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Remarking
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Physics of Remote Sensing

Abstract

Remote Sensing technique is widely used to map on the different layers of earth for different purposes. The Geographical Information System adds the mapping accurate to appreciable extent.This paper deals with the physics behind the technique which is explained in this paper.Majority of researchers wish to know the basic principle on which it works.

Keywords: Photography, Mapping and Analysis of Map for the Specific Purpose.

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Introduction

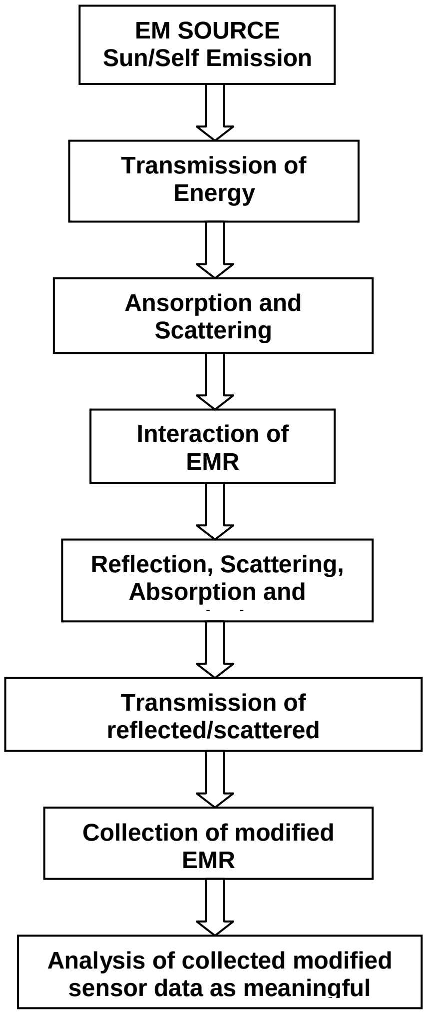
Remote sensing is a technique in which sensors are mounted on the platform and are kept at known distance from targets on the satellite or other means. The e.m. waves at different spectral range are passed for interaction between specified targets. The matching of coloured photograph with standard imageries gives relevant information about different layers of earth, its subsurface and atmosphere.

Interpolation of data like altitude, latitude, longitude, water level, temperature, wind speed, rain falls, absorption and surface flow gives complete picture of the earth surface and subsurface.

Normally sensors on near polar orbiting satellite for weather forecast and earth resources gives information over 110-190 km. long and 300 km wide region about dynamics and pattern of surface vegetation cover, nature of clouds, seasonal variation, surface morphology, wave heights and wind speed.

Remote sensing is techniques used for measurement of change on an object from a distance. It depends on interaction of electromagnetic radiation (EMR) with matter.

The Flow Chart



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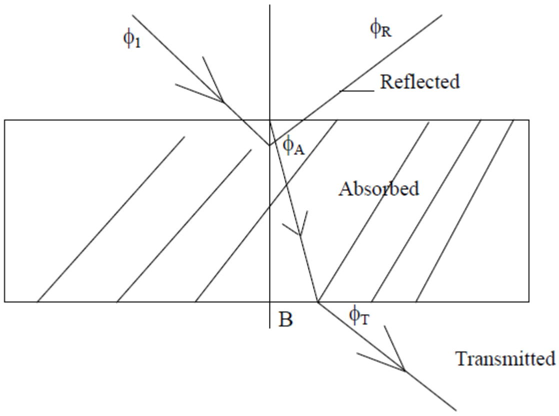
We know the basic e.m. nature by the equation :
$\phi_1(\lambda) = \phi_R(\lambda) + \phi_A(\lambda) + \phi_T(\lambda)$-----------------------------(1)
Incident wave = Reflected + Absorbed + Transmitted



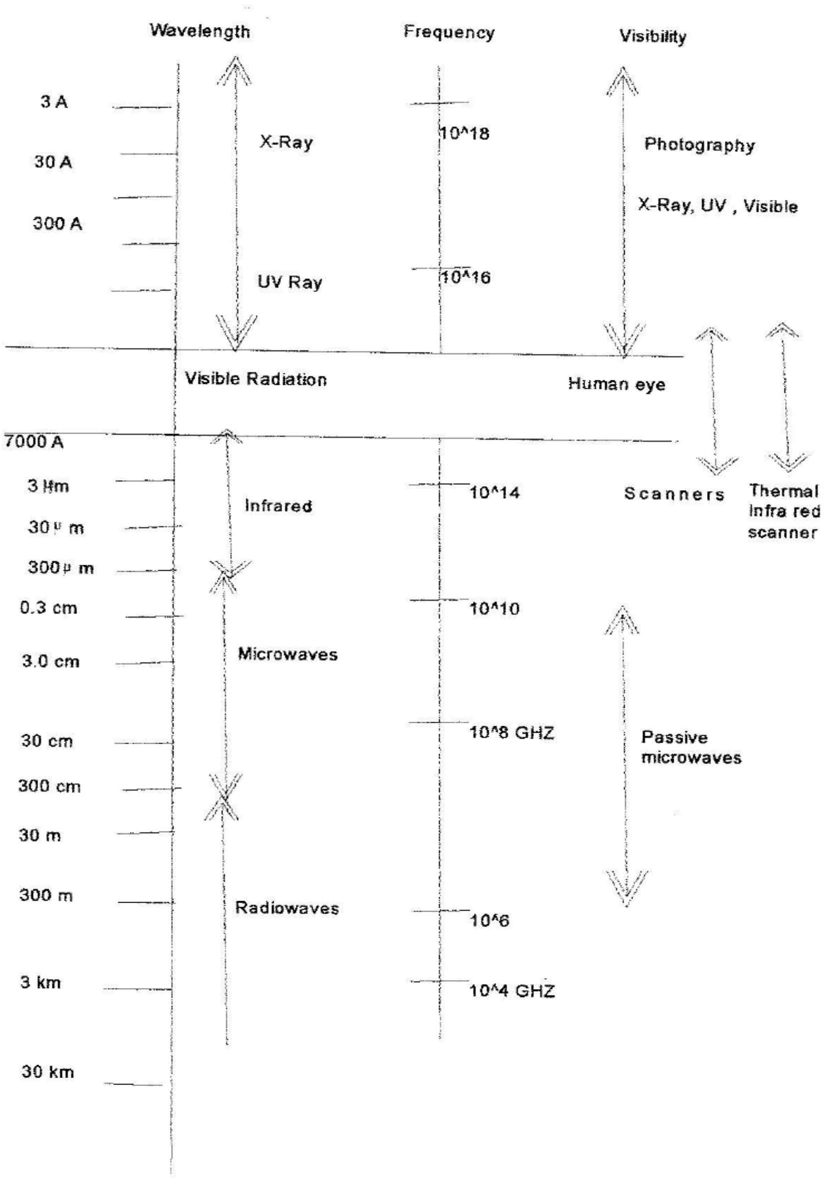
Aim of the Study

Remote sensing and Geographical Information system are basic tools to study Physical status of the place. Normally the experts explain the results required which are closest to the ground truthing data, but the basic physics and principles behind remote sensing technique is not known.This paper explains the basics of remote sensing.

Simple Remote Sensing System

The frequency, intensity or polarization of e.m. wave is carried by e.m. energy and encoded. The informations are propagated by e.m. wave with velocity of light directly from objects through free space and indirectly by reflection, scattering and re-radiation by aerosols to sensors. The interaction of em wave with natural environment, surface and atmospheric layers strongly depends on frequency of wave.

The em spectrum is divided into different spectral regions.



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Effect of Atmosphere in Remote Sensing

We arrange to pass e.m. radiation through atmosphere before it is detected by remote sensor. Remote sensing by satellites at an attitude above 700 km involves atmospheric degradation from the entire atmospheric column. Thus spectral line absorption in visible and near IR region are due to electronic quantization level of atmos. The transition of electron in an atom or molecule can occupy only certain select energy level in certain wave length range of incident radiation. The photon energy cause a transition from one to another permissible energy range giving selectively absorbed molecules of certain gases.

The vibrational energy relates to and from movement of atoms.

The energy of an isolated molecule is represented by

E = Ee + Ev + Er + Et + Ei --- (2)

Where :- Ee = electronic energy,
Ev = vibrational energy,
Er = rotational energy,
Et = translational energy,
Ei = interaction energy,

Incident radiation have different classification of range. The rotational vibrational and electronic spectra are classified as below :

Type of Transition	Energy range in wave number in cm^{-1}	Wave length Range in metric system	Spectral category
Rotational	1 - 500 cm^{-1}	1 cm - 20 µm	Microwave to far infra red
Vibrational	501 cm^{-1} - 2000 cm^{-1}	2l µm - 5 µm	Infra red
Electronic	10000 cm^{-1}	1 µm to 10	Visible to ultra violet

Water vapour (H_2O), Oxygen (O_2), Ozone (O_3), Carbon dioxide (CO_2) and aerosols are important atmospheric constituents influencing incident radiations.

In Remote Sensing ultra violet to Micro waves have atmospheric windows with small attenuation for use.

Normally wave lengths smaller than 0 - 3 µm are completely absorbed except 1216^0A by ozone layer in upper atmosphere. Different range of wave lengths are used to estimates different constituents.

1. In IR region (near IR to mid IR) the selective attenuation is due to water vapour present in atmosphere.
2. CO_2 absorption bands within range 4.3 to 15 µm are used to estimate atmospheric temperature upto 50 km altitude.
3. Absorption band of 6.7 µm in used to estimate water vapour distribution upto 10 km altitude.
4. Scattering of e.m. radiation within the atmosphere reduces the image contract and changes the spectral signature of ground objects as seen by sensors.
5. Scattering of e.m. waves obey's Ray length Scattering described by RS coefficient

$$B(\theta_1\lambda) = \frac{2\pi^2 [N(\lambda) - 1]^2 [1+\cos^2(\theta)]}{H\lambda^4} \quad (3)$$

H = No of mol per unit volume in atmosphere.
n(λ) = Spectrally dependent molecules refractive index.
θ = Angle between incident and scattered flux.
λ = Wave length of incident radiation.

Remote sensing measurement are not undertaken within range 0.3 to 0.45 µm spectral window because within this range blue light is severely scattered compared to green or red.

When particles are comparable to interacting wave length scattering occurs. The scattering coefficient σ(λ) applies when scattering volume is defined by a distribution of varying particle size given by :

$$\sigma(\lambda) = 10^5 \pi f^{\alpha 1}_{\alpha 2} N(\alpha)\, K(\alpha\eta)\, \alpha^2 d\alpha \quad \text{--- (4)}$$

Where :-
σ(λ) = Scattering coefficient at wave length.
N(α) = Number of particles in radius range α to (α + dα)
K(αη) = Scattering coefficient a function of cross section.
α = Radius of spherical particles ranging within limits α_1 to α_2.
η = refractive index of particles.

Mic scattering varies between λ^{-4} to λ^0 depending upon particle size.

The scattering element size parameter q is given by = q = 2πr--- (5)
r = radius of scattering element.
λ = Effective wave length of radiating flux.
For :- q<1 --- Ray light scattering
l<q>2 --- Transition from ray light to mic.

The Mic scattering deteriorates multispectral image under heavy atmospheric haze condition presence of fog, cloud, dust causes non selective scattering affecting remote sensing in infra red region and reduced image contrast.

Effect on Human Eye

Our eye is sensitive to wave lengths 0.35 µm to 0.74 µm.

The object is identified on background information :

If : L_1 = Initial radiance of object.
L_2 = Radiance of surrounding.

$$\left.\begin{aligned} L &= (L_1 - L_2) = \textit{Relative contrast.} \\ L &= \frac{L_1 - L_2}{L_2} = \textit{Contrast Ratio} \\ L &= \frac{L_1 - L_2}{L_1 + L_2} = \textit{Contrast Modulation} \end{aligned}\right\} \text{--- (6)}$$

L = Thermal contrast in Infra red region
K = Universal contrast applicable to human eye.
C = Used for optical information and optical transfer function.

Interaction of Earth Surface with EMR

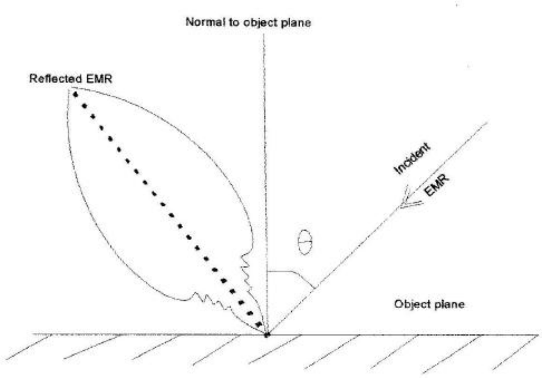
In visible, near infra red and middle infra red regions, total radiated flux

$$\phi = \phi r + \phi A + \phi t \text{ --- (7)}$$

Value of ϕ r (reflected flux) ϕ A (absolute flux) and ϕ t (transmitted flux) change when interact with different feature's of earth surface.

Smooth Surface = Reflection follows snells law
[Equal angle of incidence and reflection]
= Specular reflection shows glint or glance for standing water or man made structure.

Rough Surface = Reflects EMR in all direction irrespective of angle of incidence called diffuse reflection. A perfectly diffuse surface is called Lamberation surface. It is maximum along normal to surface and reduces as cosine of angle w.r. to normal. Most of natural surface reflected is in mixed mode.



In final analysis remote sensor records combined earth atmosphere sensor effects. The change in total reflectance of earth surface is combined effect of wave length angle of incidence, physical, chemical and biological properties of earth cover.

Thus we get surface and subsurface maps of desired area which are matched with maps prepared from actual physical survey of ground data. The mechanism is helpful in local area planning.

Conclusion

With these additives the use of remote sensing will be more easy to understand along with basic rules governing such complex system.

References

1. Sinha S.P. Ph.D. Thesis 2012 Ranchi University.
2. Jaishwal B.K. Paper in Research Journal Anusandhan dec 2012.
3. Jaishwal B.K. & Sinha S.P. Paper in Research Journal Anusandhan Dec 2012.