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A Remote Sensing Tutorial

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A Remote Sensing Tutorial

Many different Earth-sensing satellites, with diverse sensors mounted on sophisticated platforms, are in Earth orbit r soon to be launched. These sensors are designed to cover a wide range of the electromagnetic spectrum and are generating enormous amounts of data that must be processed, stored, and made available to the user community.

This rich source of unique, repetitive, global coverage produces valuable data and information for applications as diverse as forest fire monitoring and grassland inventory in Mongolia, early typhoon warning over the vast Pacific Ocean, flood assessment in coastal zones around the Bay of Bengal, and crop health and growth within the plains of the United States. Additionally, the commercial realm is also developing and launching various high resolution satellites and marketing these data worldwide.

Dr. Nicholas Short, a former NASA Goddard employee in the Applied Information Sciences Branch, NASA Goddard Space Flight Center, has prepared a highly intuitive, easily accessible remote sensing tutorial for new users of remote sensing and for the educational community. This tutorial will provide a detailed understanding of the utility of remote sensing data in light of the fundamental principles of electromagnetic energy, especially as they relate to sensor design and function.

Dr.Short is the author of several NASA-sponsored books (Mission to Earth: Landsat Views the World; The Landsat Tutorial Workbook; The HCMM Anthology; and Geomorphology from Space) germane to the subject of remote sensing.

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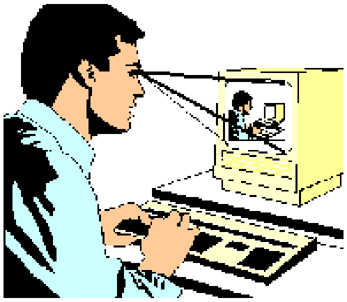
The Concept of Remote Sensing

If you have heard the term "remote sensing" before you may have asked, "what does it mean?" It's a rather simple, familiar activity that we all do as a matter of daily life, but that gets complicated when we increase the scale. As you view the screen of your computer monitor, you are actively engaged in remote sensing.



A physical quantity (light) emanates from that screen, which is a source of radiation. The radiated light passes over a distance, and thus is "remote" to some extent, until it encounters and is captured by a sensor (your eyes). Each eye sends a signal to a processor (your brain) which records the data and interprets this into information.

Several of the human senses gather their awareness of the external world almost entirely by perceiving a variety of signals, either emitted or reflected, actively or passively, from objects that transmit this information in waves or pulses. Thus, one hears disturbances in the atmosphere carried as sound waves, experiences sensations such as heat (either through direct contact or as radiant energy), reacts to chemical signals from food through taste and smell, is cognizant of certain material properties such as roughness through touch, and recognizes shapes, colors, and relative positions of exterior objects and classes of materials by means of seeing visible light issuing from them. In the previous sentence, all sensations that are not received through direct contact are remotely sensed.

I-1 In the illustration above, the man is using his personal visual remote sensing device to view the scene before him. Do you know how the human eye acts to form images? If not, check the answer. ANSWER

However, in practice we do not usually think of our bodily senses as remote sensors in the way we use the term technically. A formal and comprehensive definition of applied remote sensing *, as it is customarily formulated to include determination of geophysical parameters, is:

The acquisition and measurement of data/information on some property(ies) of a phenomenon, object, or material by a recording device not in physical, intimate contact with the feature(s) under surveillance; techniques involve amassing knowledge pertinent to environments by measuring force fields, electromagnetic radiation, or acoustic energy employing cameras, radiometers and scanners, lasers, radio frequency receivers, radar systems, sonar, thermal devices, seismographs, magnetometers, gravimeters, scintillometers, and other instruments.

* The term "remote sensing" is itself a relatively new addition to the technical lexicon. It was coined by Ms Evelyn Pruitt in the mid-1950's when she, a geographer/oceanographer, was with the U.S. Office of Naval Research (ONR) outside Washington, D.C.. No specific publication or professional meeting is cited in literature consulted by the writer (NMS) in which the words "remote sensing" were stated. Those "in the know" claim that it was used openly by the time of several ONR-sponsored symposia in the late '50s at the University of Michigan. The writer believes he first heard this term at a Short Course on Photogeology coordinated by Dr. Robert Reeves at the Annual Meeting of the Geological Society of America in 1958.

As defined above, the term generally implies that the sensor is placed at some considerable distance from the sensed target, in contrast to close-in measurements made by "proximate sensing." (sometimes given as "in situ" sensing), which can apply to some of the set-ups used in medical remote sensing. It seems to have been coined by Ms Pruitt to take into account the new views from space obtained by the early meteorological satellites which were obviously more "remote" from their targets than the airplanes that up until then provided mainly aerial photos as the medium for recording images of the Earth's surface.

I-2 To help remember the principal ideas within this definition, make a list of key words in it. ANSWER

This is a rather lengthy and all-inclusive definition. Perhaps two more simplified definitions are in order: The first, more general, includes in the term this idea: Remote Sensing involves gathering data and information about the physical "world" by detecting and measuring radiation, particles, and fields associated with objects located beyond the immediate vicinity of the sensor device(s). The second is more restricted but is pertinent to most of the subject matter of this Tutorial: Remote Sensing is a technology for sampling electromagnetic radiation to acquire and interpret non-immediate geospatial data from which to extract information about features, objects, and classes on the Earth's land surface, oceans, and atmosphere (and, where applicable, on the exteriors of other bodies in the solar system, or, in the broadest framework, celestial bodies such as stars and galaxies).

I-3 What is the meaning of "geospatial"? Are there any differences in meaning of the terms "features", "objects", and "classes"? ANSWER

Or, try this variation: Applied terrestrial Remote Sensing involves the detecting and measuring of electromagnetic energy (usually photons) emanating from distant objects made of various materials, so that the user can identify and categorize these objects by class or type, substance, and spatial distribution.

All of these statements are valid and, taken together, should give you a reasonable insight into the meaning and use of the term "Remote Sensing".

Thus, some technical purists arbitrarily stretch the scope or sphere of remote sensing to include other measurements of physical properties from sources "at a distance" that are more properly included in the general term "geophysics". This would take in such geophysical methods as seismic, magnetic, gravitational, acoustical, and nuclear decay radiation surveys. Magnetic and gravitational measurements respond to variations in field forces, so these can be carried out from satellites. Remote sensing, as defined in this context, would be a subset within the branch of science known as Geophysics. However, practitioners of remote sensing, in its narrower meaning, tend to exclude these other areas of geophysics from their understanding of the meaning implicit in the term.

Still, space systems - mostly on satellites - have made enormous contributions to regional and global geophysical surveys. This is because it is very difficult and costly to conduct ground and aerial surveys over large areas and then to coordinate the individual surveys by joining them together. To obtain coherent gravity and magnetic data sets on a world scale, operating from the global perspective afforded by orbiting satellites is the only reasonable alternate way to provide total coverage. One could argue that this subject deserves a Section of its own but in the remainder of this Tutorial we choose to confine our attention to those systems that produce data by measuring in the electromagnetic radiation (EMR) spectrum (principally in the Visible, Infrared, and Radio regions). Nevertheless, just to "peak at" the kinds of non-EMR geophysical data being collected from space, we will taken a "detour" from the main theme of this Section by providing on the next page several examples of the use of satellite instruments to obtain information on particles and fields around the Earth; in Sections 19 and 20 (Planets and Cosmology) there will also be some illustrations of several types of geophysical measurements.