Introduction to Remote Sensing

Genevieve Patenaude
genevieve.patenaude@ed.ac.uk

Edinburgh seen by LiDAR

You are here!

Courtesy of the Environment Agency
Overview

• Fundamentals
  • What is RS
  • How it works
  • What is recorded
  • What is meant by resolutions

• The systems
  • Optical, Lidar
  • Radar

• Example of systems and related costs
  • Where: Acquisition of images
  • What we need to be aware of when purchasing
Fundamentals
What is remote sensing?

The science (and art) of acquiring information about an object, without entering in contact with it, by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.
How it works?

- Energy source: Passive/Active
- Atmosphere
- Target
- Recording devices
- Transmission/reception/processing
- Interpretation
- Application

© CCRS / CCT
What is recorded?

Electromagnetic Spectrum

Wavelengths

© CCRS / CCT

Courtesy of Louis E. Kleiner

Forestry Commission
The resolutions

**Spatial resolution:** The ground area represented by each pixel in an image

High resolution

Low Resolution

**Spectral resolution:** Ability of sensor to separate EM into small intervals (bands)

**Radiometric resolution:** Ability to discriminate slight differences in energy

**Temporal resolution:** How often is the target sampled (orbital characteristics, swath width, flight campaigns)

Courtesy of North Carolina University
The Systems
The systems

Three main types of sensors used

• Optical (Visible/IR)
• Radar (Microwave)
• LiDAR (Mostly NIR)

Fundamentals of each
The systems: Optical

Optical record energy in the visible/IR portion of the electromagnetic radiation

Energy recorded in bands: multi/hyperspectral
Spectral signature: How reflects/absorbs radiation per wavelengths.
Can be plotted as a spectral curve.

Unique spectral signature of vegetation

Specific bands used alone, or as ratios to discriminate vegetations

A: blue band
B: green band
C: red band
D: near IR band
E: short-wave IR band
The systems: Optical

The spectral signature is also used to discriminate between vegetation types and conditions.

Stress: damage to internal cell structure, reduction of chlorophyll and of moisture content are factors which will affect the signature.
The systems: Radar

Advantages over optical: active system, not affected by atmosphere, penetrates the canopy (wavelength)

<table>
<thead>
<tr>
<th>Radar Band</th>
<th>Frequency (GHz)</th>
<th>Wavelength (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>8.0 - 12.5</td>
<td>2.4 - 3.8</td>
</tr>
<tr>
<td>C</td>
<td>4.8 - 8.0</td>
<td>3.8 - 7.5</td>
</tr>
<tr>
<td>L</td>
<td>4.8 - 8.0</td>
<td>15 - 30</td>
</tr>
<tr>
<td>P</td>
<td>0.3 - 1.0</td>
<td>30 - 100</td>
</tr>
</tbody>
</table>

Important limitations: forestry applications not fully operational/research stage
The systems: Lidar

- **Light detection and ranging (Lidar)**
- Active system (independent of sunlight)/ Functioning
- Not an imaging system: record discrete sample points
- Waveform and discrete recording LiDAR

- Unavailable from satellite
- Expensive
Example of systems and related costs
What are the costs?

- Read the small print
  - Pricing & licensing policy
  - Regional variations
  - Minimum order quantity
  - Polygon, multi-frame, stereo
  - Acquisition
  - Urgency
  - Pan-sharpened colour
  - Fitted to map projection/datum
  - Terrain corrected (ortho-image)
<table>
<thead>
<tr>
<th>Sensors</th>
<th>Cost/ km²</th>
<th>Type (spatial res.)</th>
<th>Sales contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 5&amp;7</td>
<td>£0.01</td>
<td>Multispectral (Medium) 30 meters</td>
<td><a href="http://edc.usgs.gov/products/satellite/tm.html">http://edc.usgs.gov/products/satellite/tm.html</a></td>
</tr>
<tr>
<td>1982 to –</td>
<td></td>
<td>(£235/ ~170x180 km²)</td>
<td></td>
</tr>
<tr>
<td>Aster</td>
<td>£0.01</td>
<td>Multispectral (Medium-High) 15 to 90 meters</td>
<td><a href="http://edc.usgs.gov/products/satellite/aster.html">http://edc.usgs.gov/products/satellite/aster.html</a></td>
</tr>
<tr>
<td>2000 to –</td>
<td></td>
<td>(£50/~60x60 km²)</td>
<td></td>
</tr>
<tr>
<td>Spot</td>
<td>£0.5</td>
<td>Multispectral (Medium) 10-20 metres</td>
<td><a href="http://www.npagroup.co.uk/imagery/satimagery/pdf/price_list.pdf">http://www.npagroup.co.uk/imagery/satimagery/pdf/price_list.pdf</a></td>
</tr>
<tr>
<td>1986 to –</td>
<td></td>
<td>(£1800/ 60x60 km²)</td>
<td><a href="http://www.infoterra-global.com/">http://www.infoterra-global.com/</a></td>
</tr>
<tr>
<td>Ikonos</td>
<td>£9</td>
<td>Multispectral (High) 1-4 metres</td>
<td><a href="http://www.npagroup.co.uk/imagery/satimagery/ikonos.htm">http://www.npagroup.co.uk/imagery/satimagery/ikonos.htm</a></td>
</tr>
<tr>
<td>1999 to –</td>
<td></td>
<td>(£1089 / 11x 11 km²)</td>
<td></td>
</tr>
<tr>
<td>Aerial photography</td>
<td>~ £25</td>
<td>Variable (High)</td>
<td><a href="http://www.ordnancesurvey.co.uk/oswebsite/">http://www.ordnancesurvey.co.uk/oswebsite/</a></td>
</tr>
<tr>
<td>Lidar</td>
<td>~ £250</td>
<td>(cost dependent on sampling density and service providers)</td>
<td><a href="http://www.infoterra-global.com">http://www.infoterra-global.com</a></td>
</tr>
</tbody>
</table>

Free imagery (archive) at: [http://glcf.umiacs.umd.edu/data/](http://glcf.umiacs.umd.edu/data/)
New generation/Forthcoming sensors

- Here to stay
- Continuity
- Higher Res
- Increasing Competition

Ground Sample Distance

- 0.25m
- 0.4m
- 0.5m
- 0.6m
- 0.7m
- 1.0m
- 1.8m

Extended life

Seven 1m imaging radars also planned
Applications to Forestry

National agencies/companies
• Clear cut mapping / regeneration assessment
• Disturbances
• Infrastructure mapping / operations support
• Forest inventory / biomass estimation
• Vegetation density
• Species inventory

Environmental Monitoring
• Deforestation
• Species inventory/ habitat mapping
• Watershed protection
• Coastal protection
• Forest health and vigour
Conclusion

• Increasing number of sensors available (from videography, hand held digital cameras and high resolution satellite imagery)

• Transition from theory to information
  – Greater technological sophistication (Technological advances)
  – Explosive growth in information extraction (Data processing)
  – Improvement in understanding role of RS for forestry (Information Synthesis)
  – The use of RS to generate specific information requirements (Application context)