Challenges with Change Detection

Craig Glennie
University of Houston
Differencing 3D point clouds assumes that they have been presented in the same coordinate frame.

However, this is very rarely the case.

Choice of reference frame for project is dependent upon data source (commercial vs. research) and time frame of collection and processing.

Can be very complicated if the project was collected internationally – for now lets focus on continental US.
• Majority of commercial collections will be presented in orthometric height (NAVD88).

• Research collections tend to be delivered as ellipsoidal heights.

• Conversion between the two realized by NGS high resolution geoid models.

• The question is, which one? To date there are 5:
  • GEOID99
  • GEOID03
  • GEOID06 (Alaska Only)
  • GEOID09
  • GEOID12
**Magnitude of Geoid Model**

![Map of the United States with contour lines indicating the magnitude of the geoid model, labeled with numerical values and color-coded for depth.](image)

- **Statistics**
  - **N**: 8574241
  - **Mean**: -29.91 m
  - **SD**: 9.93 m
  - **Min**: -50.68 m
  - **Max**: 3.44 m
Does The Geoid Model Version Matter?

<table>
<thead>
<tr>
<th>Geoid Model</th>
<th>P041 (Marshall Field)</th>
<th>AC48 (Valdez, AK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOID99</td>
<td>-16.178</td>
<td>-13.515</td>
</tr>
<tr>
<td>GEOID03</td>
<td>-16.205</td>
<td>-13.164</td>
</tr>
<tr>
<td>GEOID06</td>
<td>N/A</td>
<td>-11.443</td>
</tr>
<tr>
<td>GEOID09</td>
<td>-16.242</td>
<td>-11.567</td>
</tr>
<tr>
<td>GEOID12</td>
<td>-16.254 (0.041)</td>
<td>-11.523</td>
</tr>
</tbody>
</table>

- In most areas of the continental US, change from 99 to 12 is on the order of 20 cm max.
- Bigger in AK, HI, PR due to lack of gravity data
- Effect still significant for high accuracy differencing.
Typically commercial work is tied to NGS reference frames – the current realization of the North American Datum. For LiDAR, primary ones of interest are NAD83(CORS 96) and NAD83(2011).

Scientific work tends to be tied to the current realization of the International Terrestrial Reference Frame. There are several of these: ITRF94, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008 and ITRF2014. Last four are of interest for legacy lidar.

Main difference is that NAD83 is fixed to the North America plate, whereas ITRF considers plate tectonics and publishes station velocities.

Thus for ITRF, the epoch of reference is also of significant importance.
Size of Datum Differences

• Table below gives UTM coordinate differences for P041 (Marshall Field) in 4 different reference frames. ITRF00 is reference for differences.

<table>
<thead>
<tr>
<th>DELTA FROM ITRF00 (meters)</th>
<th>NAD83 (CORS96)</th>
<th>ITRF08 (2005.0)</th>
<th>NAD83(2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>0.72</td>
<td>0.05</td>
<td>0.71</td>
</tr>
<tr>
<td>East</td>
<td>-0.87</td>
<td>0.13</td>
<td>-0.87</td>
</tr>
<tr>
<td>Up</td>
<td>-0.88</td>
<td>-0.024</td>
<td>-0.883</td>
</tr>
</tbody>
</table>
Computing Geoid/Datum Corrections

• For vertical differences, National Geodetic Survey (NGS) provides software tools for converting elevations to various Geoid models (www.ngs.noaa.gov).
  • These conversions don’t work on point clouds directly.

• For Datum differences, NGS also provides the tool HTDP (Horizontal Time Dependent Positioning) to compute correction vectors between datums and epochs.

• Crux is actually determining the datum and geoid used for legacy datasets...
Particle Image Velocimetry (PIV)

- Developed in the fluid dynamics community to track particles seeded into a fluid
PIV Example – 125 to 250 μm Particulate
PIV Example – 125 to 250 μm Particulate
Applying PIV to LiDAR data

• PIV is inherently image based but point clouds are not images
• Point clouds need to be rasterized prior to running PIV
  • Ex. Matlab, MicroStation
  • Raster resolution is key
    • Raster grid too large – features are obscured or lost
    • Raster grid too small – data too noisy
    • For instance, if detectable motion is on the scale of 10 m, a 20 m raster would not show real motion

• Algorithms
  • PIVLab – uses a combination of pixel mapping and larger feature tracking to reduce scatter
  • Home built algorithms
  • Commercial software