A semi-automated approach to building footprint extraction - ESRI Canada Community Maps Program

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Introduction

• Mapping the urban environment provides vital information for detecting urban growth and change.

• Keeping up to date information on the location of these features can be difficult.
  o Timely;
  o Accurate; and
  o Cost effective approaches
Introduction

• Historically, manually extracting urban features from aerial imagery was the default option.
  • Ineffective over large spatial scales

• State of the art research uses:
  o LiDAR or DSM
  o Ancillary data
  o VHR multispectral satellite imagery

• Operational constraints limit communities to working with available data.
  o VHR aerial imagery
Introduction

• **Goal:** Develop a best practices semi-automated method for extracting building footprints in an urban setting from orthophotos.

• **Restraints:**
  - Use orthophotos and freely-available Canada-wide datasets.
  - Implemented in an ArcGIS environment in conjunction with other cost-effective software.
Study Area

- Study site orthophoto for Nanaimo B.C., Canada
<table>
<thead>
<tr>
<th>Orthophoto</th>
<th>Road Network</th>
<th>Reference Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquired: June 2012</td>
<td>Acquired: 2012</td>
<td>Released: May 2011</td>
</tr>
<tr>
<td>Format: TIFF</td>
<td>Format: Vector (Polyline)</td>
<td>Format: Vector (Polygon)</td>
</tr>
<tr>
<td>Spatial resolution:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10 m/pixel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spectral bands: R, G, B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Reference building polygons were manually edited to ensure correctness and completeness
- Temporary structures such as sheds were excluded from the analysis
Methodology

• Image segmentation
  o Every image pixel is an object
  o Objects are merged iteratively based on
    • Threshold
    • Shape
    • Compactness

• Software
  o Berkeley Image Segmentation (BIS) software
  o ArcMap
Methodology

Segmented orthophoto

Extraction

Extraction with parcel data

Extraction with point data

Editing

Segments removed incorporating land parcel data

Segments removed incorporating building point data (in green)

Square up

Final building footprints

Roads, shadow and vegetation segments removed

Segments edited manually
Methodology
Methodology
Methodology
Methodology
Methodology
Methodology
Evaluation Metrics

- Reference and extracted buildings \(\rightarrow\) raster

### Branch factor
\[ \text{Branch factor} = \frac{FP}{TP} \]

### Miss factor
\[ \text{Miss factor} = \frac{FN}{TP} \]

### Completeness
\[ \text{Completeness} = 100\times\frac{TP}{TP + FN} \]

### Quality
\[ \text{Quality} = 100\times\frac{TP}{TP + FP + FN} \]
<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branching Factor</td>
<td>0.08</td>
</tr>
<tr>
<td>Miss Factor</td>
<td>0.08</td>
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<tr>
<td>Completeness (%)</td>
<td>92</td>
</tr>
<tr>
<td>Quality (%)</td>
<td>86</td>
</tr>
</tbody>
</table>
Discussion

- Total running time:
  segmentation method = manual digitizing
- Total manual editing time:
  segmentation method < manual digitizing
- Segmentation method running time does not increase linearly with the spatial extent.
Discussion

- Image segmentation parameters will vary by:
  - Building size
  - Shape, and
  - Colour.
Discussion

• Seasonality of the orthophoto will influence the accuracy.
  o Green ratio

[Images of March and June orthophotos]
Conclusion

• Segmentation methodology is capable of successfully extracting existing building footprints

• Provide best practices when projects are limited to using only orthophotos
Thank you
Questions?