel
  - Both can record complex geometries with undercuts
  - Different in the sense that color information is inherent or added during post processing

Data sets of color point clouds are used for

- 3D modeling
- Orthophoto production
  - Both acquire huge data sets, more that we want/need or can handle.
  - Density sometimes exceeds the ground pixel size of final orthophoto product, or at least it should as a standard photogrammetric practice
STANDARD ORTHOPHOTOMAP PRODUCTION

- **2.5D surface generation**
  - Creating 2.5D surface from 3D data is not trivial – reducing the point cloud & some manual editing might be required

- **Orthoprojection of each photo**
  - Occlusion areas must be filled in from neighboring photos

- **Mosaicking of orthophotos**
  - Seamless mosaic with tone balancing
    - Enblend/Enfuse, Smartblend etc, can cope with such stitching easily
  - Photoshop on stretches
SCOPE OF WORK: SINGLE STEP PROCESS

- Direct re-projection
  - The color information from point cloud is directly projected on the projection surface, with attention to keep visible only the highest point
    - Very fast, serial processing
    - Correct geometry (in theory)
    - No special treatment for undercuts or occluded areas
    - No mosaicking necessary

- But...
  - Not all pixels have a corresponding point
  - Filling gaps in a second step is necessary
ARCHAEOLOGICAL SITE OF ANCIENT DION

- Data available
  + Aerial survey
  + Land survey data
    - Top and bottom edges recorded
OCTAGON TEMPLE

64m x 72m
Max wall height > 2m
DATA USED

+ 12 photos from RC heli
+ Random layout
+ 0.8-2.0 cm ground pixel size (2 cm final ortho ground pixel size)
+ Canon EOS 5D 28mm, calibrated, 4368x2912 pix
+ Land survey points for control & check
LPS, ERDAS (INTERGRAPH)

- Camera calibration used
- Automatic DEM collection
- Manual corrections
- Stereoscopic break line collection
- Manual editing of visual artifacts such as occlusions, smears and stretches etc
- Excellent visual result, crisp orthophotomap
PHOTOSCAN, AGISOFT

- Self calibration
- Many tie points
- MVS for full 3D point cloud extraction
- Conversion to 2.5D DEM, for automatic orthophoto mosaic, according standard photogrammetric techniques
- Some occlusions, double imaging effects and stretches remain
BUNDLER+PMVS WT PROPOSED METHOD

- Subsampled x2 photos
- Automatic alignment with self calibration
- Dense point cloud by applying MVS @ every pixel which appears in at least 3 photos @ every photo
- 2,015,880 points
- 3D similarity for georegistration
- Gap filling
- Noise on 3D point cloud remains on ortho as well
- Blurry result, fine details are lost
CHECK POINTS

- From land survey, 26 points among edges, 4 on planar surface were selected as check points
  + Highly unfavorable for orthophotos
- Aiming to test whether the orthophoto may be used for digitization
- The selected points were digitized on the created orthophotos
  + Difficulty to interpret the edge degrades the accuracy
PLOTTING RESIDUALS

LPS

PhotoScan

Proposed method
## DIFFERENCES AMONG METHODS

<table>
<thead>
<tr>
<th></th>
<th>LPS, Erdas (Intergraph)</th>
<th>PhotoScan, Agisoft</th>
<th>Bundler+ PMVS wt proposed method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera calibration used</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td># GCPs</td>
<td>34</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>RMS GCPs [cm]</td>
<td>5.0</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Image residuals [pix]</td>
<td>1.5</td>
<td>0.5</td>
<td>0.7 (x2=1.4)</td>
</tr>
<tr>
<td>CHECK points</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XY RMS [cm]</td>
<td>7.5</td>
<td>6.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Std dev of residuals [cm]</td>
<td>3.9</td>
<td>6.6</td>
<td>2.6</td>
</tr>
<tr>
<td># outliers &gt;2σo</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>XY RMS after outlier removal [cm]</td>
<td>7.1</td>
<td>5.1</td>
<td>4.0</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- A lot of improvements & testing need to be done before implementing it to deliverables
- Best visual results (more details) using standard photogrammetric processing and a lot of manual corrections
- There is a clear geometrical accuracy advantage of the proposed method, even when subsampled images are used
- Implementation to dense laser scanning (without IBM noise) should have better visual results
- Investigation whether the IBM noise maybe filtered during the re-projection process.
- Fully automatic, and very fast. Gap filling is time consuming
- May be easy implemented to any projection plane from the raw color point cloud
- Promising for 2D digitization
Thank you for your attention.

Special thanks to Prof. of archaeology Semeli Pingiatoglu from Aristotle University of Thessaloniki, for granting access to the site.

Part of the authors would like to thank Cyprus University of Technology for the starting research grant titled "More Information".

Visit our lab site: www.photogrammetric-vision.com