CHAPTER - 1

INTRODUCTION AND DESIGN OF THE STUDY

1.1. Overview

This chapter presents the background on remote sensing, a review on the latest generation of remote sensing sensors characterized by very high geo material and spectral resolution and their applications to environmental monitoring. It describes the objectives, scope, the most critical issues related to the instinctive exploration and classification of the data collected by these sensors as well as the general motivations. Furthermore, it presents the specific issues and the novel contributions. Finally, the structure and organization of this research is described.

1.2. Definition of Remote Sensing

Remote sensing can be defined as the collection of data about an object from a distance. Humans and many other animals accomplish this task with aid of eyes or by the sense of smell or hearing. Geographers use the technique of remote sensing to monitor or measure phenomena found in the Earth's lithosphere, biosphere, hydrosphere, and atmosphere. Remote sensing of the environment by geographers is usually done with the help of mechanical devices known as remote sensors. These devices have great improved ability to receive and record information about an object without any physical contact. Often, these sensors are positioned away from the object of interest by using helicopters, planes and satellites. Most sensing devices record information about an object by measuring and transmission of electromagnetic energy from reflecting and radiating surfaces.

Generally, Remote sensing refers to the activities of recording, observing and perceiving objects or events at far away from places or spaces. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on earth by means of propagated signals. The electromagnetic radiation is normally used as an information carrier in remote sensing.

Remote sensors collect data by detecting the energy that is reflected from earth. These sensors can be on satellites or mounted on aircraft, ships, satellites or other spacecraft. Remote sensors can be either passive or active. Passive sensors respond to external incitements. These sensors record radiation that is reflected from earth's surface, usually from the sun. Because these passive sensors can be used to collect data during daylight hours. In contrast, active sensors use internal incitements to collect data about earth.

Remote sensing imagery has many applications in mapping land use and cover, agriculture, soils mapping, forestry, city planning, archaeological investigations, military observation, and geomorphological surveying. Specialized photography using color infrared film has also been used to detect disease and insect damage in forest trees.

1.2.1. Fundamentals of Remote Sensing

Remote sensing is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information. In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is illustrated by the use of imaging systems in which the following seven elements are involved.

a. Energy Source or Illumination - The first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest to the object.

b. Radiation and the Atmosphere - The second requirement for remote sensing is the energy travels from its source to the target which will come in contact and interact with the atmosphere it passes through earth. This interaction may take place at second time as the energy travels from the target to the sensor.

c. Interaction with the Target - Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

d. Recording of Energy by the Sensor - After the energy has been scattered or emitted from the target, it requires a sensor to collect and record the electromagnetic radiation.

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

f. Interpretation and Analysis - The processed image is interpreted, visually or digitally or electronically to extract information about the target which is illuminated.

g. Application - The final element of the remote sensing process is achieved when we apply the information which able to extract from the imagery about the target in order to better understanding and reveal some new information or assistance in solving a particular problem.

1.3. Effects of Atmosphere and Statistics Dispensation

The remote sensing satellites are equipped with sensors looking down to the earth. The eyes in the sky are constantly observing the earth as they go round in predictable orbits. In satellite remote sensing of the earth, the sensors are looking through a layer of atmosphere separating the sensors from the earth's surface being observed. Hence, it is essential to understand the effects of atmosphere on the electromagnetic radiation travelling from the earth to the sensor through the atmosphere. The atmospheric constituents cause wavelength dependent absorption and scattering of radiation. These effects degrade the quality of images. Some of the atmospheric effects can be corrected before the images are subjected to further analysis and interpretation. A consequence of atmospheric absorption is that certain wavelength bands in the electromagnetic spectrum are strongly absorbed and effectively blocked by the atmosphere.

The wavelength regions in the electromagnetic spectrum usable for remote sensing are determined by their ability to penetrate atmosphere. These regions are known as the atmospheric transmission windows. Remote sensing systems are often designed to operate within one or more of the atmospheric windows. Although the atmosphere is practically transparent to x-rays and gamma rays, these radiations are not normally used in remote sensing of the earth. Generally, remote sensing works on the principle of the inverse problem. The frequency of the emission may then be related to the temperature in that region via various thermodynamic relations.

1.4. Types of Remote Sensing Descriptions

The sun provides a very convenient source of energy for remote sensing. The sun's energy is either reflected or absorbed and then re-emitted (for thermal infrared wavelength). Remote sensing systems which measure this natural available energy are called passive sensors. This can only take place when the sun is illuminating the earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted can be detected day and night provided that the amount of energy is large enough to be recorded.

Remote sensing systems which provide their own source of energy for illumination are known as active sensors. These sensors have the advantage of obtaining data at any time of day or season. Solar energy and radiant heat are examples of passive energy sources. Synthetic Aperture Radar (SAR) is an example of active sensor.

1.4.1. Remote Sensing Images

Remote sensing images are normally in the form of digital images, in order to extract useful information from the images. Image processing techniques may be employed to enhance the image, to help visual interpretation and to correct or restore the image. There are many image analysis techniques available on the requirements of the specific problem concerned. In many cases, image feature selection and classification algorithms are used to define different areas in an image into thematic map classes. This thematic map can be combined with other databases of the test area for further analysis and utilization.

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to incite observation. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on earth by means of propagated signals (e.g. electromagnetic radiation). It may be split into active remote sensing, when a signal is first emitted from aircraft or satellites or passive (e.g. sunlight) when information is merely recorded.

1.4.2. Optical and Infrared Remote Sensing Images

The optical remote sensing devices operate in the visible, near infrared, middle infrared and short wave infrared portion of the electromagnetic spectrum. These devices are sensitive to the wavelengths ranging from 300 nm to 3000 nm. In Optical Remote Sensing, optical sensors detect solar radiation reflected or scattered from the earth and forming images resembling photographs taken by a camera high up in space. The wavelength region usually extends from the visible and near infrared (VNIR) to the short wave infrared (SWIR).

Different materials such as water, soil, vegetation, buildings, forests, oceans and roads reflect visible and infrared light in different ways. They have different colours and brightness when seen under the sun. The interpretation of optical images require the knowledge of the spectral reflectance signatures of the various materials covering the surface of the earth.

1.4.3. Thermal Remote Sensing Images

The thermal sensors, which operate in the range of electromagnetic spectrum record and the energy emitted from the earth features in the wavelength range of 3000 nm to 5000 nm and 8000 nm to 14000 nm. Hence thermal remote sensing is very useful for fire detection and thermal pollution.

1.4.4. Microwave Remote Sensing Images

A microwave remote sensor records the back scattered microwaves in the wavelength range of 1 mm to 1 m of electromagnetic spectrum. Most of the microwave sensors are active sensors having their own sources of energy like a RADARSAT. These sensors which have edge over type of sensors are independent of weather and solar radiations.

Some remote sensing satellites which carry passive or active microwave sensors. The active sensors emit pulses of microwave radiation to illuminate the areas to be imaged. Images of the earth surface are formed by measuring the microwave energy scattered by the ground or sea back to the sensors. These satellites carry their own flashlight emitting microwaves to illuminate their targets. The images can thus be acquired day and night. Microwaves which have an additional advantage can be acquired to penetrate clouds covering the earth surface.

A microwave imaging system which can produce high resolution image of the earth is the SAR. The intensity in a SAR image depends on the amount of microwave back scattered by the target and received by the SAR antenna.

Microwave sensing encompasses both active and passive forms of remote sensing. Passive microwave sensing is similar in concept to thermal remote sensing. All objects emit microwave energy of some magnitude but the amounts are generally very small. A passive microwave sensor detects naturally emitted microwave energy within its field of view. This emitted energy is related to temperature and moisture properties of the emitting object or surface. Passive microwave sensors are typically radiometers or scanners and operate in much the same manner as optical systems except that an antenna is used to detect and record the microwave energy.

Active microwave sensors provide their own source of microwave radiation to illuminate the target. 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 (RAdio Detection And Ranging), which essentially characterizes the function and operation of a radar sensor. The sensor transmits a microwave signal towards the target and detects backscattered portion of the signal. The strength of the back scattered signal is measured to discriminate between different targets and the time delay between the transmitted and reflected signals determines the distance to the target.

Non-imaging microwave sensors include altimeters and scatterometers. In most cases these are profiling devices which take measurements in one linear dimension as opposed to the two-dimensional representation of imaging sensors. Radar altimeters transmit short microwave pulses and measure the round trip time delay to targets to determine their distance from the sensor. Radar altimetry is used on aircraft for altitude determination and on aircraft and satellites for topographic mapping and sea surface height estimation. Scatterometers are also generally non-imaging sensors and are used to make precise quantitative measurements of the amount of energy back scattered from targets. The amount of energy back scattered is dependent on the surface properties and the angle at which the microwave energy strikes the target. Scatterometry measurements over ocean surfaces can be used to estimate wind speeds based on the sea surface roughness. Ground-based scatterometers are used extensively to measure accurately the backscatter from various targets in order to characterize different materials and surface types.

1.5. Stages in Remote Sensing Metaphors

The process of remote sensing involves a number of practices starting from energy emission from source to data analysis and information extraction. The stages of remote sensing are described in the following steps:

1.5.1. Source of Energy

The source of energy (electromagnetic radiations) is a prerequisite for the process of remote sensing. The energy sources may be indirect (sun) or direct (radar). The indirect sources vary with time and location, while we have control over direct sources. These sources emit electromagnetic radiations (EMRs) in the wavelength regions, which can be sensed by the sensors.

1.5.2. Interaction of EMR with the Atmosphere

The EMR interacts with the atmosphere while traveling from the source to earth features and from earth features to the sensor. During this whole path the EMR changes its properties due to loss of energy and alteration in wavelength, which ultimately affects the sensing of the EMR by the sensor. This interaction often leads to atmospheric noise.

1.5.3. EMR Interaction with Earth Features

The event EMR on the earth features interacts in various ways. It gets reflected, absorbed, transmitted and emitted by the features and ground objects. The amount of EMR reflected, absorbed, transmitted and emitted depends upon the properties of the material in contact and EMR itself.

1.5.4. Detection of EMR by the Remote Sensing Sensor

The remote sensing device records the EMR coming to the sensor after its interaction with the earth features. The kind of EMR which can be sensed by the device depends upon the amount of EMR and sensor’s capabilities.

1.5.5. Data Transmission and Processing

The EMR recorded by the remote sensing device is transmitted to earth receiving and data processing stations. Here the EMR are transformed into interpretable output either digital or analogue images.

1.5.6. Image Processing and Analysis

The digital satellite images are processed using specialized software meant for satellite image processing. The image processing and further analysis of satellite data leads to information extraction or selection, which is required by the end users.

1.5.7. Application

The extracted or selected information is utilized to make decisions for solving particular problem. Thus remote sensing is a multi-disciplinary science, which includes a combination of various disciplines such as optics, photography, computer, electronics, telecommunication and satellite-launching, etc.

1.6. Practices of Remote Sensing Imagery Data

1. Conventional radar is mostly associated with aerial traffic control, early warning, and certain large scale meteorological data. Doppler radar is used by local law enforcements monitoring of speed limits and in enhanced meteorological collection such as wind speed and direction within weather systems in addition to snow location and intensity.
2. Laser and radar altimeters on satellites have provided a wide range of data. By measuring the height and wavelength of ocean waves, the altimeters measure wind speed and direction and surface ocean streams and directions.
3. Light detection and ranging (LIDAR) is well known example of weapon ranging, laser illuminated homing of projectile. LIDAR is used to detect and measure the concentration of various chemicals in the atmosphere. Vegetation remote sensing is a principal application of LIDAR.
4. Radiometers and photometers are the most common instrument to collect reflected and emitted radiation in a wide range of frequencies. The most common are visible and infrared sensors followed by

microwave, gamma ray and rarely use ultraviolet. They may also be used to detect the emission spectra of various chemicals, providing data on chemical concentrations in the atmosphere.

5. Stereographic pairs of aerial photographs have often been used to make topographic maps by imagery and terrain analysts in traffic ability and highway departments for potential routes.
6. Simultaneous multi-spectral platforms such as Landsat and thematic mappers take images in multiple wavelengths of electro-magnetic radiation (multi-spectral) and are usually found on earth observation satellites including the Landsat program or the IKONOS satellite. Maps of land cover and land use from thematic mapping can be used to prospect for minerals, detect or monitor land usage, deforestation and crops including entire farming regions or forests. Landsat images are used by regulatory agencies such as to indicate water quality parameters. Weather satellites are used in meteorology and climatology.
7. Hyper spectral imaging produces an image where each pixel has full spectral information with imaging narrow spectral bands over a continuous spectral range. Hyper spectral images are used in various applications including mineralogy, biology, defence and environmental measurements.
8. Within the scope, the remote sensing allows to follow up and monitor risk areas in the long term to determine desertification factors and also to support relevant measures of environmental management, and to assess their impacts.

1.7. Excellence Features of Remote Sensing Data

The quality of remote sensing data consists of its spatial, spectral, radiometric and temporal resolutions.

1.7.1. Spatial Resolution

The size of a pixel is recorded in a raster image. Typically pixels may correspond to square areas ranging in size length from 1 to 1,000 meters. The detail evident in an image is dependent on the spatial resolution of the sensor and refers to the size of the smallest possible feature that can be detected. Spatial resolution of passive sensors depends primarily on their Instantaneous Field of View (IFOV)**.** The IFOV has three features such as the angular cone of visibility of the sensor which determines the area on the earth's surface and the distance from the ground to the sensor. This area on the ground is called the resolution cell and determines a sensor's maximum spatial resolution. For a homogeneous feature to be detected, its size generally has to be equal to or larger than the resolution cell. If the feature is smaller than this, it may not be detectable as the average brightness of all features in that resolution cell will be recorded. However, smaller features may sometimes be detectable if their reflectance dominates within a particular resolution cell allowing sub pixel or resolution cell detection.

Most remote sensing images are composed of a matrix of picture elements or pixels, which are the smallest units of an image. Image pixels are normally square and represent a certain area of an image. It is important to distinguish between pixel size and spatial resolution. If a sensor has a spatial resolution of 20 metres and an image from that sensor is displayed at full resolution, each pixel represents an area of 20m x 20m on the ground. In this case the pixel size and resolution are the same. Remote sensing images in which large features are visible are said to have coarse or low resolution. Military sensors for example are designed to view detail as much as possible and therefore have very fine resolution.

1.7.2. Spectral Resolution

The wavelength width of the different frequency bands usually recorded by the platform. Current Landsat collection of seven bands, including several in the infrared spectrum is ranging from a spectral resolution of 0.07 to 2.1 μm. The Hyperion sensor on earth observing one resolves 220 bands from 0.4 to 2.5 μm, with a spectral resolution of 0.10 to 0.11 μm per band.

Different classes of features and details in an image can often be distinguished by comparing their responses over distinct wavelength ranges. Broad classes such as water and vegetation can usually be separated using very broad wavelength ranges such as visible and near infrared. Other more specific classes such as different rock types may not be easily distinguishable because their wavelength ranges are broad and much finer. Spectral resolution describes the ability of a sensor to define fine wavelength intervals.

Black and white film records wavelengths extending over much or all of the visible portion of the electromagnetic spectrum. Its spectral resolution is fairly coarse as the various wavelengths of the visible spectrum are not individually distinguished and the overall reflectance in the entire visible portion is recorded. Colour film is also sensitive to the reflected energy over the visible portion of the spectrum but its higher spectral resolution is individually sensitive to the reflected energy at the blue, green and red wavelengths of the spectrum.

1.7.3. Radiometric Resolution

The number of different intensities of radiation of the sensor is able to distinguish. Typically, this ranges from 8 to 14 bits corresponding to 256 levels of the gray scale and up to 16,384 intensities of colour in each band. It also depends on the instrument noise. Every time an image is acquired on film or by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive is to detecting small differences in reflected or emitted energy.

Image data are represented by positive digital numbers which vary from 0 to (one less than) a selected power of 2. This range corresponds to the number of bits used for coding numbers in binary format. Thus, if the radiometric resolution would be much less than image data are generally displayed in a range of gray tones with black representing a digital number of 0 and white representing the maximum value 1.

1.7.4. Temporal Resolution

The frequency of flyovers by the satellite or plane and is only relevant in time series or mosaic image as in deforesting monitoring. Most remote sensing systems expect to extrapolate sensor data in relation to a reference point including distances between known points on the ground. For example, in conventional photographs, distances are accurate in the center of the image with the distortion of measurements increasing the beyond to get from the center. In addition, images may need to be radiometrically and atmospherically corrected. Thus, the actual temporal resolution of a sensor depends on a variety of factors including the satellite/sensor capabilities, the swath overlap and latitude.

1.7.5. Radiometric Correction

Radiometric correction is to avoid radiometric errors or distortions while geometric correction is to remove geometric distortion. Radiometric correction of remotely sensed data normally involves the processing of digital images to improve the fidelity of the brightness value magnitudes. Therefore, in order to obtain the real irradiance or reflectance, those radiometric distortions must be corrected. Radiometric correction is classified into the following three types.

1. Radiometric Correction of Effects due to Sensor Sensitivity.
2. Radiometric Correction for Sun Angle and Topography.
3. Atmospheric Correction.

Major regions of the electromagnetic spectrum remote sensing uses photographic cameras to record information which is shown in the Table 1.1.

Region Name	Wavelength	Comments
Gamma Ray	< 0.03 Nms	Entirely absorbed by the Earth's atmosphere
X-ray	0.03 to 30 Nms	Entirely absorbed by the Earth's atmosphere
Ultraviolet	0.03 to 0.4 Mms	Entirely absorbed by **ozone** in the Earth's atmosphere.
Photographic Ultraviolet	0.3 to 0.4 Mms	Available for remote sensing the Earth. Can be imaged with photographic film.
Visible	0.4 to 0.7 Mms	Available for remote sensing the Earth. Can be imaged with photographic film.
Infrared	0.7 to 100 Mms	Available for remote sensing the Earth. Can be imaged with photographic film.
Reflected Infrared	0.7 to 3.0 Mms	Available for remote sensing the Earth. Can be imaged with photographic film.
Thermal Infrared	3.0 to 14 Mms	Available for remote sensing the Earth. This wavelength cannot be captured with photographic film
Microwave or Radar	0.1 to 100 Cms	Longer wavelengths of this band can pass through clouds, fog and rain.
Radio	> 100 Cms	Not normally used for remote sensing the Earth.

Table 1.1. Major Regions of the Electromagnetic Spectrum

1.8. Principles of Object Identification of Remote Sensing

Most people have no problem for identifying objects from photographs taken from an oblique angle. Such views are natural to the human eye and are part of our everyday experience. However, most remotely sensed images are taken from an overhead or vertical perspective and from distances quite removed from ground level. Both of these circumstances make the interpretation of natural and human-made objects somewhat difficult. To overcome the potential difficulties involved in image recognition, professional image interpreters use a number of characteristics to help them identify remotely sensed objects. Some of these characteristics include:

a. Shape - This characteristic may serve to identify many objects. Examples include the long linear lines of highways, the intersecting runways of an airfield, the perfectly rectangular shape of buildings, or the recognizable shape of an outdoor baseball ground.

b. Size - Noting the relative and absolute sizes of objects is important in their identification. The scale of the image determines the absolute size of an object. As a result, it is very important to recognize the scale of the image to be analyzed.

c. Image Tone or Color - All objects reflect or emit specific signatures of electromagnetic radiation. And also the types of recording device and recording media produce images that are reflective of their sensitivity to particular range of radiation.

d. Pattern - Many objects arrange themselves in typical patterns. This is especially true of human made phenomena. For example, orchards have a systematic arrangement imposed by a farmer while natural vegetation usually has a random or confused pattern.

e. Shadow - Shadows can sometimes be used to get a different view of an object. For example, a radio transmission tower normally presents an identification problem. This difficulty can be overcome by photographing these objects at Sun angles that cast shadows. These shadows then display the shape of the object on the ground.

f. Texture - Imaged objects display some degree of coarseness or smoothness. This characteristic can sometimes be useful in object interpretation. Texture just like object size is directly related to the scale of the image.

1.9. Characteristics of Remote Sensing Images

We need to define the characteristics of a few fundamental terms and concepts associated with remote sensing images. Electromagnetic energy may be detected either photographically or electronically. The photographic process uses chemical reactions on the surface of light-sensitive film to detect and record energy variations. It is important to distinguish between the terms images and photographs in remote sensing. An image refers to any pictorial representation, regardless of what wavelengths or remote sensing device has been used to detect and record the electromagnetic energy. A photograph refers specifically to images that have been detected as well as recorded on photographic film. The black and white photos are normally recorded over the wavelength range from 0.3 µm to 0.9 µm - the visible and reflected infrared. Based on these definitions, we can say that all photographs are images, but not all images are photographs.

A photograph could also be represented and displayed in a digital format by subdividing the image into small equal sized and shaped areas are called picture elements or pixels and representing the brightness of each area with a numeric value or digital number. The photograph was scanned and subdivided into pixels and each pixel assigned a digital number representing its relative brightness. The computer displays each digital value as different brightness levels. Sensors that record electromagnetic energy as an array of numbers in digital format. The two different ways of representing and displaying remote sensing data are either pictorially or digitally.

We can combine and display channels of information digitally using the three primary colours (blue, green and red). The data from each channel is represented as one of the primary colours and depending on the relative brightness of each pixel in each channel. The primary colours combine in different proportions to represent different colours. Because the brightness level of each pixel is the same for each primary colour, they combine to form a black and white image, showing various shades of gray from black to white. When we display more than one channel each as a different primary colour, then the brightness levels may be different for each channel/primary colour combination and they will combine to form a colour image.

1.10. Geometric Distortion in Remote Sensing Image

Any remote sensing image is acquired by a multispectral scanner on board a satellite, a photographic system in an aircraft, or any other platform/sensor combination and will have various geometric distortions. This problem is inherent in remote sensing, as we attempt accurately to represent the three-dimensional surface of the earth as a two-dimensional image. All remote sensing images are subject to some form of geometric distortions depending on the manner in which the data's are acquired. These errors may be due to a variety of factors including one or more of the following:

1. The perspective of the sensor optics.
2. The motion of the scanning system.
3. The motion and stability of the platform.
4. The platform altitude, attitude and velocity.
5. The terrain relief and the curvature and rotation of the earth.

The primary geometric distortion in vertical aerial photography is due to relief displacement. The geometric variations between lines are caused by random variations in platform altitude and attitude along the direction of flight.

Images from across track scanning systems exhibit two main types of geometric distortion. First type is relief displacement similar to aerial photographs, but in only one direction parallel to the direction of scan. There is no displacement directly below the sensor at base. Another type of distortion occurs due to the rotation of the scanning optics. As the sensor scans across each line, the distance from the sensor to the ground increases further away from the centre of the binding. This effect results in the compression of image features at points away from the base and is called tangential scale distortion.

All images are susceptible to geometric distortions caused by variations in platform stability including changes in their speed, altitude and attitude during data acquisition. The resultant imagery is thus slanted across the image. This is known as skew distortion and is common in imagery obtained from satellite multi spectral scanners. The sources of geometric distortion and positional error vary with each specific situation, but are inherent in remote sensing image.

1.11. Processing of Remote Sensing Images

Digital image processing may involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation or even automated classification of targets and features entirely by computer. Several commercially available software systems have been developed specifically for remote sensing image processing and analysis. The most of the common image processing functions available in remote sensing systems can be categorized into the following four categories:

1. Preprocessing functions required prior to the main data analysis and extraction of information and are generally grouped as radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise and converting the data. Geometric corrections include correcting for geometric distortions due to sensor such as earth geometry variations and conversion of the data to real world coordinates.

2. Image enhancement is solely to improve the appearance of the images to assist in visual interpretation and analysis. Examples of enhancement functions include contrast stretching to increase the tonal distinction between various features in a scene and spatial filtering to enhance a specific spatial patterns in an remote sensing image.

3. Image transformations are operations similar to the concept for image enhancement. However, unlike image enhancement operations which are normally applied only to a single channel of data at a time, image transformations usually involve combined processing of data from multiple spectral bands. Arithmetic operations are performed to combine and transform the original bands into new images which better display or highlight certain features in the scene.

4. Image classification and analysis operations are used to identify and classify pixels digitally in the data. Classification is usually performed on multi-channel data sets and this process assigns each pixel in an image to a particular class or theme based on statistical characteristics of the pixel brightness values. There are a variety of generic approaches taken to perform digital classification, namely supervised and unsupervised classification.

1.12. Applications of Remote Sensing

Remote sensing has enabled mapping, studying, monitoring and management of various resources like agriculture, forestry, geology, water, ocean, etc. It has further enabled monitoring of environment and thereby helping in conservation. India has its own satellites like Indian Remote Sensing Satellite (IRS) series, which provide required data for carrying out various projects. Some of the important projects carried out in the country include ground water prospects mapping under drinking water mission, Forecasting Agricultural output using Space, Agro meteorology and Land based observations (FASAL), Forest Cover, Type Mapping, Grassland Mapping, Biodiversity Characterization, Snow and Glacier Studies, Land Use, Cover mapping, Coastal Studies, Coral and Mangroves Studies, Wasteland Mapping, etc. The information generated by large number of projects have been used by various departments, industries and others for different purposes like Groundwater Prospects and Recharge Zone Mapping, National Wastelands Monitoring, National Wetlands Inventory and Assessment, Snow and Glaciers Studies, Coastal Zone Studies, Forecasting Agricultural output using Space, Agro meteorology and Land based observations (FASAL), Assessment of Irrigation Potential under Accelerated Irrigation Benefit Program (AIBP), National Agricultural Drought Assessment and Monitoring System, Biodiversity Characterization, National Urban Information System (NUIS), Indian Forest Fire Response and Assessment System (INFFRAS), Water Resources Information System (WRIS), Space Based Information System for Decentralized Planning

(SISDP), Natural Resources Census, Flood Mapping and Monitoring, Watershed Monitoring and Development and Potential Fishery Zone (PFZ) Forecasting.

1.13. Motivation

Remote sensing research focusing on image classification has long attracted the attention of the remote sensing community because classification results are the basis for many environmental and socio economic applications. Classification is devoted to contributions on the design, construction, testing and performance of subsystems, with emphasis on technological aspects and methods. Special attention is due to technological developments that allow to improve accelerators from the point of view of performance, size or cost effectiveness.

Currently, there are many different algorithms available for image classification. Each has its own merit and demerit factors. In this study, different remote sensing image classification algorithms with their prospects are reviewed. The proposed method is implemented in MATLAB 7.6 version and verified using various kinds of high resolution satellite images.

1.14. Objectives

This research provides a comprehensive coverage of recently developed algorithms for learning powerful features and showcase their superior performance on a number of challenging remote sensing image classification benchmarks. The technology of remote sensing offers a practical and economical means to study the classification process reliably extracts only the parts that need to be analyzed. Remote sensing classification has two general goals. The first goal is to decompose the image into different parts for further analysis. The second goal of classification is to perform a change of representation by applying different methods. The goals are to evaluate the base method by systematic variations and extensions. The main objectives of the study area are as follows:

- ☆ Remote sensing image classification carry out quantitative interpretation using mathematical and statistical modeling.

- ☆ To classify different groups with homogeneous characteristics with the aim of discriminating multiple objects from each other within the remote sensing image.
- ☆ Classification will be executed on the basis of spectrally defined feature space in remote sensing image.
- ☆ The classification divides the feature space into several classes based on a decision rule.
- ☆ Image classes are such as Land use, Land Cover, Crop Type, Forest Types, etc.
- ☆ To identify different level of classification schemes to be applied in remote sensing images
- ☆ Level of classification depends on the spatial, spectral, temporal and radiometric resolution of the image data.
- ☆ To use histograms, statistics, profiles and separability to evaluate training data collected in a supervised mode for a classification.
- ☆ The classification is to simplify the environments, reduce the load on memory, helps to store and retrieve information and to generate a new knowledge.
- ☆ It makes the study of active remote sensing organisms convenient.
- ☆ It analyses the specific identification of any given remote sensing organism.
- ☆ To study a few representatives from each distinct group helps to integrate the idea of remote sensing images.
- ☆ It reveals the relationship features among various groups of organisms, which occur in specific geographical regions.
- ☆ It analyses information about the structure in different groups of organisms.

- ☆ Effective use of multiple features of remotely sensed data and the selection of a suitable classification method are especially significant for improving classification accuracy.
- ☆ Remote sensing image classification is to cluster pixels into salient image regions, corresponding to individual surfaces, objects, or natural parts of objects. The main points of interest in remote sensing image classifications are:
  - ☆ To examine the effect of extracting features at multiple scales.
  - ☆ To review alternate feature reduction techniques and assessment methods.
  - ☆ To inspect local and global feature probabilities.

1.15. Scope of the Study

The classification problem can be very difficult and might require application of a great deal of domain a building knowledge. All these remote image classification tasks are traditionally trusted on different shaped features to try to capture the essence of different visual patterns. Specifically, scope of this thesis focuses on the comparisons of popular remote sensing methods, commonly adopted image processing methods and prevailing classification accuracy assessments. The basic concepts available imagery sources and classification techniques of remote sensing imagery related to feature mapping are introduced, analyzed and compared. The advantages and limitations of using remote sensing imagery for different feature cover mapping are provided to iterate the importance of thorough understanding of the related concepts and careful design of the technical procedures, which can be utilized to study important feature cover from remote sensing images. The main scope of the remote sensing image classification techniques include thresholding methods, K-Means clustering, Fuzzy C-Means clustering, PCA, SVM and connected component labeling approaches.

Continuous emergence of new classification algorithms and techniques in recent years necessitates such a review, which will be highly valuable for guiding or selecting a suitable classification procedure for a specific study. The scope of the study providing a summarization of major advanced classification methods and techniques used for improving classification accuracy and discussing important issues affecting the success of image classifications. The inherent assumptions of different approaches make and constitute a good classification.

- ✰ Emphasize general mathematical tools that are promising.
- ✰ Metrics for evaluating the results.

1.16. Organization of the Thesis

The thesis is organized in nine chapters. It is mainly concerned with effective feature extraction and feature selection algorithms for remote sensing image classification and is arranged as follows:

Chapter 1 includes a brief introduction, overview and different hyper spectral sensors on remote sensing image classification. In addition, it introduces the background, scope and motivation.

In chapter 2, a brief outline of remote sensing image classification is described. It reviews the different steps of classification process, standard approaches, prediction and training procedures of remote sensing images. It also includes some challenging factors of remote sensing classification.

Chapter 3 proposes a relational color feature selection for the classification of remote sensing images using three different thresholding methods. The proposed methods are aimed at selecting a subset of the original feature that exhibits to discriminating the considered classes and variance in the spatial domain of the image. Thersholding method aimed at addressing three classification strategies such as dynamic global thresholding method, local thresholding method and Interactive adaptive thresholding method. These results are more promising with classification system and improved simplification properties with respect to standard classification methods.

Chapter 4 deals with the design, development and implementation of effective K-Means clustering method for performing remote sensing image classification. The algorithm developed to operate in decorrelation, luminosity and introduce the different cluster index and robust estimation into the different image clusters and nuclei's. The algorithm is used to provide good results and successfully applied on remote sensing image classification. It also aimed at addressing different error measurable factors and produce overall accuracy of the proposed K-Means clustering algorithms.

Chapter 5 deals with a fast and accurate PCA based classification of remote sensing image. This technique is very useful in reducing dimensionality of a dataset in order to obtain a simple dataset. The proposed algorithm is computationally efficient and has been tested for different remote sensing images, which contain a large number of natural objects.

Chapter 6 deals with an analysis on the use of fuzzy c-means clustering for remote sensing image classification. The experimental results show the different index level of clusters. It illustrates the classification results, separating into different sub classes or features. This algorithms also describes accuracy assessment factors and overall accuracy with respect to different levels of clusters.

Chapter 7 consists of an extensive and traditional review on the use of feature selection methods which handles training, performance and mapping of visual content and in particular of Support Vector Machine(SVM) in the classification of remote sensing image. This approach results in a more robust classification system with improved generalization properties like error measurable factors and overall accuracy with respect to the standard feature selection methods.

Connected Component Labeling (CCL) method in remote sensing image classification is discussed in chapter 8. It reviews some background for color feature selection and classification which are used by the proposed algorithms. This chapter also presents the pixel based techniques for the remote sensing applications. The experimental results and accuracy assessment policies of the classification obtained by the remote sensing image.

Comparative study and conclusion is given in chapter 9. It also deals with different accuracy assessment factors such as overall accuracy, computational efficiency and error matrix, etc. It also concludes the whole dissertation and sums up each chapter and suggest the future work and future developments of research activities.

1.17. Conclusion

Remote sensing is a technique to observe the earth surface or the atmosphere from out of space using satellites or from the air using aircrafts. Remote sensing uses a several parts of the electromagnetic spectrum. It records the electromagnetic energy reflected or emitted by the earth's surface. The amount of radiation from an object is influenced by both the properties of the object and the radiation hitting the object. Remotely sensed data is important to a broad range of image vision disciplines. This will continue to be the case and will likely to grow with the greater availability of data promised by an increasing number of operational systems. Radiation interaction characteristics of earth and atmosphere in different regions of electromagnetic spectrum are very useful for identifying and characterizing earth and atmospheric feature. This chapter follows with a brief historic overview of remote sensing and then explains the various stages and the basic principles of remotely sensed data collection mechanism.

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