Remote sensing

Unit I

Definition .

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth. Some examples are:

- Cameras on satellites and airplanes take images of large areas on the Earth's surface, allowing us to see much more than we can see when standing on the ground.
- Sonar systems on ships can be used to create images of the ocean floor without needing to travel to the bottom of the ocean.
- Cameras on satellites can be used to make images of temperature changes in the oceans.

Scope of remote sensing in geology

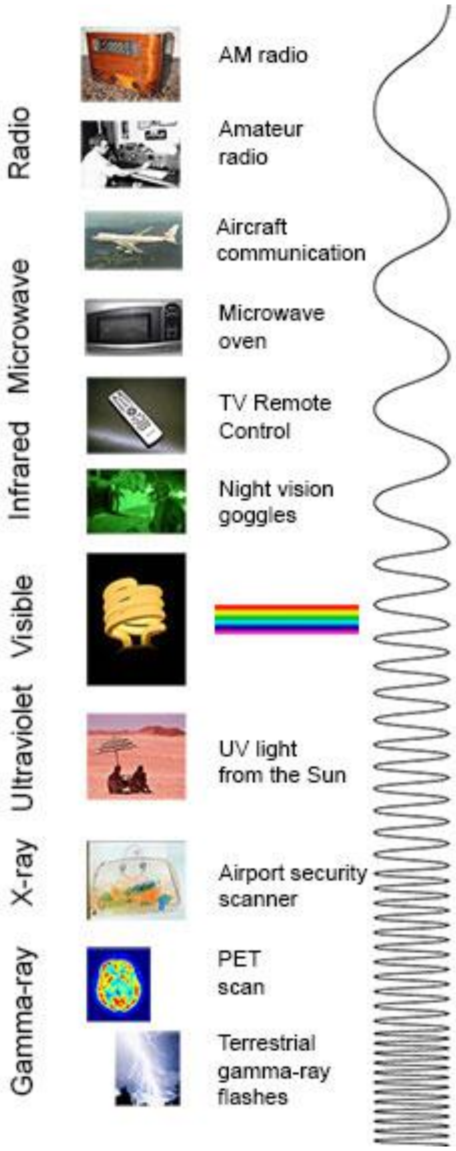
This helps geomorphological studies of ground motion, and thus can illuminate deformations associated with landslides, earthquakes. Remote sensing data can help studies involving geological mapping, geological hazards and economic geology (i.e., exploration for minerals, petroleum, etc.). These geological studies commonly employ a multitude of tools classified according to short to long wavelengths of the electromagnetic radiation which various instruments are sensitive to. Shorter wavelengths are generally useful for site characterization up to mineralogical scale, while longer wavelengths reveal larger scale surface information, e.g. regional thermal anomalies, surface roughness, etc. Such techniques are particularly beneficial for exploration of inaccessible areas, and planets other than Earth. Remote sensing of proxies for geology, such as soils and vegetation that preferentially grows above different types of rocks, can also help infer the underlying geological patterns. Remote sensing data is often visualized using Geographical Information System (GIS) tools. Such tools permit a range of quantitative analyses, such as using different wavelengths of collected data sets in various Red-Green-Blue configurations to produce false color imagery to reveal key features. Thus, image processing is an important step to decipher parameters from the collected image and to extract information.

<u>Electromagnetic spectrum</u>

<u>Definition</u>

The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays.

You know more about the electromagnetic spectrum than you may think. The image below shows where you might encounter each portion of the EM spectrum in your day-to-day life.



The electromagnetic spectrum from lowest energy/longest wavelength (at the top) to highest energy/shortest wavelength (at the bottom).

<u>Components of electromagnetic spectrum</u>

EM radiation spans an enormous range of wavelengths and frequencies. This range is known as the electromagnetic spectrum. The EM spectrum is generally divided into seven regions, in order of decreasing wavelength and increasing energy and frequency. The common designations are: radio waves, microwaves, infrared (IR), visible light, ultraviolet (UV), X-rays and gamma rays. Typically, lower-energy radiation, such as radio waves, is expressed as frequency; microwaves, infrared, visible and UV light are usually expressed as wavelength; and higher-energy radiation, such as X-rays and gamma rays, is expressed in terms of energy per photon.

Radio: Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by stars and gases in space.

Microwave: Microwave radiation will cook your popcorn in just a few minutes, but is also used by astronomers to learn about the structure of nearby galaxies.

Infrared: Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the dust between stars.

Visible: Our eyes detect visible light. Fireflies, light bulbs, and stars all emit visible light.

Ultraviolet: Ultraviolet radiation is emitted by the Sun and are the reason skin tans and burns. "Hot" objects in space emit UV radiation as well.

X-ray: A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag. Hot gases in the Universe also emit X-rays.

Gamma ray: Doctors use gamma-ray imaging to see inside your body. The biggest gamma-ray generator of all is the Universe.

Energy sources

Passive Remote Sensing depends on a natural source to provide energy. The sun is the most commonly used source of energy for passive remote sensing. The satellite sensor in this case records primarily the radiation that is reflected from the target. Remote sensing in the visible part of the electromagnetic spectrum is an example of passive (reflected) remote sensing.

A portion of the sun’s radiation that is not reflected back to the sensor is absorbed by the target, raising the temperature of target material. The absorbed radiation is later emitted by the material at a different wavelength. Passive remote sensing can also be carried out in the absence of the sun. In this latter case, the source of energy is the target material itself and the sensor records primarily emitted radiation. Remote sensing in the thermal infrared portion of the electromagnetic spectrum is an example of passive (emitted) remote sensing.

Active Remote Sensing uses an artificial source for energy. For example the satellite itself can send a pulse of energy which can interact with the target. In active remote sensing, humans can control the nature (wavelength, power, duration) of the source energy. Remote sensing in the microwave region of the electromagnetic spectrum (radar remote sensing) is an example of active remote sensing. Active remote sensing can be carried out during day and night and in all weather conditions.

Radiation

Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface material . Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it. This depends on the property of material (structural, chemical, and physical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy. The Remote Sensing is basically a multi-disciplinary science which includes a combination of various disciplines such as optics, spectroscopy, photography, computer, electronics and telecommunication, satellite launching etc. All these technologies are integrated to act as one complete system in itself, known as Remote Sensing System. There are a number of stages in a Remote Sensing process, and each of them is important for successful operation. Stages in Remote Sensing

- Emission of electromagnetic radiation, or EMR (sun/self- emission)
- Transmission of energy from the source to the surface of the earth, as well as absorption and scattering
- Interaction of EMR with the earth's surface: reflection and emission
- Transmission of energy from the surface to the remote sensor
- Sensor data output

Interaction of electromagnetic spectrum with atmosphere and earth surface features

Interation with earth surface

Radiation from the sun, when incident upon the earth's surface, is either reflected by the surface, transmitted into the surface or absorbed and emitted by the surface (Fig. 3). The EMR, on interaction, experiences a number of changes in magnitude, direction, wavelength, polarization and phase. These changes are detected by the remote sensor and enable the interpreter to obtain useful information about the object of interest. The remotely sensed data contain both spatial information (size, shape and orientation) and spectral information (tone, colour and spectral signature).

From the viewpoint of interaction mechanisms, with the object-visible and infrared wavelengths from 0.3 µm to 16 µm can be divided into three regions. The spectral band from 0.3 µm to 3 µm is known as the reflective region. In this band, the radiation sensed by the sensor is that due to the sun, reflected ER (λ) = Reflected energy EI (λ) = ER(λ) + EA (λ) + ET (λ) EI (λ) = Incident energy EA(λ) = Absorbed energy ET(λ) = Transmitted energy Shefali Aggarwal 31 Figure 4. Different types of scattering surfaces (a) Perfect specular reflector (b) Near perfect specular reflector (c) Lambertain (d) Quasi-Lambertian (e) Complex. by the earth’s surface. The band corresponding to the atmospheric window between 8 µm and 14 µm is known as the thermal infrared band. The energy available in this band for remote sensing is due to thermal emission from the earth’s surface. Both reflection and self-emission are important in the intermediate band from 3 µm to 5.5 µm. In the microwave region of the spectrum, the sensor is radar, which is an active sensor, as it provides its own source of EMR. The EMR produced by the radar is transmitted to the earth’s surface and the EMR reflected (back scattered) from the surface is recorded and analyzed. The microwave region can also be monitored with passive sensors, called microwave radiometers, which record the radiation emitted by the terrain in the microwave region.

Interaction with atmosphere

The sun is the source of radiation, and electromagnetic radiation (EMR) from the sun that is reflected by the earth and detected by the satellite or aircraft-borne sensor must pass through the atmosphere twice, once on its journey from the sun to the earth and second after being reflected by the surface of the earth back to the sensor. Interactions of the direct solar radiation and reflected radiation from the target with the atmospheric constituents interfere with the process of remote sensing and are called as “Atmospheric Effects”. The interaction of EMR with the atmosphere is important to remote sensing for two main reasons. First, information carried by EMR reflected/ emitted by the earth’s surface is modified while traversing through the atmosphere. Second, the interaction of EMR with the atmosphere can be used to obtain useful information about the atmosphere itself. The atmospheric constituents scatter and absorb the radiation modulating the radiation reflected from the target by attenuating it, changing its spatial distribution and introducing into field of view radiation from sunlight scattered in the atmosphere and some of the energy reflected from nearby ground area. Both scattering and absorption vary in their effect from one part of the spectrum to the other.

Spectral signatures

Spectral signature is the variation of reflectance or emittance of a material with respect to wavelengths (i.e., reflectance/emittance as a function of wavelength).[1] The spectral signature of stars indicates the composition of the stellar atmosphere. The spectral signature of an object is a function of the incidental EM wavelength and material interaction with that section of the electromagnetic spectrum.

The measurements can be made with various instruments, including a task specific spectrometer, although the most common method is separation of the red, green, blue and near infrared portion of the EM spectrum as acquired by digital cameras. Calibrating spectral signatures under specific illumination are collected in order to apply a correction to airborne or satellite imagery digital images.

The user of one kind of spectroscope looks through it at a tube of ionized gas. The user sees specific lines of colour falling on a graduated scale. Each substance will have its own unique pattern of spectral lines.

Most remote sensing applications process digital images to extract spectral signatures at each pixel and use them to divide the image in groups of similar pixels (segmentation) using different approaches. As a last step, they assign a class to each group (classification) by comparing with known spectral signatures. Depending on pixel resolution, a pixel can represent many spectral signature "mixed" together - that is why much remote sensing analysis is done to "unmix mixtures". Ultimately correct matching of spectral signature recorded by image pixel with spectral signature of existing elements leads to accurate classification in remote sensing.

Atmospheric window

The general atmospheric transmittance across the whole spectrum of wavelengths is shown in Figure 6. The atmosphere selectively transmits energy of certain wavelengths. The spectral bands for which the atmosphere is relatively transparent are known as atmospheric windows. Atmospheric windows are present in the visible part (.4 μm - .76 μm) and the infrared regions of the EM spectrum. In the visible part transmission is mainly effected by ozone absorption and by molecular scattering. The atmosphere is transparent again beyond about λ= 1mm, the region used for microwave remote sensing

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