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GROUND INVESTIVATIONS IN SUPPORT OF REMOTE SENSING

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GROUND INVESTIVATIONS IN SUPPORT OF REMOTE SENSING

INTRODUCTION

The purpose of ground investigation in remote sensing is to give the investigator or operational user a realistic portrait of the target. These ground observations (sometimes called 'ground truth' despite some measurement error) are necessary in both research and operational applications. Sometimes the ground observations can be obtained from regularly collected or already available data, but often a ground investigation data collection program must be specifically designed for the remote sensing mission.

According to the objective of remote sensing activity and the accuracy level required, nature of information to be collected and quality & quantity requirement for information are determined. At the end of any remote sensing project where limited ground truth data is used, accuracy of the results obtained are also to be checked and again for accuracy evaluation, some more ground investigation is required.

Uses of Ground Data

According to the purpose, we can group ground investigation into four major categories.

Calibration/Correction

Sensors used in remote sensing can only measure electromagnetic radiation reflected or emitted from the surface and attenuated or incremented by the intervening atmosphere. There are also changes in the signal, which are independent of any change in surface properties, caused by variations in the angle of illumination of the incident irradiance and angle of viewing by the sensor. The purpose of calibration or correction is to account for these effects. For some applications we require absolute calibration, and thus try to estimate the surface existence integrated over some wavelength interval. For other applications we require only relative calibration.

Interpretation of Properties

To interpret any remote sensing data, the interpreter should know about the 'behavior' of any target with electromagnetic radiation i.e. spectral signature of any object. The 'behavior' of interest may be reflectance in visible and NIR region of EMR, emittance in MIR or passive microwave remote sensing studies, or, backscattering in active microwave remote sensing studies. Ground investigations are necessary to establish relationships between radiative and physical properties of any object over electromagnetic spectrum.

Training Sets

Training sets are the representative locations for any particular class i.e. agriculture or built-up area in a remote sensing data. These sites are to be chosen in such a way that these locations should have purity for a single class, should be a well defined and identifiable location on both imagery and map and should also be accessible for ground investigations. Thorough investigation in training sites is necessary for visual as well as digital analysis of remote sensing data.

Accuracy evaluation

The performance of any procedure for making interpretations from remotely sensed data should be verified by ground observations. The areas used for verification should be distinct from those used for training, and normally should be distributed, as should the training sites - according to some appropriate sample design.

Test Sites

Interpretation of most remotely sensed data depends on ancillary data and knowledge of the geographic area. The more the interpreter knows about the area over which the data were obtained, better is the interpretation. Some ancillary data must be obtained during the acquisition of the airborne/ spaceborne remote sensor data; others can be obtained before or afterward. When large areas are sensed by spaceborne instruments, it is impractical to obtain ground data for the entire area, instead data from small selected portions of the area are easily and efficiently gathered.

Knowledge gained by study of these selected small areas can be used to aid in the interpretation of data from the entire area. These smaller areas are called 'test sites'. Their physical and biological characteristics have been extensively studied, and a variety of remotely sensed data have been tested over them. For many remote sensing experiments, the choice of a test site for which extensive field data already exist is advisable. If a test site is to be chosen and then investigated, the selection should be in such a way that, the area should have minimum consistence i.e. easily accessible, well identifiable in map and remote sensing data, easily locatable for fieldwork etc.

GROUND TRUTH INSTRUMENTS AND SPECTRAL SIGNATURES

Introduction

Proper selection of ground investigation equipment is dependent on proper selection of the variables to be measured. When correctly used, the combined remotely sensed data and ground truth data reduce the time for analysis of the scene. Some surface conditions are so dynamic that they may change within the hour. Under such conditions ground data collection at the time of over flight is the only way to verify, what was actually present and what the imagery may subsequently reveal. This type of data collection is most expensive and may require the greatest instrumentation, planning and logistical support. The ground investigations should include physical, chemical, biologic and atmospheric features of the site. Various remote sensors are used to record the emitted and reflected EMR of various components of the test sites.

The ground investigations with respect to remote sensing involve two kinds of observations depending upon the objective to be achieved. These are (a) Visual and (b) spectral measurements. The visual ground truth involves observation such as colour, shape, size, texture, and temperature of the object of interest. The spectral observation involve measurements of spectral reflectance of a particular objects, in-situ using specially designed equipment for this purpose.

Energy matter interaction:

The interaction of electromagnetic energy with physical matter may cause the EMR to be

a) Reflected
b) Emitted or remitted at different wavelength
c) Transmitted
d) Absorbed
e) Scattered.

Reflection, emission, absorption, transmission and scattering of EM energy depends primarily upon its atomic and molecular structure and is a function of wavelength of the radiation. Multispectral scanning techniques used in remote sensing is based on such spectral response of matter.

Signature

Any remotely sensed parameter, which directly or indirectly characterizes the nature and/or condition of the object under observation, is defined as its signature. We actually use the spectral signature of the object in remote sensing. This can be defined as a unique pattern of wavelengths radiated by an object. These can be categorised as

Spectral Variation: Variation in reflectivity and emissivity as a function of wavelength.

Spatial Variation: Variation of reflectivity and emissivity with spatial position (i.e. shape, texture and size of the object).

Temporal variation: of emissivity and reflectivity like that in diurnal and seasonal cycle.

Polarization variation: are introduced by the material in the radiation reflected or emitted by it.

Each of these four features of EM radiation may be interdependent i.e. shape may be different at different times, or in different spectral bands. A measure of these variations and correlating them with the known features of an object provides signature of the object concerned. The knowledge of the state of polarization of the reflected radiation in addition to spectral signatures of various objects in remote sensing adds another dimension for analysis and interpretation of remote sensing data. Various techniques have been attempted to measure the degree of polarization and Stoke's parameter. These parameters are extremely useful in providing valuable data for discriminating the objects.

Techniques and Instrumentation:

The aim of field and laboratory study is to establish the capability for detection and identification of various earth resources. These are therefore essential towards establishing spectral signatures and the parameters that influence them. This involves the measurement of reflectance and emittance of various materials in laboratory and at natural field conditions. All radiation measuring instruments can be broadly divided into two category a) Spectrometer and b) Radiometer. The Spectrometer measured the spectral distribution of EMR. The Radiometer on other hands quantitatively energy measures the content of radiation within a predetermined spectral band.

The two most common forms of dispersing elements are the prism and the diffraction grating. They can both be used in similar optical arrangements to produce a spectrum from a particular source. If the spectrum is observed by eye, the instrument is called spectroscope. If the spectrum is recorded on photography film, the instrument is called a spectrograph. If the instrument produces a spectrum that can be scanned in some way with a detector to determine the wavelength position of emission or absorption lines in the source, the instrument is called a spectrometer. If in addition, the instrument can measure the radiant exitance of these lines, then it is called a spectroradiometer. All these instruments are used in spectral analysis of a source of radiation.

Spectrometer

Spectrometer is a device to measure the spectral distribution of EMR. This may be achieved by a dispersive prism, grating or circular interference filter with a detector placed behind a slit. If one detector is used, the dispersed element is moved so as to sequentially pass all dispersed wavelength across the slit. It has the following main components-

a) Source of radiant energy
b) Monochromator - usually a prism or a grating or a combination of both

c) Sample container or attachment device
d) Detector
e) Recorder
f) Reference or standard substance

A spectrometer having an internal source of illumination is known as spectrophotometer. If the geometry of the instrument is such that it views the reflected radiation from the target, it is known as spectroreflectometer. If it measures the radiation that has passed through the target, it is called spectrotransmissometer. Most important laboratory instrument is a spectroreflectometer. In a typical spectroreflectometer an integrating sphere is used as a source for measuring reflectance. It is possible to measure either the total or diffuse reflectance of the sample.

Spectrophotometer

It measures the intensity of EMR as a function of the frequency of EMR visually used in the visible portion.

These are used for measurement of Reflectance, Transmission and Absorption of various solids, liquid and other type of samples in the laboratory. The data obtained can be utilized as a supporting ground truth data.

Spectrophotometer is an integrated system for examining or analysing luminous sources and materials as a function of spectral information. Generally such systems consists of a source of radiant energy, a monochromator, a detector and a recorder. It has provisions for inserting a sample for analysis into the beam of radiant energy. The tungsten filament lamp sources are used in visible region of the spectrum in so far as continuous radiation is concerned. For line source in visible region, gas discharge source such as mercury, xenon and neon can be resorted to. Tungsten sources are further useful in the near infrared region of the spectrum. In the middle and far IR regions, Globar elements and Nernst glowers are used. The heart of a spectrophotometer is a its monochromator, which divides source radiation into discrete wavelength bands. This can be accomplished by using the selective absorption or transmission properties of filters or by employing the dispersive properties of prism and gratings.

Radiometer

It is an instrument for quantitatively measuring the intensity of EMR in some band of wavelengths in any part of the EM spectrum.

- An optical system, including the sensitive surface of the detector, which determines the combination of receiving aperture and angular field of view through which radiation is collected.

- A detector element, which transduces changes in incident e.m. radiation into corresponding variations of an easily measured property.
- An amplifier and output indicator, to transform the output of the detector element into the desired form of presentations. In addition, an ideal radiometer should have optical system free from aberrations and it should respond uniformly to all polarization. Response of the detector should be linear over its dynamic range.

Spectroradiometer

It is a device which measures flux in much narrower spectral bands. In the spectro radiometer simple filter is replaced with a dispersive device. That separates optical radiation into its spectral components which are directed towards a detector. It is used primarily to prepare spectral reflectance curve for various objects.

Radiation Detectors

Radiation detectors used in remote sensing may be grouped into three categories viz. chemical, thermal and photon (or quantum) detector.

- **Chemical Detectors**: Photographic films are the best known detectors in which the incident radiation causes formation of a latent image. This latent image is developed chemically. Black and white as well as coloured films sensitive to both visible and near infrared (upto 0.90 micrometer) are commercially available.
- **Thermal Detectors**: Operation of thermal detectors is based on heating effect of radiation. Any temperature sensitive physical property of the detector element can be made use of for monitoring the effect. These detectors have flat spectral response over the entire spectrum. These can be divided into following main groups.
  - Bolometers
  - Thermocouple/Thermopile
  - Pneumatic cells i.e. Golay Pneumatic Cell.
- **Photon Detectors:** Photon (quantum) detectors are semi-conductor devices based on internal photoelectric effect. This results from the direct photon electron interaction. The time response of these detectors is about microsecond or less which is about three orders of magnitude faster than the thermal detectors. Their spectral response is non-linear. There are two different types of photoconductive detector. (a) Intrinsic excitation, wherein electron hole pairs are generated by exciting an electron from valance band to conduction band. (b) Extrinsic excitation, wherein current carriers are produced by exciting electrons either from or to impurity doping levels which lies within the forbidden band of the semi-conductor. All photovoltaic

detectors, however, utilize intrinsic excitation of whole electron pairs from valance to conduction band.