SATELLITE REMOTE SENSING

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Summary

Satellite remote sensing is defined as a technology for obtaining information about the surface of the earth with special sensors mounted on satellites. Each type of earth surface features, for example, soils, rocks, vegetation, and water bodies, absorbs and reflects solar radiation in a characteristic manner. It also emits electromagnetic radiation in different degrees according to the temperature. These characteristics allow distinguishing between earth features by detecting electromagnetic radiation reflected and/or emitted from the surface of the earth. This is the fundamental principle of satellite remote sensing. Its applications involve a broad range of fields, including topographic mapping, land cover/use mapping, environmental assessment, prediction of agricultural crop production, natural resource exploration, and meteorological prediction. Potential application of a satellite remote sensing system to a specific field depends on characteristics of the system such as spatial, spectral, and temporal resolution of the on-board sensor. High spatial resolution is required for topographic mapping for relatively small areas. Likewise high spectral resolution is crucial for precisely distinguishing between conditions of objects. Temporal resolution is important for repetitive observations such as environmental monitoring. A remote sensing system that

possesses all of these high-resolution characteristics is obviously a target of satellite remote sensing projects, especially for topographic mapping.

1. Introduction

Remote sensing is a science, art, and technology of extracting information about an object without actual contact with it. It involves a variety of sensing methods, which use electromagnetic radiation, terrestrial gravitation, magnetic intensity, sonic wave, and so forth. However, particularly in the field of civil engineering and surveying, remote sensing is generally referred to as a technology that surveys the earth surface by sensing and analyzing electromagnetic radiation reflected and/or emitted from the surface with sensors carried on satellites or aircrafts.

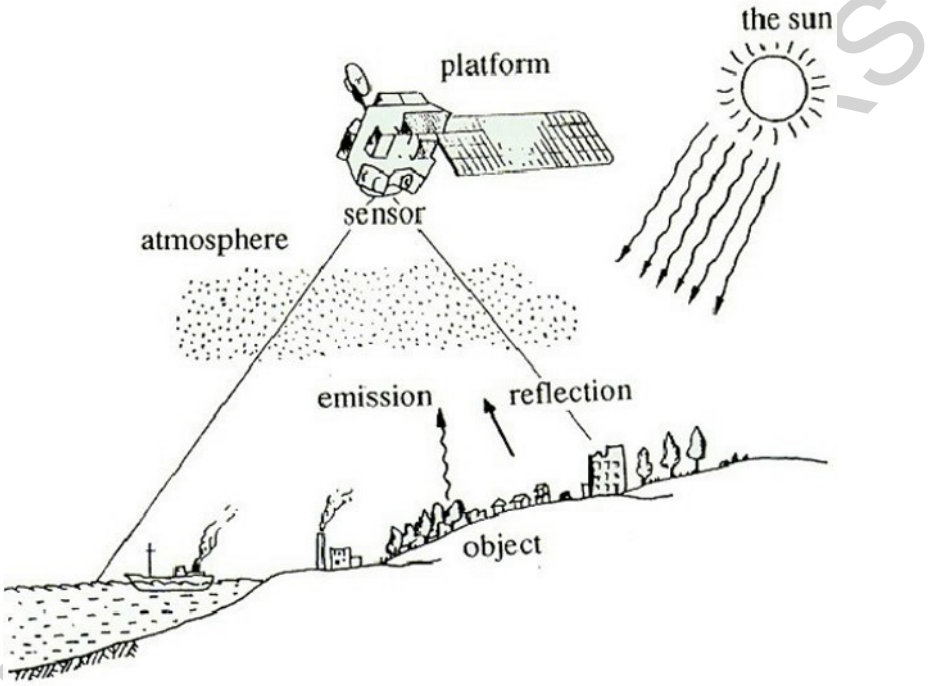

Figure 1: Data Collection by Satellite Remote Sensing

Remote sensing is divided into two broad categories: passive and active. Passive remote sensors detect only electromagnetic radiation naturally emanating from the surface of the earth, for instance, reflected sunlight or emitted thermal infrared rays that depend upon the temperature of objects. Typical passive sensors are photographic camera, electro-optical sensor, and passive microwave sensor. Active sensors, such as laser radar, illuminate the object of study with their own artificially produced radiation and record the reflected component.

When compared with the conventional methods of obtaining information on the earth surface, satellite remote sensing offers several distinct advantages. With this technology, it is possible (1) to collect consistent data over extensive area at a single point of time; (2) to acquire the data of the same area repetitively; (3) to make investigation over the attributes that are not visible to human eyes (by recording electromagnetic spectrum other than visible light, for example the near and thermal infrared regions); and (4) to

obtain information in the form of digital data that can directly be fed into computer for efficient processing. Due to these remarkable characteristics of satellite remote sensing, it has been applied to a wide variety of scientific and technical fields, e.g., topographic and land cover/use mapping, environmental assessment and monitoring, agricultural mapping and prediction, resource exploration, meteorological monitoring and prediction and so forth.

Because of space limitations, this chapter is concerned mainly with the passive satellite remote sensing, and deals with the introductory items which are intended to import a basic knowledge required for those who will use satellite remote sensing to land-oriented surveys such as small-scale topographic and land cover/use mapping.

2. Principles of Remote Sensing

2.1. Electromagnetic Radiation

Electromagnetic radiation is energy that is propagated through free space or through a material medium in the form of electromagnetic waves. The characteristics of electromagnetic radiation vary in the wavelength. The whole range of wavelengths is called the electromagnetic spectrum. Largely for the convenience of reference, different names are assigned to different regions of the spectrum, which share similar characteristics. Visible light is only one of these spectral bands. Radio waves, infrared rays, and ultraviolet rays are other familiar forms. Figure 2 shows the electromagnetic spectrum.

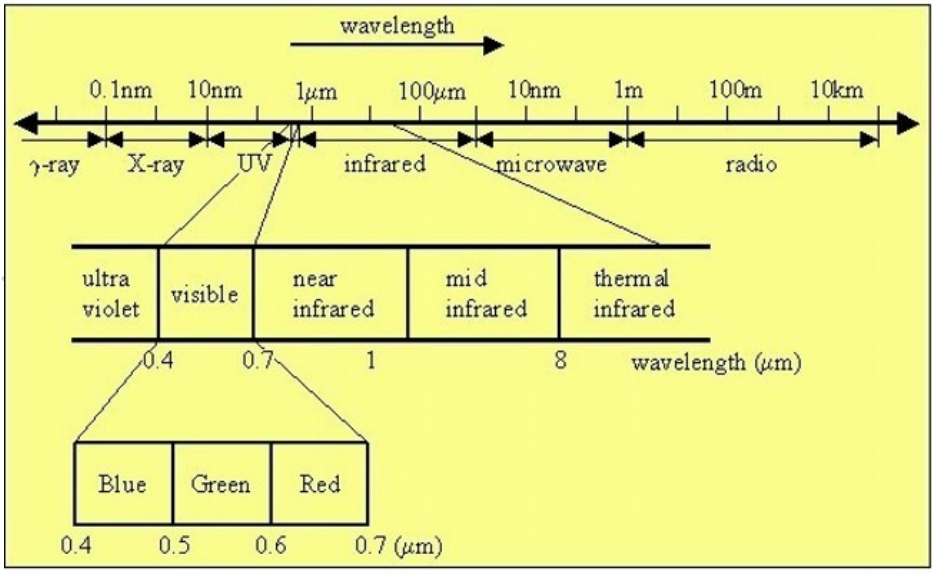

Figure 2: Electromagnetic Spectrum

When the electromagnetic radiation interacts with the earth's atmosphere, different spectral bands behave differently. The radiation at certain wavelengths passes freely through the atmosphere, whereas it is restricted at some other wavelengths. Regions of the spectrum where the radiation can pass through the atmosphere are called atmospheric windows or, in short, windows. Satellite remote sensing makes use of

electromagnetic radiation passing through these windows. Given in the order of increasing wavelengths, the spectral regions available for satellite remote sensing are ultraviolet, visible, infrared (in particular, near and thermal infrared), and microwave. Most commonly used regions in satellite remote sensing are visible and near infrared, and thermal infrared.

Electromagnetic radiations detected by satellite remote sensing instruments are divided into (1) solar radiation, which emanates from the sun and is reflected by the earth's surface and (2) terrestrial radiation, which is emitted by the earth's surface in different degrees according to the temperature. The intensity of solar radiation is high in the visible and near infrared bands, whereas the intensity of terrestrial radiation, although the absolute value of intensity is much lower than that of solar radiation, is relatively high in the thermal infrared band.

It should be noted that the remote sensors on-board satellites do not capture all of the electromagnetic radiation that reaches from the earth to satellites. Mainly due to technological and economical constraints, only some limited regions or bands of the electromagnetic spectrum are selectively detected by remote sensors. Potential applications of a certain remote sensor depend on the number of bands it can detect and the range these bands are located in the spectrum.

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Biographical Sketch

Eihan Shimizu is currently Professor at the Department of Civil Engineering of the University of Tokyo, Japan. Professor Shimizu graduated with his Master of Engineering from the Department of Civil Engineering of the University of Tokyo in 1984. After completing his doctorate in engineering there in 1989, he became Associate Professor at Gifu University, Japan in 1990. Subsequently, he became Associate Professor at the University of Tokyo in 1993 before assuming the position of Professor at the University of Tokyo in 1998. His research interests include satellite remote sensing, image processing, geographic information system (GIS), mathematical cartography, spatial statistical analysis, and regional and urban planning. Professor Shimizu has served as a council member of several Japanese academic societies and associations, such as Japan Society of Photogrammetry and Remote Sensing and GIS Association in Japan. He is currently Secretary General of the Japan Society of Photogrammetry and Remote Sensing.