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Study on Remote Sensing and their Spectral Characteristics

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Abstract—Remote Sensing is one of the most important application in the world. It is used for sensing the objects in the surface of the earth and land-cover mapping. They are used for land-use.It maintains a global coverage and is used for studying land-cover dynamics. The objects are being classified based on the Spectral characteristics. It is not only used for classifying the objects it is also used for identifying the quantity of water, type of soil, vegetation (as both yielding and non yielding crops), buildings, weather, level of atmosphere. There are numerous spaceborne and airborne sensors for collecting the petabyte of data continuously. The fully automated procedures are used for generating faster maps with high consistency. The input images are given as the Lansat images and the output produces the classified image. Spatial resolution influences the accuracy of the object.

Keywords-Remote Sensing; Spectral Characteristics; Lansat images; Spatial resolution.

1.INTRODUCTION

The information about the particular land area are defined through Remote Sensing. They are done by rapid monitoring of the land area. The classification of an image is based on the Temporal Correlation by Change detection methods. Every object has its own Spectral Characteristics. Remote Sensing images are based on Spectral band as they are represented in RGB channels. The mapping depends on particular purpose of the image.[1]

- *True color:* It uses only the RGB channels which are being mapped to respective colors. In this usually Plain color Photographs are used.
- *Green red infrared***:** It is used for representing the Vegetation areas.
- *Blue:* It is used for representing the Water Depth.

Remote Sensing is classified into 3 types based on the band as Multispectral, Super spectral, Hyper spectral.

1.1 Multispectral

Multispectral images provide a combination of various bands and combine them into a single system. Wavelengths are being separated through filters. It is mainly used for extracting the information which is not visible to the human eye. It uses only small number of bands as from (3-15) bands.

1.2Hyper spectral

Hyper spectral images process and collects the information through Electromagnetic spectrum. They uses more than 100 bands and are represented in three-dimensional format. In this the target pixel is represented in hyper spectral images. It measures Contiguous Spectral band which is being opponent to Multispectral images.

1.3Super spectral

Superspectral images use more than 30 bands. The word Super spectral means Sensors. It is used for acquiring images in many Wavelengths.

1.4 Electromagnetic energy

The continuous range of electromagnetic radiation is the Electromagnetic Spectrum which extends from the gamma rays to the radio rays which also includes visible light. They are divided into seven regions as Gamma rays, X-rays, Ultraviolet rays, visible light, microwave, infrared and radio waves. It usually interacts with the earth atmosphere and the earth surface. Every materials exhibit three types of properties while interacting with the light as partly transmission, partly reflection and partly absorption. The reflectance of light depends on the target light counters.(fig:1)The spectral reflectance pattern determines the reflected component over a particular range of wavelength. The measurement of energy in remote sensing is done by Electromagnetic Spectrum through spectral bands.[1]

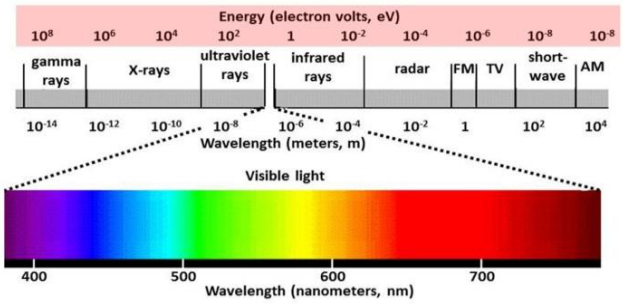

Fig 1: Electromagnetic Spectrum

1.5 Reflection and absorption

The radiation from the sun reaches the earth surface where some of the energy wavelengths are reflected and the rest wavelengths are reflected by the surface material. A detector is used for measuring the electromagnetic radiation and discern the type of soil, water, building and vegetation which have separate patterns of absorption and reflectance (fig:2) with different wavelength.[1]

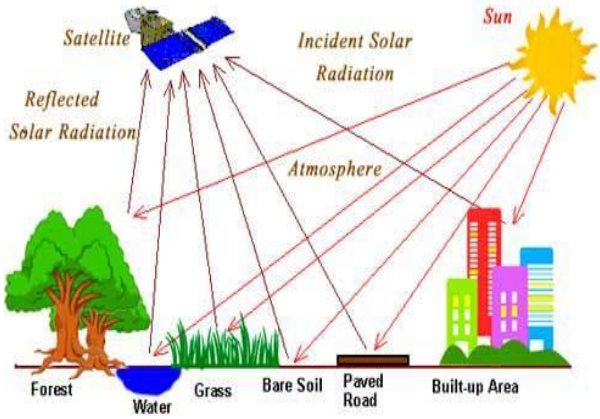

Fig 2: Reflection and Absorption

2. Space borne Sensors

The device that measures and records the electromagnetic energy is called as Sensor. At present more than 50 countries are operating remote sensing satellites. More than 1000 satellites are there in space.[2] There are two groups of Sensors as Active Sensor and Passive Sensor.(fig:3)

(1)Active Sensor:
Active Sensor have an own source of energy. These Sensor send out a signal and measures the reflectance.

(2)Passive Sensor:
Passive sensors are usually based on the external source of energy.

Remote sensing is an important mean for collecting the information about the spatial data. It usually measures the electromagnetic radiation by interacting with the land and atmosphere. The interaction provides the information about the target such as distance between the object and the sensor. The measurement is based on intensity, distance, wavelength and polarization of electromagnetic radiation.

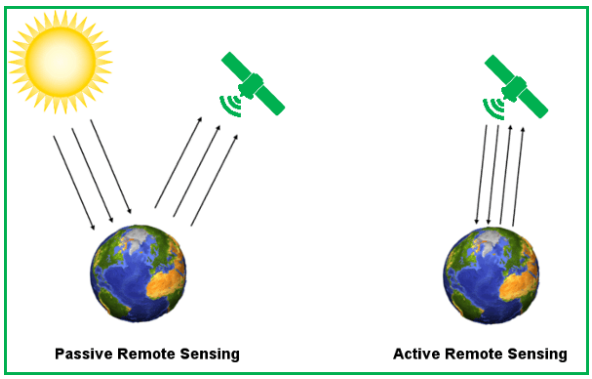

Fig 3: Sensor

The Space borne Sensors include various Spectral characteristics as Optical imaging Sensor, Thermal imaging Sensor, Radar imaging Sensor.(fig:4)

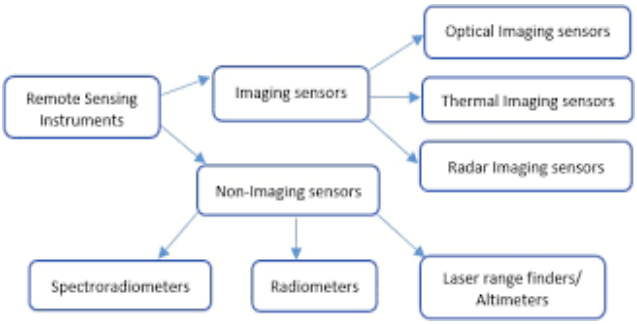

Fig 4: Remote sensing instruments

2.1 Optical imaging Sensor

Optical imaging Sensor functions in the Visible and reflective IR ranges. The Optical imaging system present in the space platform includes panchromatic system, Multispectral system and Hyper spectral system.

2.1.1 *Panchromatic system*:

It contains a detector sensor which is a Monospectral channel sensitive to Radiation across a particular broad Wavelength range. The image is usually black and white or grey-scale.

Application

(1)They are used for the purpose of observation and reconnaissance.

2.1.2 *Multispectral sensor*:

It contains a few spectral bands which act as a multichannel detector.

Application

(1)True color is used for visual analysis.

(2)Green-Red IR is used for the detection of vegetation and camouflage.

(3)Blue-NIR-MIR is used for the detection of deep water, soil moisture content, presence of the fire, deep vegetation.

2.1.3 *Hyper spectral sensors:*

It process and collects the information from 10 to 100 bands. It contains a set of images. Every narrow spectral band produces an image.

Application

(1)Used in agriculture, eye care, Food processing, astronomy and mineralogy.

Advantages

(1)They are highly applicable in imaging multiple targets.

(2)They provide linear feature acquisition like coastline, roads and pipelines.

(3)They are used as a mosaic strip to large areas.

Disadvantages

(1)They are affected by cloud coverage and the sun illumination.

(2)In polar areas, there is a seasonal changes in the sun illumination.

(3)The Equatorial belt faces cloud coverage.

2.2 Thermal IR imaging sensors

Thermal sensor functions in electromagnetic spectrum between mid-to-far-infrared and microwave range. If any object is found with an temperature above zero then they can emit infrared radiation produce an thermal image. They are used for tracking the movement of living creatures like animals and humans, detecting volcanoes, forest fires. Most frequently used thermal imaging sensors are Radiometer, Spectroradiometer, IR imaging camera.

2.2.1 *IR imaging radiometer*:

It measures the electromagnetic radiation intensity. They have UV mid-to-far-infrared or microwave as operational waveband and uses ASTER as the satellite sensor.

Application

(1)They are used in volcano logical, mineralogical and hydrothermal studies.

(2)They are also in forest fires, glacier, climatologically studies and DEM.

2.2.2 *Imaging Spectro radiometer*:

It uses infrared as operational wave band and measures the intensity of radiation as multiple spectrums. They uses MODIS, IRIS, ASAS as sensor satellites.

Application

(1)They are used to measure the temperature of the sea surface, cloud characteristics and ocean color and vegetation.

(2)They are also used in tracing chemical species in atmosphere.

2.2.3 *IR imaging camera:*

It measures the reflected energy from the earth surface by using mid-far-infrared as an operational wave band.

Application

(1)They are used for determining the intensity of thunderstorm.

(2)Identification of fog and low clouds.

2.3 Radar imaging sensor

Radar imaging sensor is an active sensor functioning in an electromagnetic spectrum. It transmits the light into the ground and some of the energy is reflected from the target into the radar antenna to produce an image in micro wavelength.[2] The microwave instrument can function in foggy or in cloudy weather conditions at the same time it can also predict sand, water and walls. Various types of Spectral bands in Table 1.

Band	Characteristics
Ka	Used for astronomical observation
K	Used for Purpose of satellite communication, automotive radar
Ku	Used for satellite communications
X	Used for Mapping and surveillance
C	Used for sea-ice surveillance
S	Used for meteorological applications
L	Identifies vegetation and vegetated areas
P	Used for research and experimental purposes

Table 1: Spectral bands for Radar imaging

2.4 Non-imaging sensor

A Non-imaging sensor is used for measuring the intensity of the particular field as a profiler recorder. In contrast, this sensor does not record the input across the fields. Some of the Non-imaging sensors are radiometer, altimeter, spectrometers and LIDAR. Laser scanning system is called as LIDAR system. There are different carrier platforms they are airborne LIDAR, mobile mapping LIDAR, satellite LIDAR. Lasers are used for measuring the height and distance of the object in the remote sensing their applications are explained in Table 2. It provides Objects shape, physical size which are based on spatial resolution and sampling. There are various types of lasers as solid-state laser, liquid laser, gas laser, semiconductor laser and chemical laser.[2]

Laser name	Application
UV laser	It is used for cutting and drilling
Violet laser	Used for data recording and laser microscopy
Blue laser	Used for environmental monitoring and telecommunications
Green laser	Used for bathymetric measurement
Red laser	Used for measuring the vegetation
NIR laser	Used for airborne laser scanning

Table 2: Types of lasers and their application

Application:

(1)They are used for measuring the height, wind speed, temperature and atmospheric parameters.

(2)They are used in military, telecommunication and weapons machining.

(3)Mostly they are used in the manufacturing of medical instruments.

3. SPECTRAL SIGNATURE

Spectral signatures are used for the classification of an image for land-use and land-cover mappings. The reflected spectra from different materials are defined as Spectral signatures. They are used to determine the materials in the surface. Spectral signatures are recorded using the Spectroradiometer which are extracted from airborne or spaceborne data on the ground. These classes are usually a group of pixels with specific spectral characteristics. Raw images with their digital numbers are being given and they are converted into surface reflectance with respective to the image classification.[5] With their respective spectral classes it represents the materials present in the ground which are similar to the time of image acquisition. Land-cover usually

covers the certain portion of ground, whereas the Land-use gives the mapping of socio-economic use. It is very difficult to obtain the Land-cover area based on their spectral characteristics.[3]

The values of the spectral signatures are stored in the Spectral library. There are various indices for calculating the Land-cover vegetation, water, soil, and building with their respective indices. Every satellite cotains different formulas for obtaining the indices values based on their band. For example, the vegetation, soil, water and building indices for Lansat-8 is given as,

3.1 Vegetative indices

In this Normalized Differentiate Vegetation Index (NDVI), is used for representing the respective biomass of the land area. It is an standard vegetative index. In this the Chlorophyll absorption is represented by the Red band and the vegetation of high reflectance is represented by Near Infrared as NIR band by combining these both the particular NDVI is classified.Eq.(1)

$$\mathbf{NDVI = (NIR\text{-}RED) \div (NIR+RED)} \quad \mathbf{(1)}$$

It takes ratio of two bands and places the value between -1 to +1. Positive value of the NDVI represents the greeny vegetation.(fig:5)

FIG 5: Land classified as Vegetation area

3.2 Soil indices

In this Soil Adjusted Vegetation Index (SAVI), is used for representing the backgroud of soil conditions. It is a hybrid between NDVI and PVI (Perpendicular Vegetation Index). Here, L is represented as soil brightness. If the area is with high vegetation it is taken as L=0; and if it is with low or no vegetation the L=1. Eq.(2)They uses NIR as band 5 and RED as band 4 by combining these two bands they provide the SAVI value.(fig:6)

$$\mathbf{SAVI = [(NIR\text{-}RED) \div (NIR + RED)] \times 2} \quad (2)$$

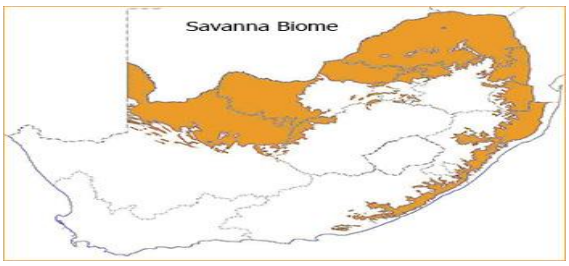

Fig 6: Land classified as Soil area

3.3 Water indices

In this Normalized Differential Water Index (NDWI), is used for representing the water bodies. It uses two bands as band 3 as Green and band 5 as NIR for presenting the water areas.Eq.(3)

$$\mathbf{NDWI = (GREEN\text{-}NIR) \div (GREEN+NIR)} \quad (3)$$

For the extraction of water bodies, multi band threshold methods are widely used. They extract the water bodies based on their respective band.

NDWI is used for improving the accuracy for extracting the water bodies, this is done by suppressing the non water body information.

The Modified Normalized Differential Water Index (MNDWI) method was implemented to improve the water body results in urban areas. MNDWI is also used for extracting water body results in mountainous areas which provide the accurate results. [4]

NDWI improves the water body signals by considering the reflectance of the wavelength and therefore by removing a portion of noise from the different wavelength. If the wavelength has been increased then the water region is found with low reflectance.

NDWI is used for differentiating the water bodies from vegetation.

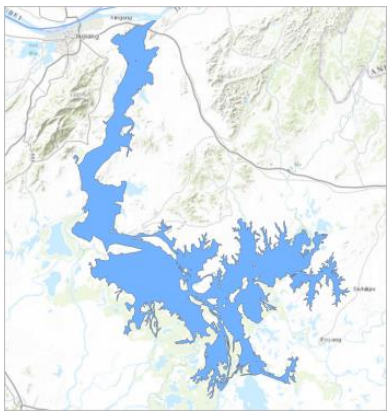

FIG 7: Land classified as water bodies

3.4 Building indices

In this Normalized Differential Buildup Index (NDBI), is used for describing the building areas. Eq.(4)They uses two bands as MIR and NIR bands for representing the building areas.(fig: 8)

$$NDBI = (MIR-NIR) \div (MIR+NIR) \quad (4)$$

Fig 8: Land classified as building area

4. CONCLUSION

Finally by using these Spectral signatures the images are being classified into separate classes as vegetation, water, soil and building. Based on their wavelength range they are determined into a classified image. The limitation found in them is in some of the images the ground truth are important to get classifying them.

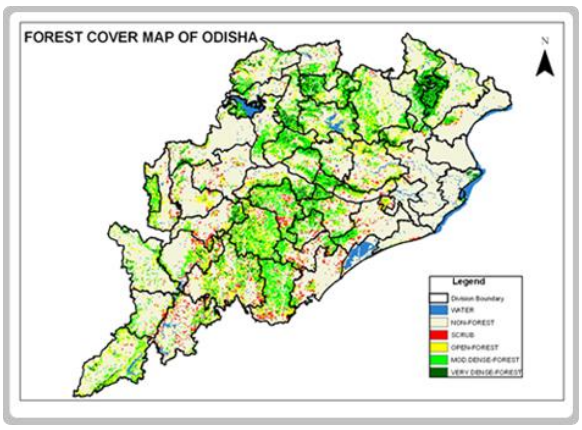

Fig 9: Land classified with all indices values

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[3] Author: Dr. Abdul rahman K. Book: "AlIAUTOMATIC CLASS LABELING OF CLASSIFIED IMAGERY USING A HYPERSPECTRAL LIBRARY ILIA PARSHAKOV" Bachelor of Science, University of Lethbridge, Canada.