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A Short Investigation on Effective Spectral Properties of Multispectral and Hyper Spectral Images for Object Detection

Jenice Aroma R, Syed Ali Fathima S. J, Raniya Harini R

Abstract- The Satellite based imaging system which is based on a network of artificial satellites is more efficient for remote monitoring of our ecosystem. It provides geospatial positioning and high precision information regarding the local time which can be used in global positioning, air and sea traffic and so on. Effective monitoring of our ecosystem has been achieved through remote sensing which extracts even fine spatial details of the earth, thus producing an image with good resolution for better clarity to be analyzed. This paper discusses about two different variants of satellite imaging on spatial objects which varies with the spatial significance. These satellite imaging instruments are primarily stresses on the pixel count for ejecting an accurate and more specific image. Increase in spatial resolution produces an accurate and precise overview about the chosen spatial entity thereby supporting the data collection technology and offers effective data interpretation. This can bring out better discrimination among the various resolution strategies and their relevance to a specific need.

Keywords: air and sea traffic and so on.

I. INTRODUCTION

Remote sensing is the methodology of extracting the details about an object by observing the electromagnetic radiations emitted by them through the use of sensors. These radiations are emitted from transmitters and the reflected electromagnetic radiations are recorded by the receivers at the ground stations and which are finally recorded as digitized satellite images [1]. The accuracy of the image directly depends on the spatial and spectral resolution rather than the pixel count. A large number of remote sensors had been launched to study the Earth's atmosphere, land cover, vegetation, oceans and also to monitor the weather since the launch of the first remote sensing weather satellite in 1960 (TIROS-1) and the first earth resources satellite (LANDSAT) in 1972 [2,38]. These advancements in image resolution comes from data capture technology enabled through spatial, spectral or radiometric resolution imaging. These different sources may produce a wide range of imagery with various levels of accuracy. The spatial resolution is termed as the surface area that is covered within a pixel of an image like how a photographic image is visible to a human eye in details [3].

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***Correspondence Author(s)**
Jenice Aroma R, Assistant Professor Sri Krishna College of Technology Coimbatore, India.
Syed Ali Fathima S.J, Assistant Professor, Kumaraguru College of Technology Coimbatore, India.
Raniya Harini R UG Scholar Sri Krishna College of Technology Coimbatore, India.

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The remote sensing modes are of two types-active and passive remote sensing modes as shown in Fig.1 and 2. Active remote sensing uses artificial sensors for the propagation of signals whereas in passive mode it avails the illumination of the sun[4]. The passive sensing mode is limited as the radiations emitted at night is too less due to the less exposure of sunlight. Hence tracking of objects during night time becomes quite difficult. Active sensors are thus advantageous s they can record the captured images all through the day and can also function under climatic and seasonal variations. Hence active sensing mode is found to be the best method for recording images.

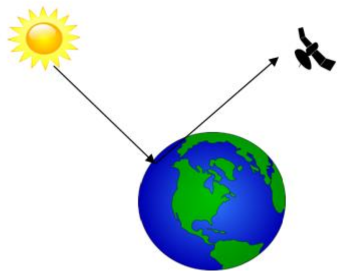

Fig.1 Passive remote sensing

Fig.2 Active remote sensing

The main focus is on spatial resolution which brings out the smallest discernible information about the object by the sensor's instantaneous field of view (IFOV). Depending on this pixel resolution the data contents are stored. The current developing technologies have been producing considerably good spatial resolution imagery with each objects holding a specific number of pixels. These objects when placed closer to each other may collide appearing as a single image. In order to enforce anti-collision mechanism special types of sensors have been used. These sensors imbibe the signals and accumulates it in the raster. Each cells in these raster's constitute a pixel. More the pixels, higher is the level of information collected [5]. The received signals are quantified into various phases each with a different band.

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The clarity changes proportionally with the change in levels. Hence the components are resolved into subparts producing meticulous images. The images were trapped into the various raster cell compartments each having its own level of explicit outlook. There is a special type of sensor RFID sensor which is based on Tag Communications Slot which provides unique tags contributing towards anti-collision [6].

The altitude of the satellite can determine the clarity and accuracy of an image. A minimum of 4 satellites is required to determine the location precisely. More the number of satellites, more the accuracy in positioning. The satellites can effectively broadcast the codes that contain the time signals. These signals contain data that are used by the receivers to compute the time and they make some adjustments for accurate positioning [7]. Thus the electronic receivers calculate the range and the time difference between signal reception time and the broadcast time. The distance ambiguity is removed by the 4th satellite [8]. Remote sensing finds its application in weather forecasting, hydrological modelling and various other land cover usages (Assefa M. Mellesse et al. 2007)[9].

Satellite imaging may be grouped into multispectral and hyperspectral images on the basis of the number of spectral bands and various other characterization.

II. MULTISPECTRAL IMAGING

Multispectral imaging is the methodology of capturing the images at a particular frequency from the electromagnetic spectrum reflected by the object. The discrete segment of the electromagnetic spectrum which is described by the interval size of the wavelength constitutes its characteristic. The altitude of the satellite's orbit is a main factor for the resolution accuracy. Each spectrum comes out with different wavelengths which is captured by the filters having instruments each with different properties.

The Multispectral imagery consists of about 3 to 4 wider bands where each band is generated by a remote sensing radiometer. This technique is more suited than panchromatic data which has only a single band. It undergoes complete extraction of details refining the signal and digitizing the output collectively cumulating the information which even the human eyes fail to capture. While the average wavelength sensitive to human eyes is around 400 to 700 nm the multispectral imaging perceives further and extracts details even about the smallest entity. This is achieved by allowing the electromagnetic spectrum to perforate into various infrared regions like near infrared (NIR), Mid-infrared(MIR), Thermal infrared(TIR) and other ultraviolet layers [9]. Receptors for red, green and blue distils the image accumulating its various attributes. Multispectral and hyper spectral images find their relation from the inverse proposition of geometric and spectral resolution (C. Lanaras et al) [10]. They aid in drought indices, vegetation water indices and land cover detection applications.

A. Low Resolution Imaging

Low resolution imagery (range 30-1000 m) restricts its use within a surrounding by embracing the particulars and to elide the gratuitous records. This provision helps in monitoring programmes and other agriculture and energy applications. This opposes the myth that only high resolution images can produce clear cut clarity images. Low resolution images thus aims at providing precise information about a source [11]. This is partially based on the pixel count, larger the count of pixel more is the clarity of the image [12]. They are mostly applied for analysis of large land covers. Aligning the image emphasized the 30 m imagery to 1 m imagery by geo-referencing through gathering a complete set of spectral bands (Jonathan R.B Fisher et al) [13].

One of the main satellite which aided the low resolution image was Landsat 7(April 15, 1999) producing Terra colour geographical images on web mapping services. Low resolution imaging supports higher area platforms which enables ease of interpreting data's about a particular unit. Reduces the volume of data manipulation by limiting the pixel count for a particular object extracting only its most essential trait. This must include approximately 3 spectral bands for complete digitization.

B. High Resolution Imaging

The high resolution multispectral images (range 0.41-4 m) are used mainly for surveillance purposes where the target features can be discriminated (Sarah A. Boyle et al) [14]. DMS3/Triplesat emphasized more on high resolution images anticipating completely on higher volume data collection for field mapping and logistics. High resolution imagery finds its application in land coverage enabling us to identify small patches of land and other habitat spots [15].

C. WorldView-2

Worldview-2 is the first high-resolution commercial satellite that simultaneously collects panchromatic imagery (0.49m) and Multispectral imagery (1.84m) with the aid of 8 multispectral imaging bands [16]. Thus they assist in locating small regions and individual structures like buildings but they are available only to the licensed users. The high altitude and the swiftness of this satellite enables it to revisit any location on the earth in typically 1.1 days [17]

D. Quick bird

This satellite provides the highest resolution of any commercial satellite available that combines both the multispectral and panchromatic imagery simultaneously which enables to view large areas in a single image. It also offers a spatial resolution of 2.44 - 2.88m in either natural or infrared colours [18]. It is capable of gathering about 75 million km^2 of imagery data in a year and also updates the data at an aberrant speed.

E. GeoEye-1

It is a polar satellite that can revisit any place on earth within 3 days or very sooner than that. It collects upto 70,000 km panchromatic imagery at 0.41m and 350,000 km multispectral imagery at 1.65m [19]. It also offers 3-m geolocation which enables the users to map both the man-made and natural features of the actual location without the use of ground control points.

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It has robotic precision where it can be rotated easily and can train the cameras to focus on multiple targets.

F. Ikonos

It provides a spatial resolution of 4m multispectral such as red, blue green and infrared and 1m panchromatic such as black and white. It collects data about earth's ever changing features like land and water resources by using 8 multispectral bands and has a dynamic range of about 11-bits per pixel [20]. Hence it is used in applications such as agricultural monitoring, disaster assessment and national security.

G. RapidEye

The RapidEye has about 5 satellite sensors in which obtains imagery in 77 km wide swaths [21]. It has 5 spectral bands and they cover a ground resolution of about 5m. These satellites map about 4 million square km each day. This satellite offers continuous monitoring which can be a strong basis for most of the projects and acts a get source of time series data [22].

H. Pleiades

The Pleiades provides a spatial resolution of panchromatic imagery at 0.7m and band data at 2m. They can obtain about 500 images from anywhere in the earth with a span less than 24 hours. It is used in tracking active volcanoes in the planet, urban expansion and also includes a wide variety of applications like civil security, military and renewable resource management [23].

I. SPOT 5

Just like any other satellite, they can be used to acquire high resolution images from any place on earth but it has very high acquisition flexibility and is well suited to cover large areas. The spatial resolution of the SPOT ranges from 2.5m panchromatic and 10m multispectral and has a dynamic range of 8-bits per pixel [24]. Environmental Assessment,

Utility corridor mapping, Infrastructure planning and telecommunications are some of its applications.

III. Hyper-Spectral Imaging

The Hyperspectral imagery is capable of having thousands of bands but generally it consists of much narrower bands (10-20 nm) which is obtained by using a imaging spectrometer. It is a combination of both digital imaging and optical spectroscopy. For each pixel in the given image, the hyperspectral sensor captures the light intensity of a large number of contiguous spectral bands [25]. Thus each pixel in the image has a continuous spectrum which can be used to characterize the details of the objects present in the image with great accuracy. This can be used to distinguish the objects based on their spectral properties.

An example of hyperspectral sensor is the Hyperion Imaging Spectrometer that uses 220 contiguous spectral bands (0.4-2.5 μm) to produce 30 m resolution images [26]. It has a higher level of spectral imaging that aids human to see the unseen. For instance the multispectral LANDSAT Thematic Mapper did not distinguish between a given three mineral whereas the hyperspectral remote sensor could aid the need. It used in many real world applications that ranges from mineral exploration, surveillance, target detection, [27], clinical instruments for medical diagnostics like early optical diagnosis of pressure ulcers [28], mapping land cover using AVHRR data[29], invasive plant species [30] and also used to identify landslides [31]. It contributes towards Land Use Land Cover (LULC) study. Some of the well-known hyperspectral satellites are the PROBA, PRISMA, IMS-1, Lewis and Earth observing-1.

One of the notable hyperspectral imager is the Hyperion instrument with quality calibration which is used for Earth surface characterization. This is enabled via Earth observation data classes to improve the characterization. Complex land eco-systems can be captured and classified precisely by dividing the spectral properties into 220 spectral bands (0.4 -2.5 µm) with 30m resolution. With these detailed spectral bands having high radial spectrometry, it is possible to cover 7.5km by 100km land area per image. Thus Hyperion helps to obtain precise data in the field of mineral exploration, containment mapping and crop yield prediction [32].

The following Table 1 includes the detailed information on renowned characteristics of the hyperspectral datasets.

TABLE I

HYPERSPECTRAL DATASETS

S. No	Satellite	Study Area	Sensor Instruments	No. of Spectral bands
1.	Indian Pines	North Western Indiana	AVIRIS sensor	224 spectral reflectance bands
2.	University of Pavia	Pavia, North Italy	ROSIS sensor	103 spectral bands
3.	Salinas	Salinas valley, California	AVIRIS sensor	224 spectral bands
4.	Botswana	Okavango Delta, Botswana	NASA EO-1	242 spectral bands
5.	Kennedy Space Center	Florida	NASA AVIRIS	176 spectral bands

IV. SATELLITE IMAGE ACQUISITION AND PROCESSING

The role of satellite images in surveillance and ecosystem monitoring is highly inevitable. However, the rate of research been carried with these spatial datasets is still under scarce. It is due to the insufficient knowledge on data acquisition and tedious processing for results [36]. The following section details the prominent phases of satellite image analysis.

A . Satellite Image Acquisition

The satellite are mostly available for free to the registered users but it is still unaware to most of the researchers. To acquire datasets from National and International agencies for academic research, proper mode of requests must be sent through the Institutions.

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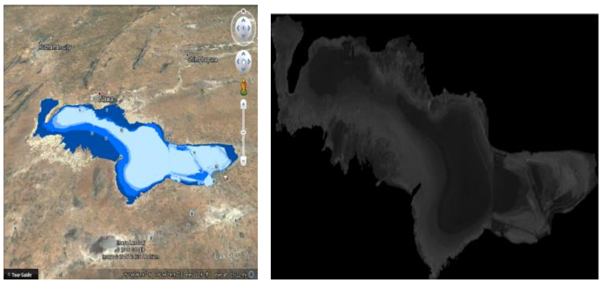
However, only moderate resolution images are available for public access. In order to gain access for very high resolution images, it's been available only for licensed users. Certain data portals that offer wide range of satellite images are United States Geological Survey (USGS), Bhuvan portal and DEM Explorer etc.

B. Image Pre-Processing & Dataset Construction

The data collected from data portals are considerably very large in size. In case of study area specific examination, only a selected region can be exploited with segmentation and classification as shown in Fig.3 (a).



(a) **(b)**

Fig. 3. (a) Thumbnail view of a water body in data portal; (b) Surface Reflectance Product.

In order to fit the data for spatial objects examination, the spectral influence of respective objects must be considered. To explore the spectral characteristics, the raw images are in need to be converted to Surface Reflectance Products (SR) through atmospheric correction as shown in Fig.3 (b). The widely available Geographic Information System (GIS) such as QGIS, ERDAS IMAGINE etc- holds the in-built functions for applying such image preprocessing. To extract the exact boundaries of spatial objects, the shapefiles can be used. The Google Earth explorer holds in-built functions for selection of Ground Control Points (GCP) to convert as respective shapefiles [37].

C. Image Interpretation on Spectral vs. Spatial Discrimination

The satellite image analysis includes two major variants of interpretation : (a) Spectral influence based examination and (b) Spatial discrimination with Soft Classifiers. In order to inhibit the spectral significance of images, it can be converted as SR Products, these images can be applied with image ratioing in accordance with the spectral channels for spatial objects examination.

The well known spectral indices are Normalized Difference Vegetation Index (NDVI) which consider Green and Red bands of detatils for classifying the vegetation / agriculture products and Normalized Difference Water Index (NDWI) which considers Green and Near Infra Red Bands for classifying the available water bodies from the cluster of spatial objects in the images. The False Color Composite (FCC) generation through specific channel selection and composition as shown in Fig.4.

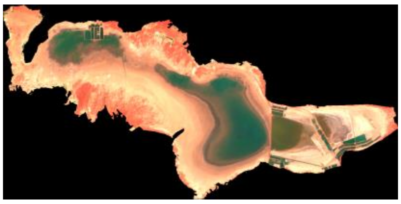


Fig. 4. False color composite of a water body

In case of Soft Classification, the raw images can be subjected with image filters for initial preprocessing and can be processed with clustering algorithms such as K-Means algorithm, Fuzzy C-Means algorithm etc-.

V. CONCLUSION

By the recent advances in remote sensing and computing power of the satellites, we are able to create more reliable and accurate analytical instruments [33]. These advancements in satellite imagery has reached a peak where the entire location can be viewed along with the elaborate information about the particular land area.The land areas have been grouped into patches in order to obtain the maximized information. The Hyperspectral remote sensing technology merges the spectral and spatial information and thus proves to be an innovative tool to analyze the spatial phenomena at different variations [34] and finds a promising place both in the present and future by its evolution (Staenz-2009) [35].

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