"Remote sensing"- A part of an Applied Physics

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Abstract: *Physics is the most fundamental of all the sciences & scientific developments or technologies. Physics is also behind the modern technologies such as internet & mobile, whereas applied physics does the role of their application to modern technologies. Applied physics describes the laws & phenomenon of nature with their application in different fields like: Physics of imaging, Atmospheric Physics, Nanotechnology, Remote Sensing etc. The Remote Sensing (R. S.) technology is discussed in detail through this paper.*

Keywords: Applied Physics, electromagnetic spectrum, Active R.S., Passive R. S., manned & unmanned aircraft systems, superiority.

1. INTRODUCTION:

Applied Physics is rooted in the fundamental truths & basic concepts of physical sciences but is concerned with the utilization of specific principles in practical devices & systems. Applied physics is the study of the basic laws of nature & their application to modern technologies. The Bachelor of Science in Applied Physics program is designed in Pashimanchal campus IOE, Lamachaur- Pokhara(TU); Kathmandu University, to give students a broad background in physics knowledge & on its implementation in technology of different fields like above mentioned.

Nanotechnology: It is a part of science & technology about control of matter on the atomic and molecular scale, which make materials or machines of nanoscale (1nm=10 to the power minus 9).

Atmospheric Physics: Global satellite observations computed with increasingly sophiscated computer simulation have led to rapid advances in our understanding of the atmosphere. The earth's atmosphere is the gaseous envelope surrounding the planet. Like other planetary, the earth's atmosphere figures centrally in transfer of energy between the sun & the planet surface and form one region of globe to another, these transfers maintain thermal equilibrium & determine the planet's climate. However the earth's atmosphere is unique and to surface processes, which together with the atmosphere form the basis for life. (1).

Physics of imaging: It has the properties of medical imaging & magnetic resonance imaging(MRI). Ultrasonic imaging(that is sonography) is used both in veterinary & human medicine. In non-destructive testing of products & structures, ultrasound is used to detect invisible flaws.

Remote sensing: is the science of obtaining information about objects or areas from a distance , typically from aircraft or spacecraft. Remote sensors (airborne sensor & spaceborne sensor) observe and measure the energy emitted, transmitted or reflected from an object. The methods of sensing are based on electromagnetic energy emitted or reflected from Earth's surface at some distance above the ground. Remote sensors can be either passive or active depending upon source of electromagnetic energy. Passive remote sensing is based on detecting available electromagnetic energy from natural sources, such as sunlight. Active remote sensing depends on an artificial light source, such as radar, airborne Lidar. Today remote sensing science collects data from variety of areas like ocean, airport surveying, disaster response, control mapping, analysis of harmful algal blooms, and shoreline change analysis. In another language, the remote sensing lies in making numerous types of accurate, current, and high- resolution remotely sensed data and derived geospatial information products readily available for every area of interest. Remote sensors perform two systems for photography such as Manned Aircraft System and Unmanned Aircraft System. (2).

2. METHODOLOGY:

Remote sensing is the observation & measurement of objects from a distance. One of the most common types of remote sensing is photography. Remote sensing techniques are based on sensing electromagnetic energy or reflected from the Earth's surface and detected at some altitude above the ground. The electromagnetic energy is, thus, starting point for understanding remote sensing and wavelength data of corresponding rays of electromagnetic spectrum is presented below in fig.1 . All photographic cameras have certain basic components: lens, diaphragm, shutter, viewfilder, and image plane. The diaphragm and shutter control the amount of light to expose each photograph. The spectral sensitivity of photography ranges from about 0.3 μm(near ultraviolet) to 0.9 μm(near infrared). Different parts of the spectrum may be photographed by using various combinations of film & filters. Every image is black-white at a precise wavelength(usually 0.4-0.12) microns. These electronic cameras only collect information in b/w, but they can obtain many images at the same time in different parts of space. Aerial photographs are routinely taken in b/w panchchromatic, b/w infrared, color-visible, color-infrared ,and multiband types. For example, color-infrared film is exposed to green, red, and near-infrared wavelengths, which are depicted as blue, green & red in the photograph. This shifting bands to visible color is called false-color. (3).

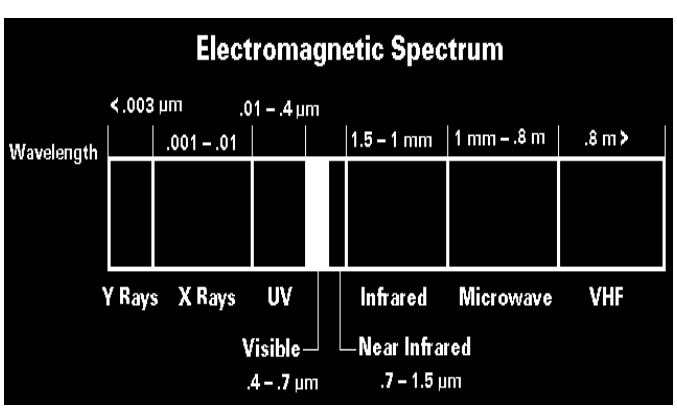


Fig.1

Aerial photography is typically done from specially airplanes or helicopters nowadays. However many other manned or unmanned platforms may be utilized to hold the camera above the ground including balloons, tethered blimps, kites, radio controlled planes, and rockets. Digital cameras are replacing film-based cameras, which is used in aerial photography to offer more potential advantages.

Manned space technology- Astronauts on space-shuttle missions have taken more than 250,000 photographs with hand-held cameras. A large portions of these are Earth-looking images that provide unique views of the world's surface features: natural, atmospheric, and human settlement. Space-shuttle photographs are taken in possible orientations-near verticals, low oblique, and high oblique while photographs in any orientations are possible with unmanned satellite instruments.

Unmanned Aircraft Systems (UASs): UASs are remotely piloted or self piloted aircraft that carry cameras, sensors or communication equipments . UASs have been used by the military to gather intelligence since 1950 but have only recently been used to calculate highly resolution spatial data. They may prove to extremely benifictial in disaster response applications as this type can even be sent in dangerous situation for records.

3. PRINCIPLE:

We observe the surrounding in world through our five senses. Some senses require contact (touch & taste) with the objects whereas rest sense organs are able to sense from far place. For taste & feeling, the used organs tongue and skin get sensing by touching. However, the maximum information about our surrounding through the senses of sight and hearing, which don't need close contact between the sensing organs & external objects. In another language, we are performing remote sensing all the time and eye & ear are remote sensors.

Actually, remote sensing refers to the activities of recoding objects or events being observed but this

phenomenon completes through an intervening medium by an electromagnetic wave. The electromagnetic radiation (4a) is normally used as an information carrier. In fig.2, electromagnetic radiations emit from the sun and they reflect radiations to our eyes, in this way the brain records the information about remote objects or events. The remote sensing process is of two types, known as passive remote sensing and active remote sensing. In the case of passive sensors, the natural light (visible) such as sun plays role of perceiving either the objects or events. (4b).

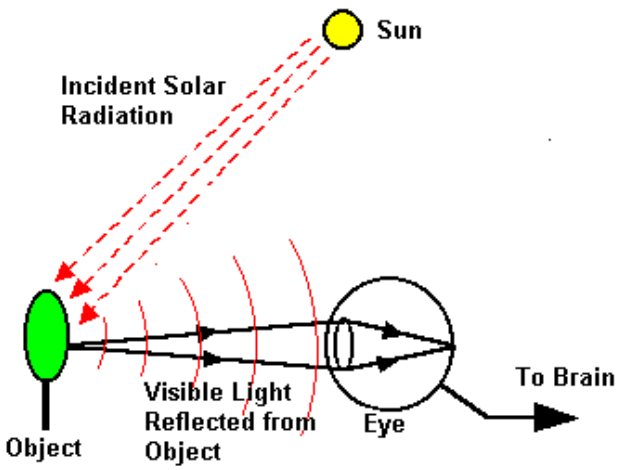


Fig. 2: Passive Remote Sensing.

For another type, active remote sensing process artificial light (flashlight) is used to observe any objects. In fig.3, a flashlight or shining the beam towards the object from an artificial source, has been applied to have image even in night. The output of a remote sensing system is usually an image representing the science being observed.

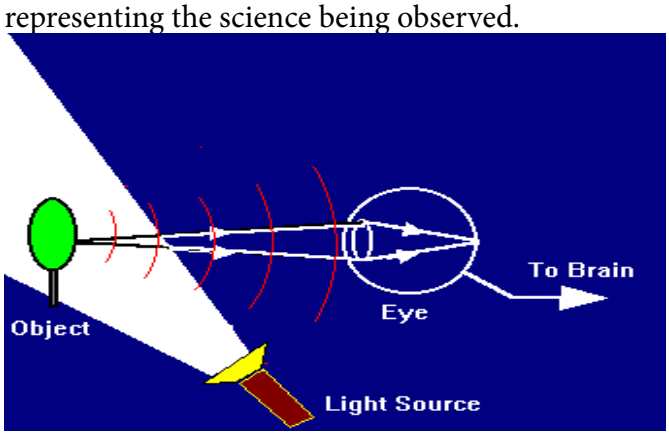


Fig.3 : Active Remote Sensing

Remote sensing usually refers to the technology of acquiring information about the earth's surface(land & ocean) and atmosphere using sensors onboard airborne (aircraft, balloons) or spaceborne(satellites, space shuttles) platforms. In airborne remote sensing, downward or sideward looking sensors are mounted on an aircraft to obtain images of the earth as shown in fig.3.

In spaceborne remote sensing, sensors are mounted on-board a spacecraft(satellite or space shuttle) orbiting the earth. Satellite imagery has generally lower resolution compared to aerial photography. At present, very high resolution imagery (up to 1-m resolution) is available to civilian users with the successful launch of the IKONS-2 satellite in September 24, 1999.(4c)

4. TYPES:

Acquiring records of objects & events on the earth at far by different sensors, are summarized differently due to electromagnetic spectrum as follows:

4.1 Satellite Remote Sensing:

Remote sensing satellites are equipped with sensor looking down to the earth. (They are "eyes in the sky" constantly observing the earth as they follow generally elliptical orbit around the earth). Several remote sensing satellites are currently available, providing energy for various types of applications such as water temperature, chlorophyll levels, ocean currents, natural disasters on the earth. Each of these satellite- sensor is charecterized by the wavelength bands employed in image acquisition, spatial resolution of the sensor, the coverage area & the temporal coverage, that is how frequent a given location on the earth surface can be imaged by the imaging system. (5a).

Effects of Atmosphere:

In satellite remote sensing of the earth, the sensors are looking through a layer of atmosphere separating the sensors from the Earth's surface being observed. The electromagnetic radiation is observed by the atmospheric constituents in different forms (ozone

layers in the stratosphere absorbs about 99% of the harmful solar ultraviolet radiation shorter than 30 nm). When each radiation travels through the atmosphere, it may be absorbed or scattered by the constituent particles of the atmosphere as shown in fig.4. Molecular absorption converts the radiation energy into excitation energy of the molecules. Scattering redistributes the energy of the incident beam to all directions. The overall effect is the removal of energy from the incident radiation. These effects degrade the quality of images. A consequence of atmospheric absorption is that certain wavelength bands in the electromagnetic spectrum are strongly absorbed and efficiently blocked by the atmosphere. The wavelength regions in the electromagnetic spectrum usable for remote sensing and determined by their ability to penetrate atmosphere. These regions are known as atmospheric transmission windows. Remote sensing systems are often designed to operate within one or more of the atmospheric windows. These windows exist in the microwave region, some wavelength bands in the infrared, the entire visible region & part of the near ultraviolet regions. Although the atmosphere is practically transparent to X-rays and gamma rays, these radiations are not normally used in remote sensing of earth. (5b).

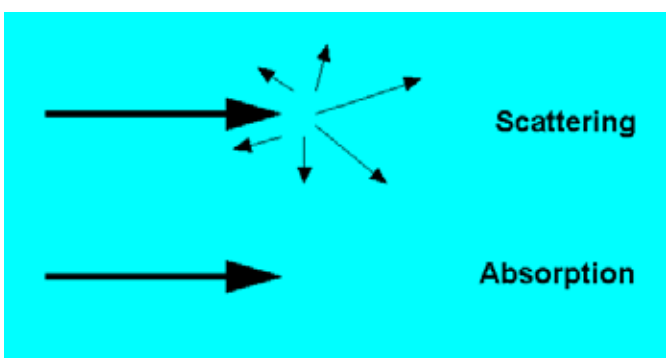


Fig.4. Effects of Atmosphere.

4.2 Optical & Infrared Remote Sensing:

Optical remote sensing makes use of visible, near infrared & short infrared sensors to form images of the earth's surface by detecting the solar radiation reflected from targets on the ground. Different materials such as water, soil, vegetation, buildings, & roads reflect visible and infrared light in different ways by their spectral reflectance signatures in the remotely sensed images. Optical remote sensing systems are classified into different types, depending on the number of spectral bands used in the imaging process. Fig.5, clarifies that incident beam from sun reflect from different materials to the satellite in the Optical Remote Sensing (ORI). (6).

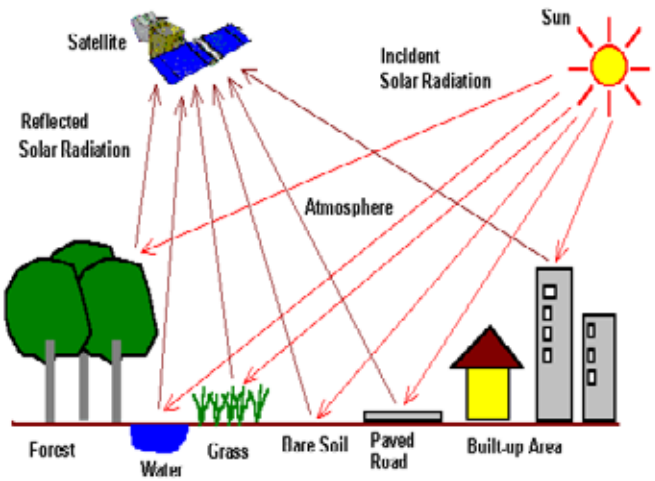


Fig.5, Optical Remote Sensing

Infrared remote sensing makes use of infrared sensors to detect infrared radiation emitted from the Earth's surface. The middle- wave infrared ray (MWIR) and long-wave infrared ray (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. Fig.6, represents the emission of thermal emitted radiation to the satellites from different materials on the earth's surface like vegetation (forest & grass), water, soil, roads and buildings.(7).

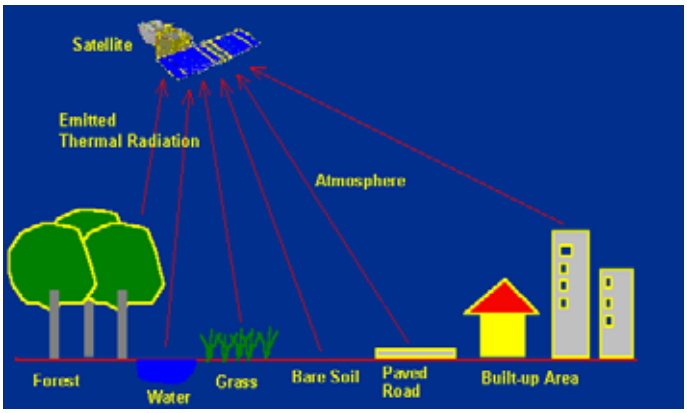
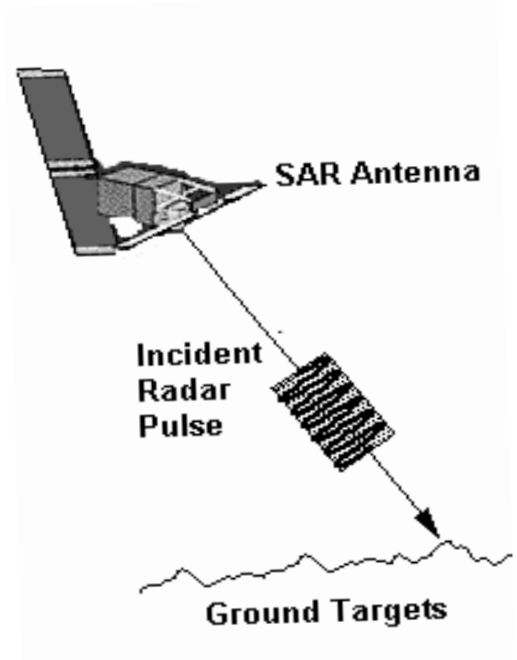


Fig.6, Infrared Remote Sensing

4.3 Microwave Remote Sensing:

Electromagnetic radiation in the microwave wavelength region is used in remote sensing to provide useful information about the Earth's surface (atmosphere, land & ocean). Microwaves have an additional advantage as they can penetrate clouds. Images can be acquired even when there are clouds covering the earth's surface. A microwave imaging system which can produce high resolution image of the earth is the synthetic aperture radar (SAR). The intensity in a SAR image depends on the amount of microwave backscattered by the target fig. 8, and received by the SAR antenna as shown in fig.7, below.



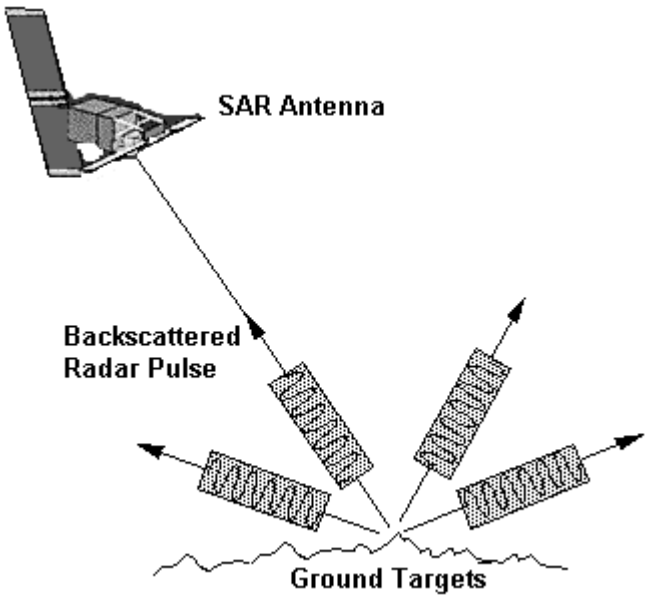


Fig.7, Received by SAR antenna

Fig.8, Backscattered by the targets [Microwave Remote Sensing]

Some of instruments being used in microwave remote sensing are listed here.

Microwave Radiometer- A passive device which records the natural microwave emission from the earth & it can be used to measure the total water current of the atmosphere within its field of view.

Radar Altimeter- It sends out pulses of microwave signals scattered back from the earth surface. The height of the surface can be measured from the time delay of return signals.

Wind scatterometer- It can be used to measure wind speed & direction over the ocean surface. It sends out pulses of microwaves along several directions & record the magnitude of the backscattered from the ocean surface. The magnitude of the backscattered signal is related to the ocean surface roughness, which in turns is independent on the sea surface wind condition, and hence the wind speed & direction can be derived to generate high resolution images of the earth surface using microwave energy. (8).

5. APPLICATIONS:

The uses of remote sensing is rise in number of computers around the world even being instrumental & some of psycological disadvantages but most of advantages such as in acquiring up-to-date data information rapidly over a large geographic area(also in accessible regions). Due to the number of advantages like less costly(working at home part or full time, means less or no commuting), less sick days(may be able to work at home even in bad situation), technological advances(available at home) etc, the remote sensing has wide range of applications. For example: within the National Ocean Service, in coastal mapping, shoreline change analysis, airport surveying, disaster response, analysis of harmful algal blooms, monitoring of coastal ecosystems, and nautical charting. Some more specific applications of the remote sensing are going to present here.

Remote Patient Monitoring:(9).

Zephyranywhere.com, when used in either home or hospital ZephyrLIFE helps to stream-line care coordination & communication between clinics, patients, family & friends.

Hyspex Hyperspectral Cameras:(10).

Hysex, NEO's line of hyperspectral cameras aims to offer high performance and versatile instruments for a multitude of applications, ranging from airborne to laboratory & industrial use of imaging spectroscopy. The line of HySpex cameras comprised VNIR models, operating in the range 400 to 100 nm, and SWIR models operating in the range 900 to 2500 nm.

Copernicus: (Most ambitious Earth observation programe to-date),(11).

This programe provides accurate, timely, & easily accessible information to improve the management of environment, understand & mitigate the effects of climate change & ensure civil security. This is the competition of the challenges such as (Best service challenge, Ideas challenge & Enviromental challenge). Since 2011, the annual Copernicus Master Competition is awarding prizes to innovative solutions for business & society based on Earth observation data.

Who uses remote sensing & why? (12).

Geographer: who looks for changes on the Earth's surface that need to be mapped.

Forester: who needs information about what types of trees are growing and if they have been affected.

Enviromentalist: who wants to detect, identify and follow of pollutants such as oil slicks on the ocean.

Geologist: who is interested in finding valuable minerals.

Farmer: who wants to keep an eye on how his crops are growing and if they've been affected by drought, floods & disease.

Ship Captain: who needs to find the best route through the northern ice packs.

Firefighter: who sends out his crews based on movement of a forest fire.

Urban Planner: who makes plans for development & management of society after using open land & other sources of energy.

Oceanographer: who needs to study seawater composition & organism.

Coastal Manager: who guides on balancing protection of the fragile coastal resources.

Conclusion: The remote sensing is an advance technology of acquiring the data of objects or events about earth surface & atmosphere from far. Remote sensors are of two types, passive & active depending upon availability of acting source. Passive remote sensors need the visible light whereas the active sensors senses on the presence of flashlight and photographs even in night. In this way, the electromagnetic spectrum is the key point of remote sensing in both manned & unmanned aircraft systems. Corresponding to different wavelengths of rays in the spectrum; the number of remote sensing are possible and among which satellite remote sensing, optical & infrared remote sensing, and microwave remote sensing have been described here.

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