SENSOR SYSTEMS

Sensor is a device that gathers energy, EMR or other, converts it into a signal and presents it in a form suitable for obtaining information about the environment. On the basis of energy source sensors can be grouped in following two categories:

1) **Active sensor**: An active sensor operates by emitting its own energy, which is needed to detect the various phenomena. RADAR and camera with flesh gun is the example of active sensor.
2) **Passive sensor**: The passive sensor depends on the existing source of energy, like Sun. Photographic systems and multi-spectral scanners are the examples of passive sensor.

In the design of an optimal sensor, an ideal set of parameters is an essential requisite. In multispectral sensors these parameters have strong interrelationships with one another. The specific parameters are

a) Spatial resolution – The minimum detectable area on the ground by a detector placed on a sensor in called spatial resolution. Generally the spatial resolution is understood as a projection of detector element (which defines the instantaneous field of view IFOV) on to the ground. In simple words the spatial resolution is the size of smallest object definable on the image. MSS of LADSAT has 80m resolution, SPOT has 20m (MLA) and 10m (PLA) resolution, in IRS series of satellites LISS I has 72.50m,LISS II has 36.25m, LISS III has 23.5m and PAN has 5.8m resolution. The IKONOS PAN has resolution of 1m.
b) Spectral resolution – The smallest amount of spectral change that can be detected by the sensor is called as the spectral resolution. It is a function of the location and breadth of the wavelength region. The finer the spectral channels; the better is the spectral resolution. In IRS 1C & 1D the PAN has coarse spectral resolution (0.5-0.75 μm) as compared to band 2 (0.52-0.59μm), 3 (0.62-0.68μm) and 4 (0.77-0.86μm).
c) Radiometric resolution – It is the sensitivity of the sensor to discriminate very slight energy differences, usually expressed in terms of grey levels. More the number of grey levels better is the radiometric resolution. E.g. The IRS 1A 1B has 128 grey levels (0-127) and IRS 1C & 1D LISS III has 256 grey levels (0-255).
d) Temporal resolution – How often a sensor obtains the imagery of a particular area is the temporal resolution. In other words it is the repetivity or revisit or time interval between the two successive visits. Smaller the time interval, better the temporal resolution. Repetivity of LANDSAT is 18 days, IRS 1B 22 days ad IS 1C &1D is 24 days.

In order to detect the EMR, which exists in a wide range of wavelengths, different varieties of remote sensing instruments or sensors are used. Some commonly used sensors and their characteristics are given below:

i) **Photographic cameras**: - The most commonly used sensor is the conventional photographic camera designed to detect energy in the visible (0.4–0.7 μm) and near infrared (0.7-0.9 μm) portions of the electromagnetic spectrum. An important component of the photographic system is the lens system, which can cause images of points to be displaced o the photograph. The films which are used with photographic systems are generally panchromatic black-and-white but infrared black-ad-white, true colour or false colour (or colour IR) films ca also be used. Though different types of cameras are available, frame cameras are most commonly used in remote sensing. The photographic cameras have a limited spectral response extending up to 0.9 μm. The middle and thermal IR regions, which are of great interest, can not be covered with the photographic cameras.
ii) **Return beam vidicon (RBV): -** This is very similar to a television/video camera. In such a system the ground image is formed by a fixed camera lens on a photosensitive semi-transparent sheet. The image is created as electrical charge or potential. These devices image an entire scene

instantaneously like a photographic camera. LANDSAT 1,2 & 3 carried three RBV cameras, each corresponding to a different waveband 0.475-0.585 μm (green), 0.580-0.690 μm (red) and 0.690-0.830 μm (near IR). The RBV on LANDSAT 1 & 2 were aimed to view the same 185x185 Km ground area simultaneously. The ground (spatial) resolution was 80 meters. Bhaskara I & II also carried two band TV camera system. These sensors had problems with the registration of the different bands. These are no more used in any remote sensing system.

iii) **Optical-mechanical scanners:** - The optical-mechanical scanners or 'whiskbroom' scanners can operate in any wavelength region so that by using proper detectors multispectral data can be collected simultaneously. Such scanners have the combination of beam splitters and filters for collecting multispectral data. The most widely used scanner in this category is the MSS o board LADSAT series. MSS has 4 spectral bands, covering from 0.5 to 1.1 μm region. MSS consists of a telescope with 23-mm aperture. An oscillating mirror achieves the cross tack scan. The mirror oscillates once every 33 milliseconds. Six contiguous lines are scanned simultaneously with each mirror oscillation. Thus for each scan, 6 lines are generated per spectral band. The IFOV is defined by the ends of optical fibers arranged in a 6x4 matrix at the optical plane of the telescope. The analog signal produced by detectors is converted to a digital signal on board by A to D converter. A digital number range of 0 to 63 (6 bit) is used for this purpose. These data are then scaled to other rages during subsequent ground based processing. MSS scans each line from west to east with the southward motion of a spacecraft. Each frame covers 185x185 sq. km area with 10% end-lap. A nominal scene consists of 2340 scan lines and 3240 pixels per scan line or about 7,581,600 pixels per channel/band. LADSAT 4 & 5 carried a new generation of sensor system called 'Thematic mapper' (TM) in addition to 4 band MSS scanner. TM works on the same basic principle as the MSS, but it provides higher spatial and radiometric resolution. in case of TM the data are collected in both the forward and reverse scan.

iv) **Linear Imaging Self-Scanning Sensors (LISS)**: - These scanners use solid state detectors operating in the **pushbroom** mode. Detector is made by arrays of charged-coupled devices (CCDs). A CCD is a microelectronic silicon chip, a solid state sensor that detects light. CCDs are capable of recording a wide range of light intensities than either photographic film or RBV. CCDs are used because of their small size and weight, their durability and their light sensitivity. LISS cameras of IRS 1A & 1B have CCD array of 2048 elements. SPOT uses linear array of 6000 elements in its panchromatic mode (PLA) and 3000 elements in multi spectral mode (MLA). In pushbroom scanning only the forward motion of the satellite is used to sweep a linear array of detectors oriented perpendicularly to the flight direction or path. Thus there are no moving pats and this eliminates complex geometric distortions inherent in the optical-mechanical scanners.

v) **Thermal Scanners: -** These operate in infrared and a part of microwave region. The principle of data collection is same as that of the optical-mechanical scanners. In the case of thermal scanners photoconductive detectors are used. It is worthy to mention that the thermal detector has to cooled to required operating temperature (mostly about 77 K). Within the recordable temperature range of detector, warm objects appear in lighter grey tones than cool objects, whilst the objects hotter or cooler than the recordable temperature will be imaged as white or black respectively.

vi) **Radar and microwave sensors: -** It is a type of active sensor, which map the terrain by transmitting a series of microwave pulses and recording the strength and timing of echoes reflected from objects in the systems field of view. As the name implies, radar (Radio Detection and Ranging) was designed for measuring distance and determining locations of objects. A major advantage of radar is its all weather, day and night operation capability. A commonly used radar imaging system is the Side-Looking Airborne Radar (SLAR). The term SAR (synthetic aperture radar) is used for the radar systems, which operate from the space. Seasat, SIR-A, SIR-Band Radarsat-1 has SAR system on board.