Remote Sensing – Introduction

EMR Spectrum

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CE 259: Remote Sensing and GIS in Water Resources and Environmental Engg (3:0)

Syllabus: Basic concepts of remote sensing; Airborne and space borne sensors; Digital image Processing; Geographic Information System; Applications to rainfall-runoff modeling, Watershed management, Irrigation management, soil moisture estimation, Drought and Flood monitoring, Environment and ecology, Introduction to Microwave remote sensing and Global Positioning System (GPS); Digital Elevation Modeling; Use of relevant software for Remote sensing and GIS applications.

References:
1. Remote Sensing and Image Interpretation
2. Remote Sensing – Principles and Interpretation
3. An Introduction to Geographical Information Systems
4. Remote sensing in water resources management: The state of the art
http://www.civil.iisc.ernet.in/~nagesh/rs_gis.htm

Evaluation

- Assignments (10%)
- Surprise Tests (15%)
- Class Test (15%)
- Seminar (20%)
- Final Test (40%)

Remote Sensing

Remote Sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area or phenomenon under investigation.

Examples
1. Eyes are living examples (EMR distribution)
2. Sonar (like bats): Acoustic wave distribution
3. Gravity Meter: Gravity force distribution

Remote Sensing

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Passive RS

Active RS

Earth Surface

Passive and Active Remote Sensing
Remote Sensing

SUN
(a) Sources of energy
(b) Propagation through the atmosphere
(c) Earth surface features

Electromagnetic Wave

Simuoidal Electric Wave (E)
Magnetic Wave (M)
Right angles to the source

λ = c/f
λ is wave length (µm)
f is Frequency
c is Celerity (3x10^8 m/s)

EMR Spectrum

Electromagnetic Spectrum

Diagram of EM waves at different frequencies.
**EMR Energy**

- Energy of a quantum
  
  \[ E = h f \]
  
  - Energy in Joules (J)
  - \( h \) – Planck’s constant, \( 6.626 \times 10^{-34} \) J sec
  - \( f \) – Frequency

  \[ E = h c / \lambda \]
  
  - Energy of a quantum is inversely proportional to its wavelength
  - Longer the wavelength, the lower its energy content
  - The low energy content of long wavelength means that, in general, systems operating at long wavelength must ‘view’ large areas of the earth in order to obtain a detectable signal

**EMR Source**

- Sun is the primary source
- All matter at temperature above absolute zero (0°K or ~273° C) continuously emit EMR
- Energy emitted is, among other things, a function of surface temperature
- Stefan-Boltzmann Law (Black body)
  
  \[ W = \sigma T^4 \]
  
  - \( W \) – Total radiant emittance in W m\(^{-2}\)
  - \( \sigma \) – Stefan-Boltzmann constant, \( 5.6697 \times 10^{-8} \) Wm\(^{-2}\)oK\(^{-4}\)
  - \( T \) – Absolute temperature (°K) of the emitting material

  - Energy from an object varies as \( T^4 \)

  Increases rapidly with increase in Temperature

A black body is a hypothetical ideal radiator that totally absorbs and re-emits all energy incident upon it

**Spectral distribution of energy radiated from black bodies of various temperatures**

- Total radiant emittance is given by the area under the spectral radiant emittance curve
- Peaks shift toward shorter wavelengths as temperature increases
- Wien’s Displacement Law \((\lambda_{\text{max}} = \frac{A}{T})\)

  - As we heat an object, it color changes successively to shorter wavelengths
  - Dull red, to orange, to yellow, eventually to white

**Energy Interactions in the Atmosphere**

- All radiation detected by sensors passes through some distance of the atmosphere

**Energy Interactions (Contd..)**

- Scattering & Absorption
  
  - **Scattering**
    - Scattering is unpredictable distribution of radiation by particles in the atmosphere
    - **Rayleigh scatter** is common when radiation interacts with particles which are smaller in diameter than the wavelength.
      - Inversely proportional to fourth power of wavelength
      - Short wavelengths get scattered more
      - A blue sky is a manifestation of Rayleigh scatter
      - Rayleigh scatter is primary cause for ‘haze’ in imagery (results in bluish-gray photos) (Blue Filter)

  - **Mie Scatter** is common when radiation interacts with atmospheric particles diameters which are essentially equal to the wavelength.
    - Water vapor and dust are major causes of Mie scatter
    - Influences longer wavelengths when compared to Rayleigh scatter
    - Mie scatter is significant in overcast conditions

  - **Nonselective scatter** is common when radiation interacts with particles which are much larger in diameter than the wavelength.
    - Water droplets (5-100 µm) cause such scatter
    - Scatter all visible and reflected IR wavelengths
    - Fog and Clouds appear white

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Absorption

- In contrast to scatter, atmospheric absorption results in effective loss of energy to atmospheric constituents.
  - Most efficient absorbers are water vapour, carbon dioxide and ozone.
  - As absorption occurs in specific wavelengths, they strongly influence "where we look" spectrally with any sensor.
  - Wavelength ranges in which the atmosphere is particularly transmissive of energy are called Atmospheric Windows.

Spectral Characteristics …

- Spectral sensitivity range of eye coincides with an atmospheric window and peak level of energy from the sun.
- Emitted heat energy from the earth is sensed through the windows at 3.5 µm and 8-11 µm using Thermal scanners.
- Multi Spectral Sensors sense simultaneously through multiple, narrow wavelength ranges that can be located at various points in visible through the thermal spectral regions.
- Radar and Passive microwave systems operate through a window in the 1 mm to 1 m region.

Sensor Selection

- Spectral sensitivity of the sensors available.
- Presence or absence of atmospheric windows in the spectral range(s) in which one wishes to sense.
- Source, magnitude, and spectral composition of the energy available in these ranges.
- Manner in which the energy interacts with the features under investigation.