Image Classification

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.

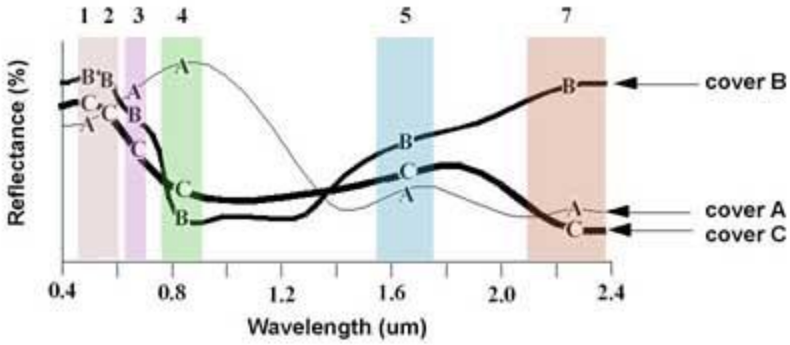

Figure Spectral Reflectance curve of 3 land covers

Image classification is perhaps the most important part of digital image analysis. It is very nice to have a *"pretty picture"* or an image, showing a magnitude of colors illustrating various features of the underlying terrain, but it is quite useless unless to know what the colors mean. (PCI, 1997). Two main classification methods are *Supervised Classification* and *Unsupervised Classification.*

Supervised Classification

With supervised classification, we identify examples of the Information classes (i.e., land cover type) of interest in the 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 analyses 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 which of the signatures it resembles most. (Eastman, 1995)

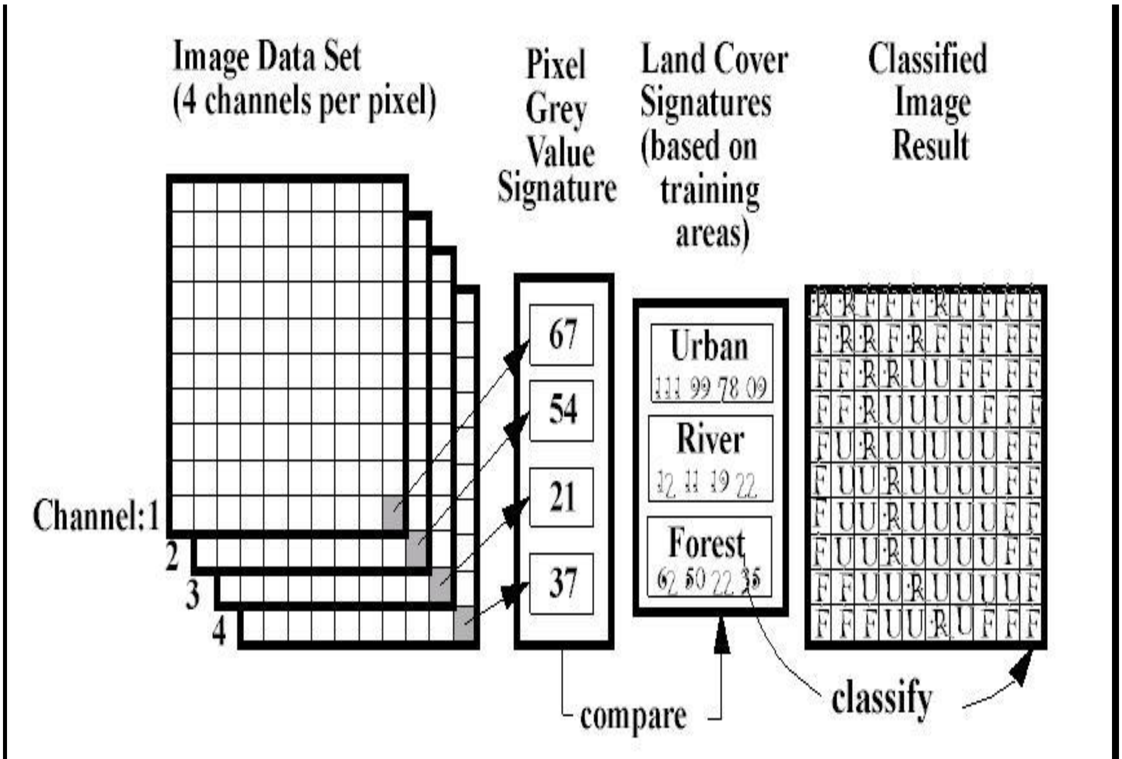

Figure Steps in Supervised classification

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 classifier is considered to 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.

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 a pseudo-color table should be loaded so that each class is represented by a different color.

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 within 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 draw back is (in many cases) poor accuracy and a large number of pixels classified as ties (or overlap, class 255).

Unsupervised Classification

Unsupervised classification is a method which examines a large number of unknown pixels and divides into a number of classed based on natural groupings present in the image values. 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 classed 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 from 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.

Image Types and Formats

Image data are rasters, stored in a rectangular matrix of rows and columns. Radiometric resolution determines how many gradations of brightness can be stored for each cell (pixel) in the matrix; 8-bit resolution, where each pixel contains an integer value from 0 to 255, is most common. Modern sensors often collect data at higher resolution, and advanced image processing software can make use of these values for analysis. The human eye cannot detect very small differences in brightness, and most GIS software can only read an 8-bit value.
In a greyscale image, 0 = black and 255 = white; and there is just one 8-bit value for each pixel. However, in a natural color image, there is an 8-bit value for red, an 8-bit brightness value for green, and an 8-bit value for blue. Therefore, each pixel in a color image requires 3 separate values to be stored in the file. There are three possible ways to organize these values in a raster file.

- BIP - Band Interleaved by Pixel: The red value for the first pixel is written to the file, followed by the green value for that pixel, followed by the blue value for that pixel, and so on for all the pixels in the image.
- BIL - Band Interleaved by Line: All of the red values for the first row of pixels are written to the file, followed by all of the green values for that row followed by all the blue values for that row, and so on for every row of pixels in the image.

- BSQ - Band Sequential: All of the red values for the entire image are written to the file, followed by all of the green values for the entire image, followed by all the blue values for the entire image.

Orthoimages are delivered in a variety of image formats, either compressed or uncompressed. The most common are TIF and JPG. Compression eases data management challenges, as large high-resolution orthophoto projects can easily result in terabytes of uncompressed imagery. Compression can also speed display in GIS systems. The downside is that compression can introduce artifacts and change pixel values, possibly hampering interpretation and analysis, particularly with respect to fine detail. The decision to compress should be driven by end user requirements; it is not uncommon to deliver a set of uncompressed imagery for archival and special applications along with a set of compressed imagery for easy use by large numbers of users. If there is an intention for web-based display or distribution of orthoimagery, a compressed set of orthoimagery is often recommended. In any event, georeferencing information must also be provided. Both TIFF and JPG image formats can accommodate georeferencing information, either imbedded in the image file itself, as in the case of GeoTIFF, or as a separate file for each image, as in the case of TIFF with a TFW (TIF World) file. The georeferencing information tells GIS software 1) the size of a pixel, 2) where to place one corner of the image in the real world, and 3) whether the image is rotated with respect to the ground coordinate system.

Other popular image formats you may encounter are:

- ECW(link is external): developed by ERMapper, now owned by ERDAS. Uses wavelet compression to reduce file size.
- GRID(link is external): developed by Esri; supported by some remote sensing software packages, but not as common as other formats.
- IMG(link is external): developed by ERDAS for Imagine; supported by many GIS and remote sensing software packages.
- JP2(link is external): JPEG 2000, developed by JPEG group. Widely supported by most GIS and remote sensing software packages.
- SID(link is external): MrSid, developed by Lizard Tech. Uses wavelet compression to reduce file size. Read by many software packages, but requires proprietary software license to create.