A Study on Hyperspectral Remote Sensing Classifications

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ABSTRACT
In this paper, we discuss about hyperspectral image processing where it plays an important role in remote sensing, hyperspectral verses multispectral image processing and image classifications. Where these classifications includes image sensors, image preprocessing, object detection, object segmentation, feature extraction and object classification. Mainly there are two types of classifications we are describing they are supervised and unsupervised classifications.

Keywords
Hyperspectral, multispectral, image processing, remote sensing, classifications.

1. INTRODUCTION
The success of any GIS [10, 11] application depends on the quality of the geographical data used. GIS [15] means "Geographic Information System". Which defined as computer assisted systems for the capture, storage, retrieval, analysis and display of spatial data. This will collect the high-quality geographical data for input.

1.1 Remote Sensing
Remote sensing [9, 10] was defined as acquisition of information about an object or phenomenon without making physical contact with the object. This was defined in 1960s. This remote sensing usually refers to the gathering and processing of information about earth's environment. These resources can be taken by aircraft and satellite. Today, remote sensing is the preferred method to use if environmental data covering a large area required for a GIS application.

Remote sensing data can be analog or digital in form as well as small or large in scale, according to the type of sensor and platform used for acquiring the data. In some usage, remote sensing refers only to imaginary acquired by sensors using electronic scanning, which detects radiation outside the normal visible range (0.4-0.7um) of the electromagnetic spectrum, such as microwave, radar, and thermal infrared. These remote sensing is the practice of deriving information about earth's land and water surfaces using images required from an over head perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface.

The stages of remote sensing are shown in fig 1, A source of electromagnetic radiation [10] or EMR (sun). Transmission of energy from the source to the surface of the earth, through atmosphere, interaction of EMR with earth's surface.-transmission of energy from surface to remote sensor mounted on a platform, through atmosphere, detection of energy by sensors, transmission if sensor data to ground station.

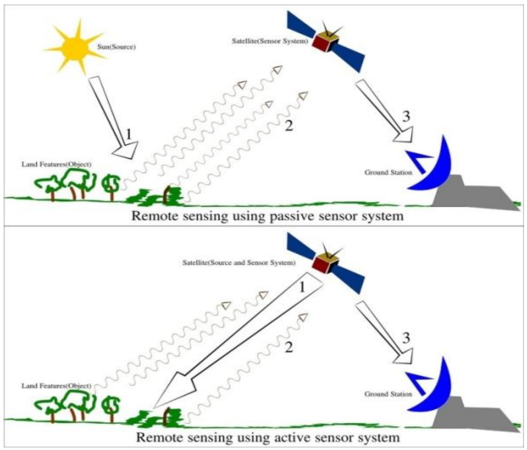

Fig 1: A remote sensing stage of working

One notable characteristics of remote sensing is that it is not just a data collection process. Remote sensing also includes data analysis: the methods and processes of extracting meaningful spatial information from the remote sensing data for direct input to the GIS. In digital form, remote sensing data are compatible with the raster-based GIS data model and can be readily integrated with other types of raster GIS data.

The advantage of remote sensing is the bird's –eye view or synoptic view it provides, so that environmental data covering a large area of earth can be captured instantaneously and can then be processed to generate map like products. Another advantage of remote sensing is that it can provide multispectral and multi scale data for the GIS database.

Remote sensing image processing [5, 6] is a mature research area allowing real-life applications with clear benefits for the Society. The main goal of remote sensing is as follows:

1. Monitoring and modeling the processes on the Earth's surface and their interaction, biological and physical variables.

2. Measuring and estimating geographical, biological and physical variables.

3. Identifying materials on the land cover and analyzing the spectral signatures acquired by satellite or airborne sensors.

2. HYPERSPECTRAL REMOTE SENSING

The hyperspectral remote sensing [1, 8, 2, 17] is an advanced tool that provides high spatial/spectral resolution data from a distance.

The most powerful tools used in the field of remote sensing are Hyperspectral imaging (HSI) and Multispectral Imaging (MSI)

Since the mid 1950's some airborne sensors have recoded spectral information [8] on the Earth surface in the wavelength region extending from 400 to 2500 nm. Starting from the early 1970's, [9] a large number of spacebarne multispectral sensors have been launched, on board the LANDSAT, SPOT and Indian Remote Sensing (IRS) series of satellites, just to name a few.

2.1 Hyperspectral Imaging

Hyperspectral image [4] is a process [14] of technique that adds a colorful third (3) dimension to a reflected image that contains the targets spectral data. It can be used in application such as topographic analysis of mineral deposits or farms.

These hyperspectral imaging combines standard digital imaging with common spectroscopic methods, such as Near IR, Visible and Fluorescence imaging. To provide increased sensitivity and discrimination.

2.2 Hyperspectral Imaging vs Multispectral Imaging

A multispectral image [1] is created by measuring energy at various wavelengths. These captures image data at specific frequencies across the electromagnetic spectrum. These wavelengths may be separated by filters or by the use of instrumentations.

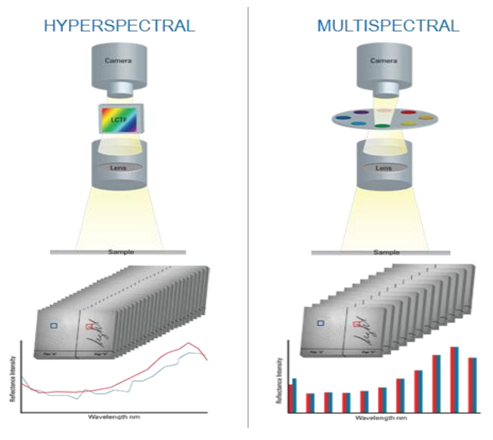

Fig 2: Comparison with hyperspectral with multispectral

A hyperspectral uses reflected transmitted or emitted light from each point. In the sample image to create a spectral based contrast with in the image. Images are acquired at multiple wavelengths via a "Liquid Cristal Tunable Filters (LCTF)" and tired together as a hyper cube dataset.

Table 1. Difference between hyperspectral and multispectral imaging

	Hyperspectral Imaging	Multispectral Imaging
Images Per Data Set	More than 20	2-20
Spectral Info	Full spectrum per pixel	4 to 20 data points per pixel
Spectral Width Per Image	10nm per image	30nm per image
Processing Methods	Spectral image	Limited image
Result	Highest discrimination	Moderate discrimination

As shown in the fig. 2 HIS systems have a very wide capability of spectral discrimination, while MSI systems are designed to support applications by providing bands that detect information in specific combinations of desirable regions of the spectrum shown in fig. 2. The number and position of bands in each system provide a unique combination of spectral information and are tailored to the requirements the sensor was designed to support. The main difference [16] is written in table 1.

3. HYPERSPECTRAL IMAGE CLASSIFICATION

Classification is a process in which individual items (objects) patterns/image regions/pixels) are grouped based on the similarity between the item and the description of the group. An image classification [3] procedure is to automatically categorize all pixels in the image into land cover classes. The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or "themes". This categorized data may then be used to produce thematic maps of the land cover present in an image. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization (Lillesand and Kiefer, 1994). The objective of image classification is to identify and portray, as a unique gray level (or color), the features occurring in an image in terms of the object or type of land cover these features actually represent on the ground.

Image classification is a process of sorting pixels in to individual classes, based on pixel values. This classification is used to assign corresponding levels with respect to groups. This classification is mostly used as extraction techniques in digital remote sensing. Most of the digital image analysis is very nice to have a "pretty picture" or an image, to show a magnitude of colors contains various features of the underlying terrain, but it is useless if you don't know what the colors mean. (PCI, 1997). Two main classification methods are Supervised Classification and Unsupervised Classification.

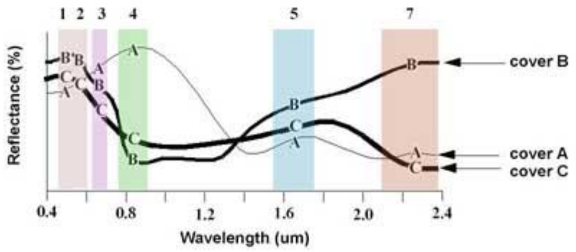

Fig 3: Spectral Reflectance curve of 3 land covers

The unsupervised classification is the identification of natural groups. The supervised classification is the process of sampling the known identity to classify and unclassified pixels to one of several informational classes. Supervised method follows the steps such as feature extraction, training and labeling processes. The first step consists of transforming the image into a feature image to reduce the data Dimensionality and to improve the data interpretability. This processing phase is optional and comprises techniques such as HIS transformation, principal component analysis and linear mixture model. In the training phase, a set of training samples in the image is selected to characterize each class. Training samples train the classifier to identify the classes and are used to determine the 'rules' which allow assignment of a class label to each pixel in the image. Different classification algorithms are available in the literature (Schowengerdt, 1997; Mather, 2004; Richards, 1993; Gonzalez Woods, 2007) and they are applied to the different types of data and application. Nowadays, the availability of high resolution images has increased the number of researches on urban land use and earth cover classification.

3.1 Supervised Classification

In supervised classification [13], we identify an Information class (i.e., land cover type) on image. These are called "training sites". The image processing software system is then used to develop a statistical characterization of the reflectance for each information class. This stage is often called "signature analysis" and may involve developing a characterization as simple as the mean or the rage of reflectance on each bands, or as complex as detailed analysis of the mean, variances and covariance over all bands. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance for each pixel and making a decision about the signatures. (Eastman, 1995).

3.1.1 Maximum Likelihood Classification

Maximum likelihood Classification is a statistical decision criterion to assist in the classification of overlapping signatures, pixels are assigned to the class of highest probability.

The maximum likelihood classification may give more accurate results than parallelepiped classification however it is much slower due to extra computations. We put the word `accurate' in quotes because this assumes that classes in the input data have a Gaussian distribution and that signatures were well selected; this is not always a safe assumption.

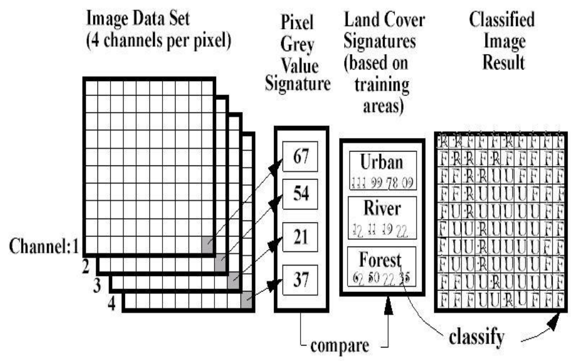

Fig 4: Steps in Supervised classification

3.1.2 Minimum distance Classification

Minimum distance classifies image data on a database file using a set of 256 possible class signature segments as specified by signature parameter. Each segment specified in signature, for example, stores signature data pertaining to a particular class. Only the mean vector in each class signature segment is used. Other data, such as standard deviations and covariance matrices, are ignored (though the maximum likelihood classifier uses this).

The result of the classification is a theme map directed to a specified database image channel. A theme map encodes each class with a unique gray level. The gray-level value used to encode a class is specified when the class signature is created. If the theme map is later transferred to the display, then pseudo-color table should be loaded so that each class is represented by a different color.

3.1.3 Parallelepiped Classification

The parallelepiped classifier uses the class limits and stored in each class signature to determine if a given pixel falls within the class or not. The class limits specify the dimensions (in standard deviation units) of each side of a parallelepiped surrounding the mean of the class in feature space.

If the pixel falls inside the parallelepiped, it is assigned to the class. However, if the pixel falls in more than one class, it is put in the overlap class (code 255). If the pixel does not fall inside any class, it is assigned to the null class (code 0).

The parallelepiped classifier is typically used when speed is required. The drawback is (in many cases) poor accuracy and a large number of pixels classified as ties (or overlap, class)

3.2 Unsupervised Classification

Unsupervised classification is a method which examines a large number of unknown pixels and divides into a number of classes based on natural groupings present in the image values [12]. Unlike supervised classification, unsupervised classification does not require analyst-specified training data. The basic premise is that values within a given cover type should be close together in the measurement space (i.e. have similar gray levels), whereas data in different classes should be comparatively well separated (i.e. have very different gray levels) (PCI, 1997; Lillesand and Kiefer, 1994; Eastman, 1995).

The classes that result from unsupervised classification are spectral class which based on natural groupings of the image values, the identity of the spectral class will not be initially known, must compare classified data to some form of reference data (such as larger scale imagery, maps, or site visits) to determine the identity and informational values of the spectral classes. Thus, in the supervised approach, to define useful information categories and then examine their spectral separability; in the unsupervised approach the computer determines spectrally separable class, and then define their information value. (PCI, 1997; Lillesand and Kiefer, 1994).

Unsupervised classification is becoming increasingly popular in agencies involved in long term GIS database maintenance. The reason is that there are now systems that use clustering procedures that are extremely fast and require little in the nature of operational parameters. Thus it is becoming possible to train GIS analysis with only a general familiarity with remote sensing to undertake classifications that meet typical map accuracy standards. With suitable ground truth accuracy assessment procedures, this tool can provide a remarkably rapid means of producing quality land cover data on a continuing basis.

4. CONCLUSION

Hyperspectral image classification has made great improvement in the development and use of recent classification algorithm. It uses multiple features such as spectral, spatial, multitemporal and multisensory information. Classification algorithms can be per pixel, sub pixel, per field, contextual and multiple classifiers. Per pixel classification is used in practice but accuracy may not effect on mixed pixel problem and may realize high accuracy. For spatial resolution data, although mixed pixels are reduced, the spectral variation with in land classes may decrease the classification accuracy. The classification is most optimal for spatial resolution data. In many cases, machine learning approaches also provide a better classification result than maximum likelihood classification because of some tradeoffs exit in classification accuracy. When using multisource data such as combination of spectral signature, texture, context information and additional data, advanced non parametric classifiers such as neural networks, decision making knowledge based classification may be more suitable to handle these complex data process and then gained increasing awareness in the remote sensing community in recent years. Valuable use of multiple features of remotely sensed data and selection of a proper classification method are especially significant for improve the classification accuracy.

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