REMOTE SENSING TECHNOLOGY AND ITS APPLICATIONS

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ABSTRACT

Remote Sensing is defined as the science and technology, by which the characteristics of objects of interest can be identified, measured or analyzed the characteristics without direct contact. Electro-magnetic radiation which is reflected or emitted from an object is the usual source of remote sensing data. However any media such as gravity or magnetic fields can be utilized in remote sensing. A device to detect the electro-magnetic radiation reflected or emitted from an object is called a “remote sensor” or “sensor”. Cameras or scanners are examples of remote sensors. A vehicle to carry the sensor is called a “platform”. Aircraft or satellites are used as platforms. The applications of remote sensing include geology and mineral exploration, oceanography, agriculture, forestry, land degradation, environmental monitoring and so on. This paper presents an overview of remote sensing, its types and applications.

Keywords : Electromagnetic radiation, Satellite, Sensors, Sensing.

1 INTRODUCTION

Remote Sensing means obtaining information about an object, area or phenomenon without coming in direct contact with it. If we go by this meaning of Remote Sensing, then a number of things would be coming under.
Remote Sensor, e.g. Seismographs, fathometer etc. Without coming in direct contact with the focus of earthquake, seismograph can measure the intensity of earthquake. Likewise without coming in contact with the ocean floor, fathometer can measure its depth. However, modern Remote Sensing means acquiring information about earth’s land and water surfaces by using reflected or emitted electromagnetic energy.
From the following definitions, we can have a better understanding about Remote Sensing: According to White (1977), Remote Sensing includes all methods of obtaining pictures or other forms of electromagnetic records of Earth’s surface from a distance, and the treatment and processing of the picture data… Remote Sensing then in the widest sense is concerned with detecting and recording electromagnetic radiation from the target areas in the field of view of the sensor instrument. This radiation may have originated directly from separate components of the target area, it may be solar energy reflected from them; or it may be reflections of energy transmitted to the target area from the sensor itself.

According to American Society of Photogrammetry, Remote Sensing imagery is acquired with a sensor other than (or in addition to) a conventional camera through which a scene is recorded, such as electronic scanning, using radiations outside the normal visual range of the film and camera- microwave, radar, thermal, infra-red, ultraviolet, as well as multispectral, special techniques are applied to process and interpret remote sensing imagery for the purpose of producing conventional maps, thematic maps, resource surveys, etc. in the fields of agriculture, archaeology, forestry, geography, geology and others.

According to the United Nations (95th Plenary meeting, 3rd December, 1986), Remote Sensing means sensing of earth’s surface from space by making use of the properties of electromagnetic wave emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment.
According to James B.Campell (1996), Remote Sensing is the practice of deriving information about the earth’s land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth’s surface.

So the stages of Remote Sensing include (Figure 1), A source of electromagnetic radiation or EMR (Sun) .

- Transmission of energy from the source to the surface of the earth, through atmosphere
- Interaction of EMR with earth's surface.
- Transmission of energy from surface to Remote Sensor mounted on a platform, through atmosphere
- Detection of energy by the sensor.
- Transmission pf sensor data to ground station
- Processing and analysis of the sensor data
- Final data output for various types of application

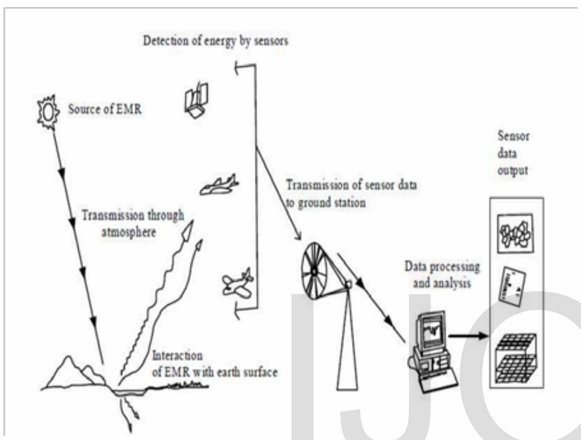

Figure 1: Stages of Remote Sensing

II. ROLE OF REMOTE SENSING

Remote sensing is the science and art of obtaining information about an object through the analysis of data acquired by a device that is not in contact with the object. Remotely sensed data can be of many forms, including variations in force distribution, acoustic wave distribution or electromagnetic energy distributions and can be obtained from a variety of platforms, including satellite, airplanes, remotely pilot vehicles, handheld radiometers or even bucket trucks. They may be gathered by different devices, including sensors, film camera, digital cameras, video recorders. Our eyes acquire data on variations in electromagnetic radiations. Instruments capable of measuring electromagnetic radiation are called sensors. Sensors can be differentiated in two main groups:

Passive sensors: without their own source of radiation. They are sensitive only to radiation from a natural origin.

Active sensors: which have a built in source of radiation. Examples are Radar (Radio detection and ranging) and Lidar(Light detection and ranging) systems.

This can be analogue (photography) or digital (multispectral scanning, thermography, radar). The elements of a digital image are called resolution cells (during the data acquisition) or pixels (after the image creation). The implementation of remote sensing data by the user requires some knowledge about the technical capabilities of the various sensor systems. The technical capabilities of the sensor systems can be listed in three resolutions:

- Spatial resolution: concerns the size of the resolution cell on the ground in the direction of the flight and across. The size of the pixel determines the smallest detectable terrain feature.
- Spectral resolution: concerns the number, location in the electromagnetic spectrum and bandwidth of the specific wavelength bands or spectral bands. This resolution differs between sensors and largely determines their potential use.
- Temporal resolution: concerns the time lapse between two successive images of the same area. This primarily determined by the platform used, and secondly by the atmospheric conditions.

Remote Sensing provides spatial coverage by measurement of reflected, emitted and backscattered radiation, across a wide range of wavebands, from the earth's surface and surrounding atmosphere. Remote Sensing-based spatial coverage was measured by reflected and emitted electromagnetic radiation from the earth's surface and surrounding atmosphere. Remote sensed from data of the land surface is possible across a wide range of 9.5
ultra-violet (UV), visible (VIS), near infrared (NIR), short wave infrared (SWIR), mid-infrared (MIR), thermal infrared (TIR), and microwave (MV) regions of the electromagnetic spectrum. They are located in so called 'atmospheric windows' as there is a signal from the surface – there is not total absorption (or scattering) of the light due to atmospheric constituents.

Each waveband provides different information about the atmosphere and land surface. Clouds, rainfall, surface temperatures, temperature and humidity profiles, solar and net radiation, and the fundamental processes of photosynthesis and evaporation can affect the reflected and emitted radiation detected by satellites. The research challenge is to develop models that can be inverted to extract relevant and reliable information from remotely sensed data, providing final users near-realtime information.

III. REMOTE SENSING SYSTEM TYPES

A. Visual Remote Sensing System

The human visual system is an example of a remote sensing system in the general sense. The sensors in this example are the two types of photosensitive cells, known as the cones and the rods, at the retina of the eyes. The cones are responsible for color vision. There are three types of cones, each being sensitive to one of the red, green, and blue regions of the visi ble spectrum. Thus, it is not coincidental that the modern computer display monitors make use of the same three primary colors to generate a multitude of colors for displaying color images. The cones are insensitive under low light illumination condition, when their jobs are taken over by the rods. The rods are sensitive only to the total light intensity. Hence, everything appears in shades of grey when there is insufficient light.

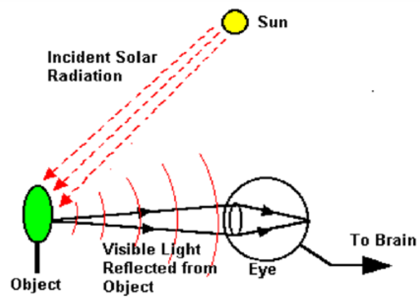

Figure 2: Visual Remote Sensing System

As the objects/events being observed are located far away from the eyes, the information needs a carrier to travel from the object to the eyes. In this case, the information carrier is the visible light, a part of the electromagnetic spectrum. The objects reflect/scatter the ambient light falling onto them. Part of the scattered light is intercepted by the eyes, forming an image on the retina after passing through the optical system of the eyes. The signals generated at the retina are carried via the nerve fibers to the brain, the central processing unit (CPU) of the visual system. These signals are processed and interpreted at the brain, with the aid of previous experiences. The visual system is an example of a "*Passive Remote Sensing*" system which depends on an external source of energy to operate. Figure 2 shows the Visual Remote Sensing System.

B. *Optical Remote Sensing*

In Optical Remote Sensing(Figure 3), optical sensors detect solar radiation reflected or scattered from the earth, forming images resembling photographs taken by a camera high up in space.

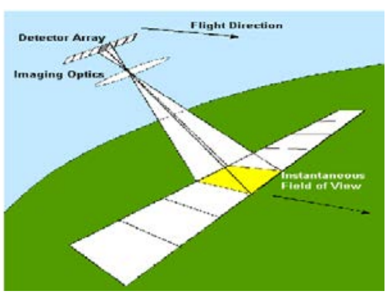

Figure 3: Optical Remote Sensing

The wavelength region usually extends from the visible and near infrared VNIR to the short-wave infrared SWIR. Different materials such as water, soil, vegetation, buildings and roads reflect visible and infrared light in different ways. They have different colors and brightness when seen under the sun. The interpretation of optical images requires the knowledge of the *spectral reflectance signatures* of the various materials (natural or man-made) covering the surface of the earth.

C. *Infrared Remote Sensing*

Infrared remote sensing(Figure 4) [5] makes use of infrared sensors to detect infrared radiation emitted from the Earth's surface. The middle-wave infrared (MWIR) and long-wave infrared (LWIR) are within the thermal infrared region. These radiations are emitted from warm objects such as the Earth's surface. They are used in satellite remote sensing for measurements of the earth's land and sea surface temperature. Thermal infrared remote sensing is also often used for detection of forest fires, volcanoes, oil fires.

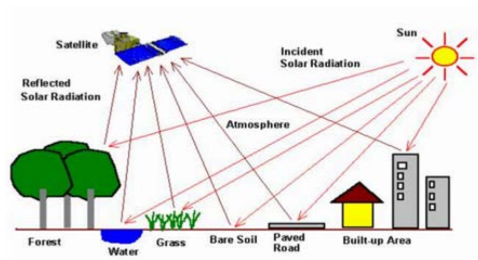

Figure 4: Infrared Remote Sensing

D. *Microwave Remote Sensing*

There are some remote sensing satellites which carry passive or active microwave sensors(Figure 5) .The active sensors emit pulses of microwave radiation to illuminate the areas to be imaged. Images of the earth surface are formed by measuring the microwave energy scattered by the ground or sea back to the sensors.

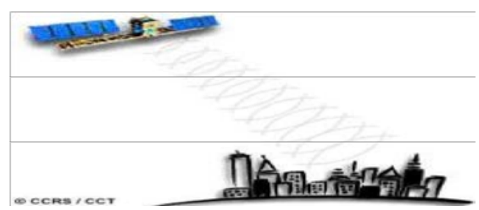

Figure 5: Microwave Remote Sensing

These satellites carry their own "flashlight" emitting microwaves to illuminate their targets. *The images can thus be acquired day and night*. Microwaves have an additional advantage as they can *penetrate clouds*. Images can be acquired even when there are clouds covering the earth surface. A microwave imaging system which can produce high resolution image of the Earth is the *synthetic aperture radar* (SAR). Electromagnetic radiation in the microwave wavelength region is used in remote sensing to provide useful information about the Earth's atmosphere, land and ocean.

E. *Radar Remote Sensing :*

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Using radar(Figure 6) , geographers can effectively map out the terrain of a territory. Radar works by sending out radio signals, and then waiting for them to bounce off the ground and return. By measuring the amount of time it takes for the signals to return, it is possible to create a very accurate topographic map. An important advantage to using radar is that it can *penetrate thick clouds and moisture*. This allows scientists to accurately map areas such as rain forests, which are otherwise too obscured by clouds and rain. Imaging radar systems are versatile sources of remotely sensed images, providing daynight, all-weather imaging capability. Radar images are used to map landforms and geologic structure, soil types, vegetation and crops, and ice and oil slicks on the ocean surface.

In synthetic aperture radar (SAR) imaging, microwave pulses are transmitted by an antenna towards the earth surface. The microwave energy scattered back to the spacecraft is measured. The SAR makes use of the radar principle to form an image by utilizing the time delay of the backscattered signals. In real aperture radar imaging, the ground resolution is limited by the size of the microwave beam sent out from the antenna.

Figure 6: Radar Remote Sensing

F. Satellite Remote Sensing

In this, you will see many remote sensing images acquired by earth observation satellites(Figure 7)[8]. These remote sensing satellites are equipped with sensors looking down to the earth. They are the "eyes in the sky" constantly observing the earth as they go round in predictable orbits. Orbital platforms collect and transmit data from different parts of the electromagnetic spectrum, which in conjunction with larger scale aerial or ground-based sensing and analysis provides researchers with enough information to monitor trends. Other uses include different areas of the earth sciences such as natural resource management, agricultural fields such as land usage and conservation, and national security and overhead, ground-based and stand-off collection on border areas.

Figure 7: Satellite Remote Sensing

G . Airborne Remote Sensing

In airborne remote sensing [9](Figure 8), downward or sideward looking sensors are mounted on an aircraft to obtain images of the earth's surface.

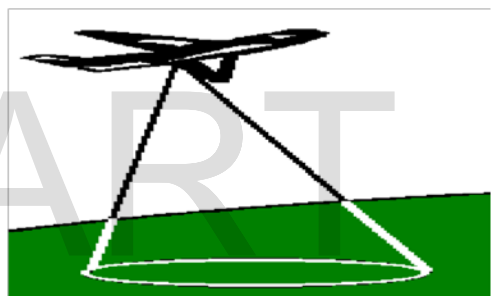

Figure 8: Airborne Remote Sensing

An advantage of airborne remote sensing, compared to satellite remote sensing, is the capability of offering very *high spatial resolution* images (20 cm or less). The disadvantages are *low coverage area and high cost per unit area of ground coverage*. It is not cost-effective to map a large area using an airborne remote sensing system. Airborne remote sensing missions are often carried out as one-time operations, whereas earth observation satellites offer the possibility of continuous monitoring of the earth.

H. Acoustic and near-acoustic remote sensing

Passive sonar, listening for the sound made by another object (a vessel, a whale etc); active sonar, emitting pulses of sounds and listening for echoes, used for detecting, ranging and measurements of underwater objects and terrain. Seismograms taken at different locations can locate and measure earthquakes (after they occur) by comparing the intensity and precise timing.

IV. REMOTE SENSING AND IMAGE PROCESSING

In order to take advantage of and make good use of remote sensing data, we must be able to extract meaningful information from the imagery. Much interpretation and identification of targets in remote sensing imagery is performed manually or visually, i.e. by a human interpreter. Recognizing targets is the key to interpretation and information extraction. Observing the differences between targets and their backgrounds involves comparing different targets based on any, or all, of the visual elements of tone, shape, size, pattern, texture, shadow, and association.

If a two-dimensional image can be viewed stereoscopically so as to simulate the third dimension of height, visual interpretation will be much easier. When remote sensing data are available in digital format, digital processing and analysis may be performed using a computer. Digital processing may be used to enhance data as a prelude to visual interpretation. Digital processing and analysis may also be carried out to automatically identify targets and extract information completely without manual intervention by a human interpreter.

Digital image processing may involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computer. In order to process remote sensing imagery digitally, the data must be recorded and available in a digital form suitable for storage on a computer tape or disk.

At last but not least, an important element in the image analysis is the integration of data. In the early days of analog remote sensing when the only remote sensing data source was aerial photography, the capability for integration of data from different sources was limited. Today, with most data available in digital format from a wide array of sensors, data integration is a common method used for interpretation and analysis. Data integration fundamentally involves the combining or merging of data from multiple sources in an effort to extract better and/or more information. This may include data that are multitemporal, multiresolution, multisensor, or multi-data type in nature.

V. APPLICATIONS OF REMOTE SENSING

As with its varied types of data, the specific applications of remote sensing are diverse as well. However, remote sensing is mainly conducted for image processing and interpretation. Image processing allows things like air photos and satellite images to be manipulated so they fit various project uses and/or to create maps. By using image interpretation in remote sensing an area can be studied without being physically present there.

The processing and interpretation of remote sensing images also has specific uses within various fields of study. In geology, for instance, remote sensing can be applied to analyze and map large, remote areas. Remote sensing interpretation also makes it easy for geologists in this case to identify an area's rock types, geomorphology, and changes from natural events such as a flood or landslide.

Remote sensing is also helpful in studying vegetation types. Interpretation of remote sensing images allows physical and biogeographers, ecologists, those studying agriculture, and foresters to easily detect what vegetation is present in certain areas, its growth potential, and sometimes what conditions are conducive to its being there.

Additionally, those studying urban and other land use applications are also concerned with remote sensing because it allows them to easily pick out which land uses are present in an area. This can then be used as data in city planning applications and the study of species habitat, for example. Finally, remote sensing plays a significant role in GIS. Its images are used as the input data for the raster-based digital elevation models (abbreviated as DEMs) - a common type of data used in GIS. The air photos taken during remote sensing applications are also used during GIS digitizing to create polygons, which are later put into shape files to create maps.

VI. CONCLUSION

This paper presents an overview of Remote Sensing technology. Remote Sensing means obtaining information about an object, area or phenomenon without coming in direct contact with it. Sensors used in remote sensing are of two types: Active sensors and Passive sensors. Passive sensors without their own source of radiation. They are sensitive only to radiation from a natural origin. Active sensors which have a built in source of radiation. Examples are Radar (Radio detection and ranging) and Lidar (Light detection and ranging) systems.

There are different types of remote sensing technologies. These include Visual, optical infrared, Electmicrowave, radar, satellite, airborne and acoustic remote sensing systems. The different applications of the systems are geology and mineral exploration, oceanography, agriculture, forestry, land degradation, environmental monitoring and so on.

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