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Review Article

REMOTE SENSING AND ITS ROLE IN AGRICULTURE

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ABSTRACT
Many scientists have provided a great deal of fundamental information relating spectral reflectance and thermal emittance properties of soils and crops to their agronomic and biophysical characteristics. This knowledge has facilitated the development and use of various remote sensing methods for non-destructive monitoring of plant growth and development and for the detection of many environmental stresses which limit plant productivity. Coupled with rapid advances in computing and position locating technologies, remote sensing from ground, air, and space based platforms is now capable of providing detailed spatial and temporal information on plant response to their local environment that is needed for site specific agricultural management approaches. This review highlights on remote sensing technology and describes how it can be used as an effective tool in agriculture.

KEYWORDS: Remote sensing, Reflectance, Spatial, Agriculture.

INTRODUCTION
Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. It was coined by Ms. Evelyn Pruitt in mid-1950's when she, a geographer/ oceanographer, was with the U.S. office of Naval Research (O.N.R.) outside Washington D.C. In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR). EMR is a form of energy that reveals its presence by the observable effects it produces when it strikes the matter.

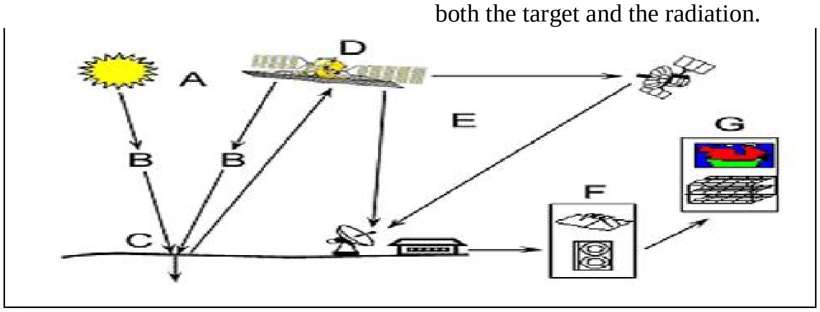
THE CONCEPT OF REMOTE SENSING
When you view the screen of your computer monitor, you are actively engaged in remote sensing. A physical quantity (light) emanates from that screen, which is a source of radiation. The radiated light passes over a distance, and thus is "remote" to some extent, until it 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. Of our five senses (sight, hearing, taste, smell, touch), three may be considered forms of "remote sensing", where the source of information is at some distance. They are sight, hearing and smell.

COMPONENTS OF REMOTE SENSING
In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where seven elements are involved. However that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.

1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - as the energy travels from its source to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.



4. Recording of Energy by the Sensor (D) - after the energy has been emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation. In order for a sensor to collect and record energy reflected or emitted from a target or surface, it must reside on a stable platform removed from the target or surface being observed. Platforms for remote sensors may be situated on the ground, on an aircraft or balloon (or some other platform within the Earth's atmosphere), or on a spacecraft or satellite outside of the Earth's atmosphere. Sensors may be placed on a ladder, scaffolding, tall building, cherry picker, crane, etc. Aerial platforms are primarily stable wing aircraft, although helicopters are occasionally used. Aircraft are often used to collect very detailed images and facilitate the collection of data over virtually any portion of the Earth's surface at any time.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/ or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target, which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

These seven elements comprise the remote sensing process from beginning to end.

PRINCIPLE OF REMOTE SENSING

Every object reflects/scatter a portion of electromagnetic energy incident on it depending on its physical properties. In addition, objects emit radiation depending on their temperature and emissivity. The reflectance/ emittance of any object at different wavelengths follow a pattern which is characteristic of that object, known as spectral signature. Proper interpretation of the spectral signature leads to identification of the object.

TYPES OF REMOTE SENSING

With respect to the type of energy resources

1. **Passive Remote Sensing**: - Makes use of sensors that detect the reflected or emitted electro-magnetic radiation from natural sources. The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected, as it is for visible wavelengths, or absorbed and then re-emitted, as it is for thermal infrared wavelengths. Remote sensing systems which measure energy that is naturally available are called passive sensors. Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded.

2. **Active remote Sensing:** - Makes use of sensors that detect reflected responses from objects that are irradiated from artificially generated energy sources, such as radar. Active sensors provide their own energy source for illumination. The sensor emits radiation, which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets. Some examples of active sensors are a laser fluorosensor and synthetic aperture radar (SAR).

WITH RESPECT TO WAVELENGTH REGIONS

Remote Sensing is classified into three types in respect to the wavelength regions

1. Visible and Reflective Infrared Remote Sensing: - The energy source used in the visible and reflective infrared remote sensing is the sun. The sun radiates electro-magnetic energy with a peak wavelength of 0.5 μ m. Remote sensing data obtained in the visible and reflective infrared regions mainly depends on the reflectance of objects on the ground surface. Therefore, information about objects can be obtained from the spectral reflectance. However laser radar is exceptional because it does not use the solar energy but the laser energy of the sensor.

2. Thermal Infrared Remote Sensing: - The source of radiant energy used in thermal infrared remote sensing is the object itself, because any object with a normal temperature will emit electro-magnetic radiation with a peak at about 10 μm .

3. Microwave remote sensing: -There is two types of microwave remote sensing, passive microwave remote sensing and active remote sensing. In passive microwave remote sensing, the microwave radiation emitted from an object is detected, while the back scattering coefficient is detected in active microwave remote sensing. Active microwave sensors are generally divided into two distinct categories: imaging and non-imaging. The most common form of imaging active microwave sensors is RADAR. RADAR is an acronym for Radio Detection And Ranging, which essentially characterizes the function and operation of a radar sensor. The sensor transmits a microwave (radio) signal towards the target and detects the backscattered portion of the signal. The strength of the backscattered signal is measured to discriminate between different targets and the time delay between the transmitted and reflected signals determines the distance (or range) to the target.

USE OF REMOTE SENSING IN THE FIELD OF AGRICULTURE

Agriculture plays a dominant role in economies of both developed and undeveloped countries. Whether agriculture represents a substantial trading industry for an economically strong country or simply sustenance for a hungry, overpopulated one, it plays a significant role in almost every nation. The production of food is important to everyone and producing food in a cost-effective manner is the goal of every farmer, large-scale farm manager and regional agricultural agency. A farmer needs to be informed to be efficient, and that includes having the knowledge and information products to forge a viable strategy for farming operations. These tools will help him understand the health of his crop, extent of infestation or stress damage, or potential yield and soil conditions. Commodity brokers are also very interested in how well farms are producing, as yield (both quantity and quality) estimates for all products control price and worldwide trading.

RS and GIS technologies have been of great use to planners in planning for efficient use of natural resources at national, state and district levels. Application of these technologies in the management of natural resources are increasing rapidly due to great strides made in space-borne RS satellites in terms of spatial, temporal, spectral and radiometric resolutions (Venkataratnam, 2001).

Remote sensing has several unique advantages (Jensen, 1996):

- RS technology is well-known as a non destructive method to collect information about earth features.
- RS data may be obtained systematically over very large geographical areas rather than just single point observations.
- RS data can reveal information about places that are inaccessible to human exploration.
- The systematic (raster) data collection in RS can remove sampling bias.
- RS can provide fundamental biophysical information that can be used in other sciences.
- RS is independent from the data produced elsewhere, in comparison with the other mapping sciences such as cartography or GIS.

New RS multispectral and hyperspectral sensors are swiftly generating vast amounts of data in a cost effective manner and at higher spatial and spectral resolutions. Hyperspectral and multispectral images, consisting of reflectance from the visible, near infrared and mid-infrared regions of the electromagnetic spectrum, can be interpreted in terms of physical parameters (such as crop cover, crop health and soil moisture) and are useful for operations such as stress mapping, fertilization and pesticide application and irrigation management (Singh *et al*., 2007; Tilling *et al*., 2007; Yang *et al*., 2003). Nutrient contents of different crops such as wheat (Tilling *et al*., 2007), paddy rice (Stroppiana *et al*., 2008), sorghum (Zhao *et al*., 2005), corn (Samson *et al*., 2000), broccoli (Shikha *et al*., 2007), citrus (Min, 2008), grape (Smart *et al*., 2007), apple (Perry and Davenport, 2007) have also been assessed using hyperspectral and multispectral RS data. Interpretation of RS data is often aided by specialized techniques such as geostatistics, image analysis and classification, and artificial intelligence.

Crop Type Mapping

Remote sensing offers an efficient and reliable means of collecting the information required, in order to map crop type and acreage. Besides providing a synoptic view, remote sensing can provide structure information about the health of the vegetation. The spectral reflection of a field will vary with respect to changes in the phenology (growth), stage type, and crop health, and thus can be measured and monitored by multispectral sensors. Radar is sensitive to the structure, alignment, and moisture content of the crop, and thus can provide complementary information to the optical data. Combining the information from these two types of sensors increases the information available for distinguishing each target class and its respective signature, and thus there is a better chance of performing a more accurate classification.

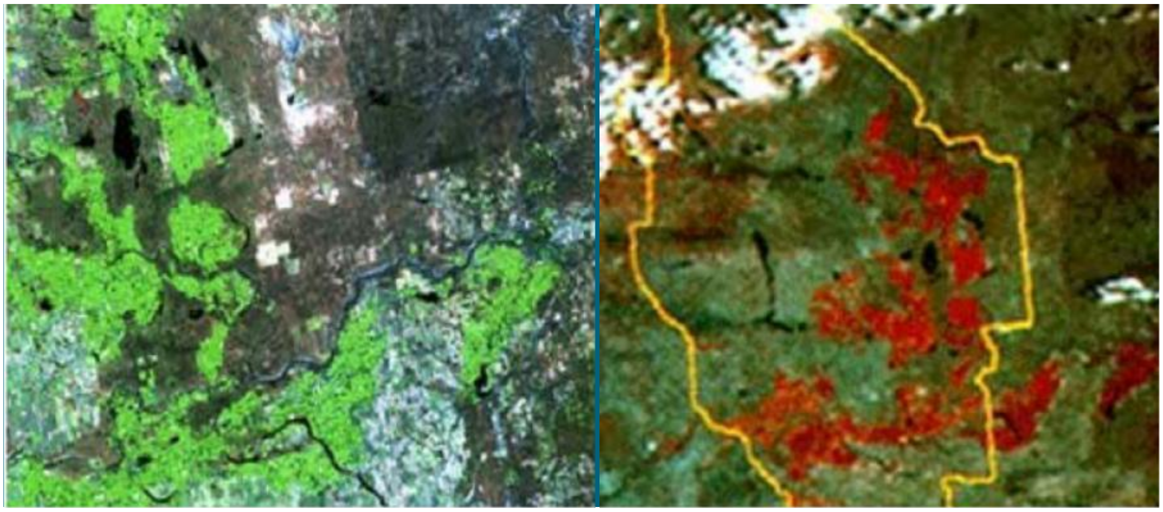
Interpretations from remotely sensed data can be input to a geographic information system (GIS) and crop rotation systems, and combined with ancillary data, to provide information of ownership, management practices etc.

Crop identification and mapping benefit from the use of multi temporal imagery to facilitate classification by taking into account changes in reflectance as a function of plant phenology (stage of growth). This in turn requires calibrated sensors, and frequent repeat imaging throughout the growing season. For example, crops like canola may be easier to identify when they are flowering, because of both the spectral reflectance change, and the timing of the flowering.

Crop Monitoring & Damage Assessment:

Remote sensing has a number of attributes that lend themselves to monitoring the health of crops. One advantage of optical (VIR) sensing is that it can see beyond the visible wavelengths into the infrared, where wavelengths are highly sensitive to crop vigour as well as crop stress and crop damage. Remote sensing imagery also gives the required spatial overview of the land. Recent advances in communication and technology allow a farmer to observe images of his fields and make timely decisions about managing the crops. Remote sensing can aid in identifying crops affected by conditions that are too dry or wet, affected by insect, weed or fungal infestations or weather related damage. Images can be obtained throughout the growing season to not only detect problems, but also to monitor the success of the treatment.

Healthy vegetation contains large quantities of chlorophyll, the substance that gives most vegetation its distinctive green colour. In referring to healthy crops, reflectance in the blue and red parts of the spectrum is low since chlorophyll absorbs this energy. In contrast, reflectance in the green and near-infrared spectral regions is high. Stressed or damaged crops experience a decrease in chlorophyll content and changes to the internal leaf structure. The reduction in chlorophyll content results in a decrease in reflectance in the green region and internal leaf damage results in a decrease in near-infrared reflectance. These reductions in green and infrared reflectance provide early detection of crop stress. Examining the ratio of reflected infrared to red wavelengths is an excellent measure of vegetation health. This is the premise behind some vegetation indices, such as the normalized differential vegetation index (NDVI). Healthy plants have a high NDVI value because of their high reflectance of infrared light, and relatively low reflectance of red light. Phenology and vigour are the main factors in affecting NDVI. An excellent example is the difference between irrigated crops and non-irrigated land. The irrigated crops appear bright green in a real-colour simulated image. The darker areas are dry rangeland with minimal vegetation. In a CIR (colour infrared simulated) image, where infrared reflectance is displayed in red, the healthy vegetation appears bright red, while the rangeland remains quite low in reflectance.



Examining variations in crop growth within one field is possible. Areas of consistently healthy and vigorous crop would appear uniformly bright. Stressed vegetation would appear dark amongst the brighter, healthier crop areas. If the data is georeferenced, and if the farmer has a GPS (global position satellite) unit, he can find the exact area of the problem very quickly, by matching the coordinates of his location to that on the image.

Soil moisture estimation

Remote sensing offers a means of measuring soil moisture across a wide area instead of at discrete point locations that are inherent with ground measurements. RADAR is effective for obtaining qualitative imagery and quantitative measurements, because radar backscatter response is affected by soil moisture, in addition to topography, surface roughness and amount and type of vegetative cover. Keeping the latter elements static, multitemporal radar images can show the change in soil moisture over time. The radar is actually sensitive to the soil's dielectric constant, a property that changes in response to the amount of water in the soil.

Users of soil moisture information from remotely sensed data include agricultural marketing and administrative boards, commodity brokers, large scale farming managers, conservation authorities, and hydroelectric power producers.

Land Cover & Land Use

Although the terms land cover and land use is often used interchangeably, their actual meanings are quite distinct. Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Identifying, delineating and mapping land cover is important for global monitoring studies, resource management, and planning activities. Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed, and provides the ground cover information for baseline thematic maps.

Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know what current quantity of land is in what type of use and to identify the land use changes from year to year. This knowledge will help develop strategies to balance conservation, conflicting uses, and developmental pressures. Issues driving land use studies include the removal or disturbance of productive land, urban encroachment, and depletion of forests.

It is important to distinguish this difference between land cover and land use, and the information that can be ascertained from each. The properties measured with remote sensing techniques relate to land cover, from which land use can be inferred, particularly with ancillary data or a priori knowledge.

Insect Pest & Disease Infestation

Some disease and insect pests of crops may be monitored by remote sensing. Riedell *et al*. (2004) introduced remote sensing technology as an effective and inexpensive method to identify pest-infested and diseased plants. They used remote sensing techniques to detect specific insect pests and to distinguish between insect and disease damage on oat. Results suggested that canopy characteristics and spectral reflectance differences between insect infestation damage and disease infection damage can be measured in oat crop canopies by remote sensing but that these differences may not be consistent from one growing season to the next.

RS techniques also play an important role in assessing yield forecasting, acreage estimates of specific crops, disaster location and mapping, wild life management, water supply information and management, weather forecasting, rangeland management, and livestock surveys.

CONCLUSION

Modern management of agricultural resources is a complex endeavor that is now benefiting from a convergence of technical advances in information sciences, geographic positioning capabilities, and remote sensing systems. Much of the fundamental research relating spectral properties of soils and crops to agronomic and biophysical parameters has been done by many researchers over the past. Many aspects of soil and crop management have already begun to benefit from the applications of remote sensing technology. The future brings tremendous prospects for integrating the spatially and temporally rich information provided through remotely sensed multi and hyperspectral imagery for efficient management and planning.

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