Tutorial 10

Information extraction from high resolution optical satellite sensors

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Section 7

Land use and land cover mapping

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Historical context

- Satellite imagery used in land cover mapping for decades
- AVHRR: 1978-present  1 km resolution
- LANDSAT: 1972-present  MSS: 80 m, TM: 30 m resolution
- SPOT: 1986-present SPOT 1-4: 20m resolution, SPOT 5: 10m resolution
- All have different spectral responses, so generate different land cover classifications
Historical context

• “Traditionally” land-cover projects have been over large areas
• Each pixel in the image gives a generalised concept of land-cover class
• Applications include:
  • Forestry
  • Hydrology
  • Ocean monitoring
  • Agricultural monitoring
  • Geology and geomorphology
  • Topographic mapping…?
Commercial high resolution satellites with multispectral sensors

<table>
<thead>
<tr>
<th></th>
<th>GSD (m)</th>
<th>Blue (nm)</th>
<th>Green (nm)</th>
<th>Red (nm)</th>
<th>IR (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ikonos</td>
<td>4m</td>
<td>450-520</td>
<td>520-600</td>
<td>630-700</td>
<td>760-850</td>
</tr>
<tr>
<td>Quickbird</td>
<td>2.8m</td>
<td>450-520</td>
<td>520-600</td>
<td>630-690</td>
<td>760-900</td>
</tr>
<tr>
<td>Orbview 3</td>
<td>4m</td>
<td>450-520</td>
<td>520-600</td>
<td>625-695</td>
<td>760-900</td>
</tr>
<tr>
<td>GeoEye 1</td>
<td>1.64m</td>
<td>450-520</td>
<td>520-600</td>
<td>625-695</td>
<td>760-900</td>
</tr>
</tbody>
</table>

- Corresponding almost exactly to bands 1-4 of Landsat
- Note that, unlike Landsat, there are no thermal or mid-infrared channels
Spatial resolution

- When compared with Landsat:
- New hi-res satellite images show far more detail…
- …and far more “noise”
500 m pixels from proposed GMES sentinel satellite
30 m pixels
from LANDSAT
10m pixels, from SPOT
0.6m pixels, from Intergraph DMC aerial camera
Uses of High-resolution multispectral satellite data

- Multispectral in this case means 4-bands
- Can be used to derive the “traditional” indices such as NDVI (normalized difference vegetation index) using the red (R) and near infrared (IR) bands

\[
\text{NDVI} = \frac{\text{IR} - R}{\text{IR} + R}
\]
Characteristics of high resolution imagery

- Pixel resolution increases complexity of classification
- Most pixels show „mixed pixel“ characteristics
- Areas covered by one image are much smaller than remote sensing practioners are used to
Methods of classification

- Based only on spectral data (3, 4, 7, or many bands)
- + height (e.g. Using stereo images)
- + texture
- + context (e.g. a high object with straight edges surrounded by lower objects)
- ...or different combinations of these
Methods of classification

- Many different ways of classifying
- Maximum likelihood (e.g. ERDAS Imagine)
- Object-based segmentation (e.g. Definiens)
- Support Vector Machines
- Decision Trees
- Neural networks
<table>
<thead>
<tr>
<th></th>
<th>Infra red</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel 1:</td>
<td>30</td>
<td>200</td>
</tr>
<tr>
<td>Pixel 2:</td>
<td>32</td>
<td>236</td>
</tr>
<tr>
<td>Pixel 3:</td>
<td>200</td>
<td>43</td>
</tr>
</tbody>
</table>
Methods of classification – which one to choose

• Depends on what you want to achieve
• Some methods are simple and fast
• Some are reliable, but slow
• Some need a lot of preparatory work (training, formulating rules)
• Find out who has a similar problem and see what they have used!
Classifications

- Again there are many to choose from
- Depends to a large extent on the nature of the data and the classifier
- Standard classifications in different regions:
  - E.g. CORINE in Europe
- These may be too general for many applications
- Most users requirements are slightly different
- So there is a tendency to make up your own classification
- This is fine for internal use, but what about collaborative work and comparison to a common standard?
A hierarchical classification scheme - Corine

1. Artificial surfaces
   1.1 Urban fabric
      1.1.1 Continuous urban fabric
      1.1.2 Discontinuous urban fabric
   4.1 Inland wetlands
5.1.1 Inland marshes
5.1.2 Peat bogs
   4.2 Maritime wetlands
5.2.1 Salt marshes
5.2.2 Salines
1.2 Industrial, commercial and transport units
   1.2.1 Industrial or commercial units
   1.2.2 Road and rail networks and associated land
   1.2.3 Port areas
   1.2.4 Airports
1.3 Mine, dump and construction sites
   1.3.1 Mineral extraction sites
   1.3.2 Dump sites
   1.3.3 Construction sites
1.4 Artificial, non-agricultural vegetated areas
   1.4.1 Green urban areas
   1.4.2 Sport and leisure facilities

2. Agricultural areas
3. Forest and seminatural areas
4. Wetlands
5. Water bodies
Future Satellite capability

- GeoEye 1 will have sensors capable of 1.64m multispectral imaging, launch planned in August 2008
- WorldView 2 will provide 1.8m multispectral images, launch planned late 2008
- With pan-sharpening, high-resolution (40cm) 4-band images may be derived from these (although these will not be the same as original 40cm images).
- Some organizations are concentrating on low-resolution rapid-repeat global-coverage satellite constellations (GMES, DMC, RapidEye)
OEEPE (EuroSDR) study

- To investigate the use of high-resolution satellite imagery for national mapping
- Started in 2001, involving mapping agencies and academic institutions from several European countries
- One aspect was to investigate land cover
- IKONOS 4m multispectral image of Chandler’s Ford (Hampshire, UK)
- A mixture of urban, agricultural and wooded land cover
Land cover from 4m Ikonos data – OEEPE results

- **Sweden**: Ikonos suitable for identification and capture of land cover types found in Swedish 1:10 000 scale mapping
- **UK**: Ikonos, when combined with national mapping vector data (OS MasterMap) suitable for identifying most of the CORINE land cover/land use classes
- **Germany**: Identified several problems when trying to classify the imagery on its own.
OEEPE results - Some comments

- High-resolution imagery introduces shadows, which are generalised out of lower resolution imagery. These shadows:
  - Could be used to identify shadow-casting objects
  - Or could be seen as a barrier to accurate classification
OEEPE results - Some comments

- High-resolution imagery is very heterogeneous – a single residential property may have building, road, low vegetation, high vegetation, and water pixels within its boundary. These are usually averaged out in lower resolution imagery.
- This leads to **lower** accuracy when assessing pixel classification techniques
- ...sounds counter-intuitive.
Successful applications of high-resolution imagery to land cover mapping

- Olive-tree identification (K. G. Karantzalos, D. P. Argialas, Greece)
- Crop monitoring (Josiane Masson, JRC, Italy)
- Forest mapping in the US and elsewhere
- Mapping urban sprawl in developing countries
Why not more application examples?

- Cost of the imagery?
- Limited extent of available data?
- Difficulty in obtaining suitable data (e.g. Too much cloud cover in Northern Europe)?
- No guarantee of continuity (no constellations of satellites – maybe soon)?
- Many remote sensing practitioners used to working with lower resolution imagery, and reluctant to abandon previous research?
- Many photogrammetrists used to working with higher resolution imagery, and reluctant to abandon previous research?
- A combination of the above?
Contact for further information

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Advantages of satellite imagery over aerial photography

- The satellite is operational 365 days of the year,
- Frequent re-visit times (e.g. every 4 days),
- Imagery is post-processed relatively quickly,
- No Air Traffic Control restrictions apply,
- Large area footprint (e.g. 16.5 x 16.5 km²) cuts down the need for block adjustment and creation of image mosaics,
- The satellite can easily access remote or restricted areas,
- No aircraft, cameras or expensive equipment are required (by the end user).
And the disadvantages …

- The typical off-nadir viewing angle of up to 25° is not acceptable
- The production processes required for high resolution satellite imagery may be different to those of traditional photogrammetric data capture
- The reliability of capture and delivery of imagery is unknown,
- Image resolution is low compared to most aerial photography.
- There is a strong possibility of cloud cover