An Introduction to Multi-Spectral Remote Sensing

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Presentation Overview
- Anticipation of 'Infrared 100'
- Why multi-spectral sensing?
  - Atmospheric 'windows'
  - A case study of energy/target interaction
    - Vegetation
- A brief history of multi-spectral imaging
- Case study of 'Landsat programme'
  - Systematic global monitoring 1972 – date
  - 'Thematic' capability
    - Each spectral band has a specific role...
- A change-detection application...

As We Approach 'IR100'...
- Actually it is very fitting to be looking at multi-spectral remote sensing in this context
  - Since we are on the brink of a year of events from the RPS to celebrate the 100th Anniversary of infrared photography
  - Which is fundamental to most of the achievements of remote sensing of the Earth

The range of wavelengths occupied by e/m waves is called the 'e/m spectrum'
- All the way from...
  - Long wave radio; \( \lambda \approx 1000 \) m
- To...
  - Gamma-rays; \( \lambda \approx 0.01 \) nm
- A spread of 100 million, million times \( 10^{14} \)
- Typically, RS satellites detect ultraviolet – microwave
  - \#250 nm (UVB) - \#100 cm (P-band)

The Sun emits its own spectrum of wavelengths
- Which peak in the 'visible' isn't evolution wonderful?
- Isn't evolution wonderfull?
- BUT, not all of it reaches the Earth's surface
  - Ozone (O\(_3\)), Water Vapour (H\(_2\)O) & Carbon Dioxide (CO\(_2\)) in the atmosphere absorb specific wavelengths
  - BUT, note, the atmosphere has transparent 'windows'
- We have to exploit these transparent windows with matching sensing capability

Vegetation Case Study of Energy/Target Interaction
- True-Colour Visualisation
- CIR Visualisation
- Normalised Difference Vegetation Index Visualisation

Canada Centre for Remote Sensing: The Fundamentals of Remote Sensing, Chapter 1
For centuries man has looked on the Nile Valley as one of the cradles of civilization. Astronaut Frank Borman noted: “Generations have explored, excavated, and interpreted the significance of the Nile and its delta, but it was not until 1965 that the world received its first panoramic view of this sprawling spectacle on the northern coast of Africa.”

“This picture revealed, for the first time as an entity, the 500 000-square-miles delta with its collar of wind-whipped rock and desert. This photograph became an important data point in man’s quest to understand his environment.”

**Moderate Resolution Means...**

- Landsat Thematic Mapper (TM) images at 30/120 m resolution
- 30 m per pixel for visible, NIR & MIR bands
- 120 m per pixel for Thermal IR band

**Landsat ‘Swath’ width is 185 km**
- i.e. The width, on the Earth’s surface, of the path scanned by the sensor

**Complete Coverage**
- At Frequent Intervals
- Adjacent swaths 7 days apart
- ‘Revisit Period’ is 16 days
- Monitoring. NOT responsive
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Sun-Synchronous Polar Orbit (SSPO)

• Satellite crosses equator at the SAME local time on EVERY orbit
• Ensures same illumination - Vital for change monitoring

Landsat 5 orbit parameters shown
Orbital descent at 09:45 gives best chance of clear skies

During orbit period of ~100 mins the Earth rotates = 25°
- 2752 km west for Landsat5
SSPO is PREFERRED orbit for:
Earth Mapping, Earth Observation, Reconnaissance & Some Weather Satellites

Each Spectral Band Has A Role...

Landsat Thematic Mapper (TM) senses in 7 separate bands:
1. 0.45-0.52 μm (Blue Visible)
2. 0.52-0.60 μm (Green Visible)
3. 0.63-0.69 μm (Red Visible)
4. 0.76-0.90 μm (Near Infra Red)
5. 1.55-1.75 μm (Short Wave IR)
6. 10.4-12.5 μm (Thermal IR)
7. 2.08-2.35 μm (SWIR2)

All at 30m resolution, except 120m TIR band
Landsat TM images of suburban Madison, Wisconsin

So land-cover can be classified into 'Themes'

Table 6.3 Thematic Mapper Spectral bands

... In The Thematic Classification of Land-Cover

Figure 1.9 Spectral reflectances of common land cover features

GP2009; - Pictures From Space
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Each Spectral Band Has A Role... 5

Thermal map of New York City during a heat wave on 14th August 2002
http://earthobservatory.nasa.gov/Features/GreenRoof/greenroof2.php

Remote Sensing imagery is a genuine successor of R. W. Wood's 1910 heritage
It is fundamentally dependent on "imaging by invisible rays"
This multi-spectral imagery is VITAL to helping us understand our threatened planet
You are now aware of some fantastic camera systems, working 24/7
Which none of us could normally afford!
- BUT a tremendous legacy of data, from all around the globe, is available free of charge to all of us...
I thoroughly recommend exploration of the Landsat data archive; for example...

Some Concluding Thoughts

7 Landsat Missions Were Launched:
- ERTS-I; Landsat 1: NASA Experimental; Functional 1972-78
- Landsat 2: NASA Experimental; Functional 1975-82
- Landsat 3: NASA Improved/Exp; Functional 1978-83
- Declared operational in 1979; Transferred to NOAA for operational control
- Landsat 4: Improved Design With TM; Functional 1982-2001
- In 1984-1999, operations were commercialised via EOSAT
- Landsat 5: Same Design As LS 4; Functional 1994-date
- Landsat 6: Improved Design With ETM: Launch Failure 1993
- Landsat 7: Improved Design With ETM+: Funcntn1999-date
- Landsat operations returned to government control
- Landsat Data Continuity Mission (LDCM); Earliest Launch 2011

This legacy supports long-term change detection...
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• Any Questions?