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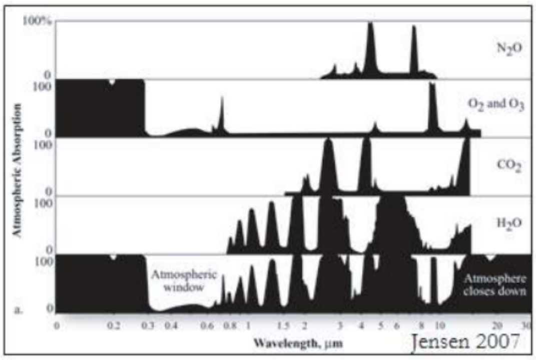
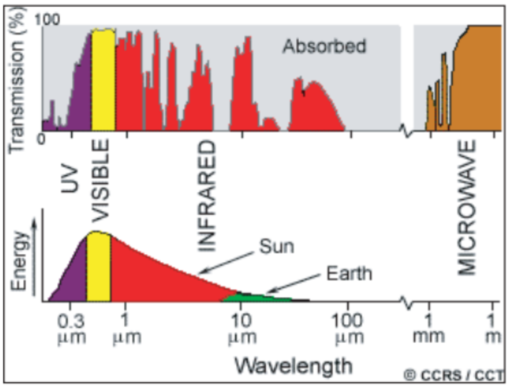
Atmospheric Absorption

Absorption causes molecules in the atmosphere to absorb electromagnetic energy at various wavelengths when it interacts with the atmospheric constituents. Ozone, carbon dioxide, and water vapor are the three main atmospheric constituents which absorb electromagnetic energy. Ozone absorbs the harmful ultraviolet radiation from the sun. Carbon dioxide, referred to as a greenhouse gas, absorbs radiation strongly in the far infrared portion of the electromagnetic spectrum which serves to trap this heat inside the atmosphere. The incoming long wave infrared and shortwave microwave radiation (between 22 and 1m) are absorbed by water vapor in the atmosphere.

Atmospheric windows: The regions of the electromagnetic spectrum, which are not severely influenced by atmospheric absorption and useful to remote sensing, are called atmospheric windows.





SPOT

SPOT is a commercial high-resolution optical imaging Earth observation satellite system operating from space. It is run by Spot Image, based in Toulouse, France. It has been designed to improve the knowledge and management of the Earth by exploring the Earth's resources, detecting and forecasting phenomena involving climatology and oceanography, and monitoring human activities and natural phenomena. The SPOT system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution.

Image Copyright © AIRBUS Defense & Space

History of SPOT Satellites

- SPOT 1 launched February 22, 1986 with 10 meter panchromatic and 20 meter multispectral picture resolution capability. Withdrawn on December 31, 1990.
- SPOT 2 launched January 22, 1990 and deorbited in July 2009.
- SPOT 3 launched September 26, 1993. Stopped functioning in November 14, 1997.
- SPOT 4 launched March 24, 1998. Stopped functioning in July, 2013.
- SPOT 5 launched May 4, 2002 with 2.5 m, 5 m and 10 m capability.

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More about SPOT 5

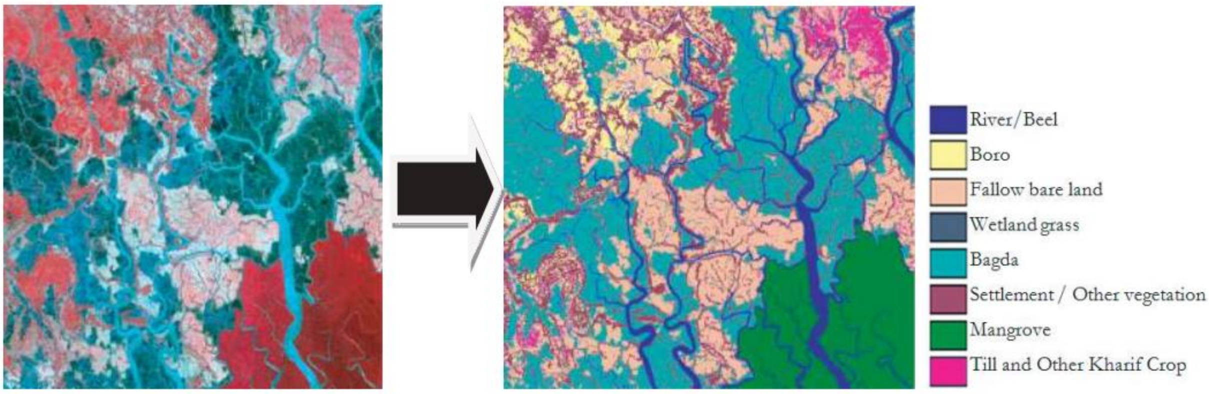
SPOT 5 has the goal to ensure continuity of services for customers and to improve the quality of data and images by anticipating changes in market requirements. SPOT 5 has two high resolution geometrical (HRG) instruments that were deduced from the HRVIR of SPOT 4.

They offer a higher resolution of 2.5 to 5 meters in panchromatic mode and 10 meters in multispectral mode (20 m on short wave infrared 1.58 – 1.75 µm).

SPOT 5 also features an HRS imaging instrument operating in panchromatic mode. HRS points forward and backward of the satellite. Thus, it is able to take stereo pair images almost simultaneously to map relief.

What is Classification ?

Classification is the process of sorting pixels into a finite number of individual classes, or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, the pixel is assigned to the class that corresponds to those criteria. The objective of image classification is to assign all pixels in the image to particular classes or themes (e.g. forest, water, settlements, fallow land, etc.). The resulting classified image is a thematic "map" of the original image.



Source: ERDAS Field Guide™. (2005). Norcross, Georgia: Leica Geosystems Geospatial Imaging, LLC

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Information Class and Spectral Class

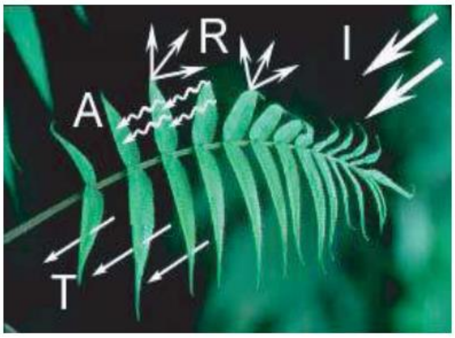
It is important to distinguish between information classes and spectral classes.

Information classes are those classes that the analyst is actually trying to identify from analysis of images, such as different forest types or tree species, different kinds of crops, different geologic units or rock types, etc.

Spectral classes are groups of pixels which are similar or near similar with respect to their brightness values in the different spectral bands of the data. The objective is to match the spectral classes in the data to the information classes of interest.

Interaction with Targets

When energy incident upon the surface, three forms of interaction take place: absorption (A); transmission (T); and reflection (R).The proportions of each depends on the wavelength of the energy and the material and condition of the feature.

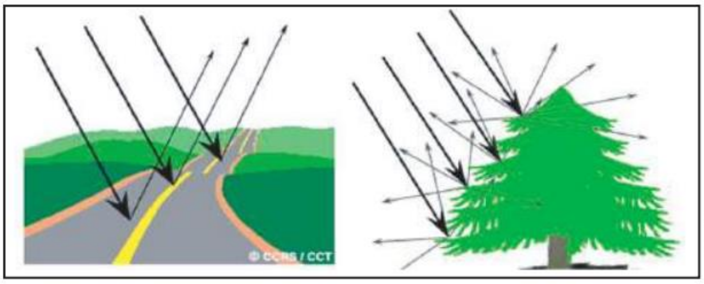


Absorption (A) occurs when energy is absorbed into the target. Transmission (T) occurs when radiation passes through a target and Reflection (R) occurs when radiation "bounces" off the target. In remote sensing, the radiation reflected from targets is measured.

There are two extreme ends of the way in which energy is reflected from a target: **specular reflection** and **diffuse reflection**.

Specular Reflection: When a surface is smooth we get specular or mirror-like reflection where almost all of the energy is directed away from the surface in a single direction.

Diffuse reflection: such reflection occurs when the surface is rough and the energy is reflected almost uniformly in all directions.



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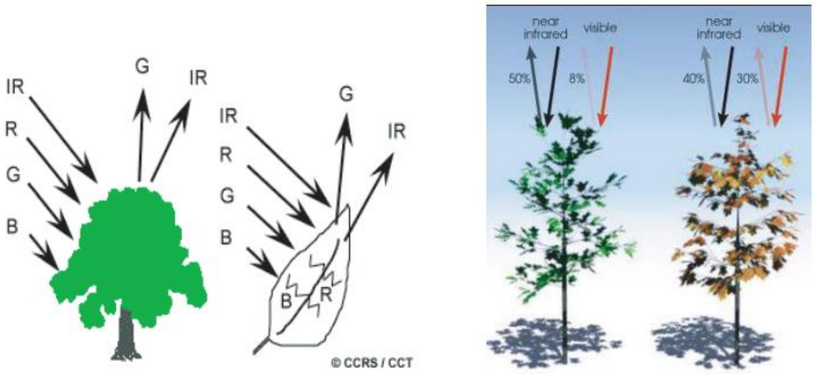
Interactions with Vegetation

Chlorophyll in leaves strongly absorbs radiation in the red and blue wavelengths but reflects greenwavelengths. That is why leaves appear green. It appears "greenest" in the summer, whenchlorophyll content is at its maximum. In autumn, there is less chlorophyll in the leaves, so there isless absorption and proportionately more reflection of the red wavelengths, making the leavesappear red or yellow.

The internal structure of healthy leaves act as excellent diffuse reflectors of near-infrared wavelengths. Measuring and monitoring the near-IR reflectance in remote sensing, one can determine how healthy (or unhealthy) vegetation may be.



http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php

Classification Process

Digital image classification uses the spectral information represented by the digital numbers in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. This type of classification is termed spectral pattern recognition. The computer system must be trained to recognize spectral patterns in the data. The result of training is a set of signatures that defines a training sample or cluster. After the signatures are defined, the pixels of the image are sorted into classes. This sorting is based on the signatures by use of a classification decision rule. The classification rule is a mathematical algorithm by which, using data contained in the signature, performs the actual sorting of pixels into distinct class values.

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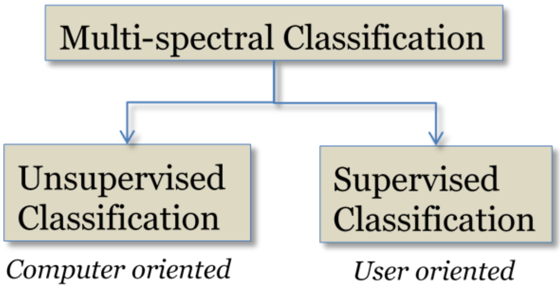
Multi-spectral Classification



Multi-spectral Classification
The process of assigning individual pixels of an image to categories, generally on the basis of spectral reflectance characteristics. Two kinds of multi-spectral classifications.

Unsupervised Classification
Digital information extraction technique in which the computer assigns pixels to categories with no instructions from the operator. Also known as Isodata Classification.

Supervised Classification
Digital-information extraction technique in which the operator provides training-site information that the computer uses to assign pixels to categories.

Pattern Recognition

Pattern recognition is the science—and art—of finding meaningful patterns in data, which can be extracted through classification.

By spatially and spectrally enhancing an image, pattern recognition can be performed with the human eye; the human brain automatically sorts certain textures and colors into categories.

In a computer system, spectral pattern recognition can be more scientific. Statistics are derived from the spectral characteristics of all pixels in an image. Then, the pixels are sorted based on mathematical criteria. The classification process breaks down into two parts: training and classifying (using a decision rule).

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Training

Training is the process of defining the criteria by which these patterns are recognized (Hord, 1982). Training can be performed with either a supervised or an unsupervised method, asexplained below.

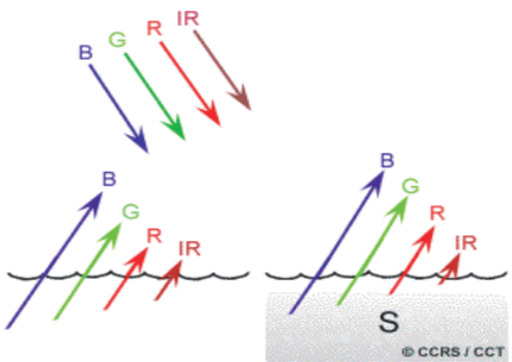
Supervised Training

Supervised training is closely controlled by the analyst such as you. In this process, you select pixels that represent patterns or land cover features that you recognize, or that you can identify with help from other sources, such as aerial photos, ground truth data, or maps. Knowledge of the data, and of the classes desired, is required before classification. By identifying patterns, you can instruct the computer system to identify pixels with similar characteristics.

Interactions with Water

Water absorbs longer visible wavelength and near infrared radiation than shorter visible wavelengths. That is why water typically looks blue or blue-green due to stronger reflectance at shorter visible wavelengths, and darker if viewed at red or near infrared wavelengths.

Because of more absorption of the blue wavelengths and reflection of the green wavelengths by chlorophyll in algae, the water appears greener in color when algae are present in water. If there is suspended sediment in the upper layers of the water body, this will allow higher reflectivity and a brighter appearance of the water.



What is Image Classification in Remote Sensing?

Image classification is the process of assigning land cover classes to pixels. For example, these **9 global land cover data sets** classify images into forest, urban, agriculture and other classes.

In general, these are three main image classification techniques in remote sensing:

- Unsupervised image classification
- Supervised image classification
- Object-based image analysis

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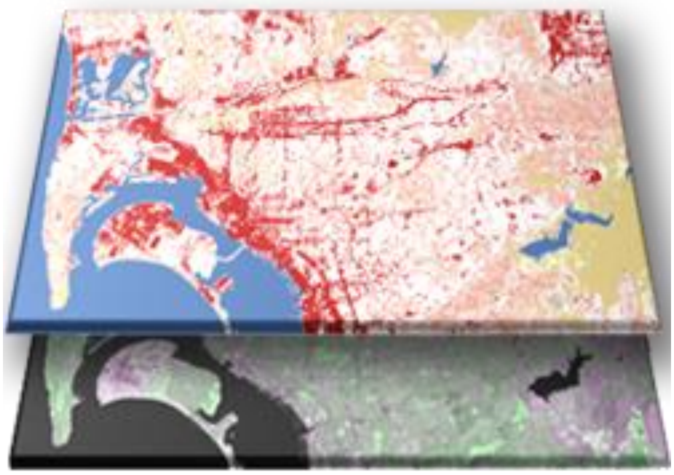
Unsupervised and supervised image classification techniques are the two most common approaches. However, **object-based classification** has been used more lately because it's useful for high-resolution data.

What are some of the differences between supervised and unsupervised classification? Find out more by reading.

Unsupervised Classification



Unsupervised Classification Example

In unsupervised classification, it first groups pixels into "clusters" based on their properties. In order to create "clusters", analysts use image clustering algorithms such as K-means and ISODATA. For the most part.

After picking a clustering algorithm, you identify the number of groups you want to generate. For example, you can create 8, 20 or 42 clusters. To be clear, these are unclassified clusters because in the next step, you manually identify each cluster with land cover classes. For example, if you want to classify vegetation and non-vegetation, you'll have to merge clusters into only 2 clusters.

Overall, unsupervised classification is the most basic technique. Because you don't need samples for unsupervised classification, it's an easy way to segment and understand an image.

Unsupervised Classification Steps:

- Generate clusters
- Assign classes

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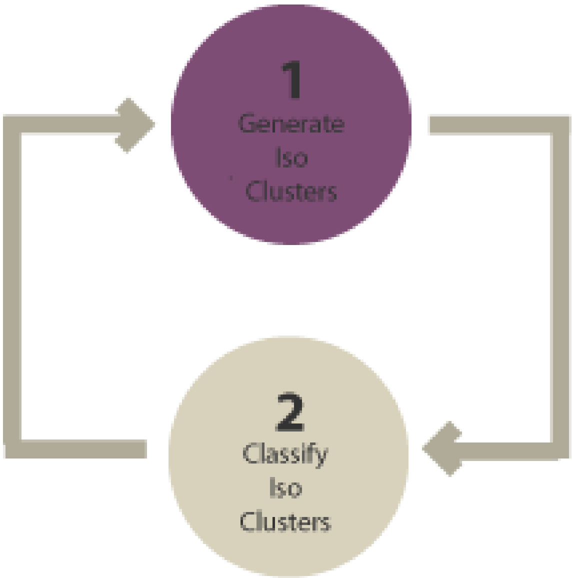
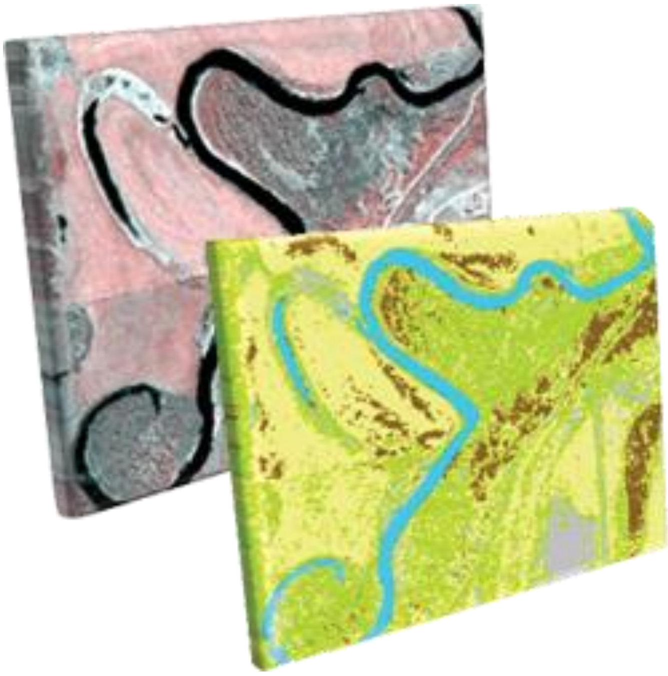


Unsupervised Classification Diagram

Supervised Classification



Supervised Classification Example: IKONOS

In supervised classification, you select representative samples for each land cover class. The software then uses these "training sites" and applies them to the entire image.

Supervised classification uses the spectral signature defined in the training set. For example, it determines each class on what it resembles most in the training set. The common supervised classification algorithms are maximum likelihood and minimum-distance classification.

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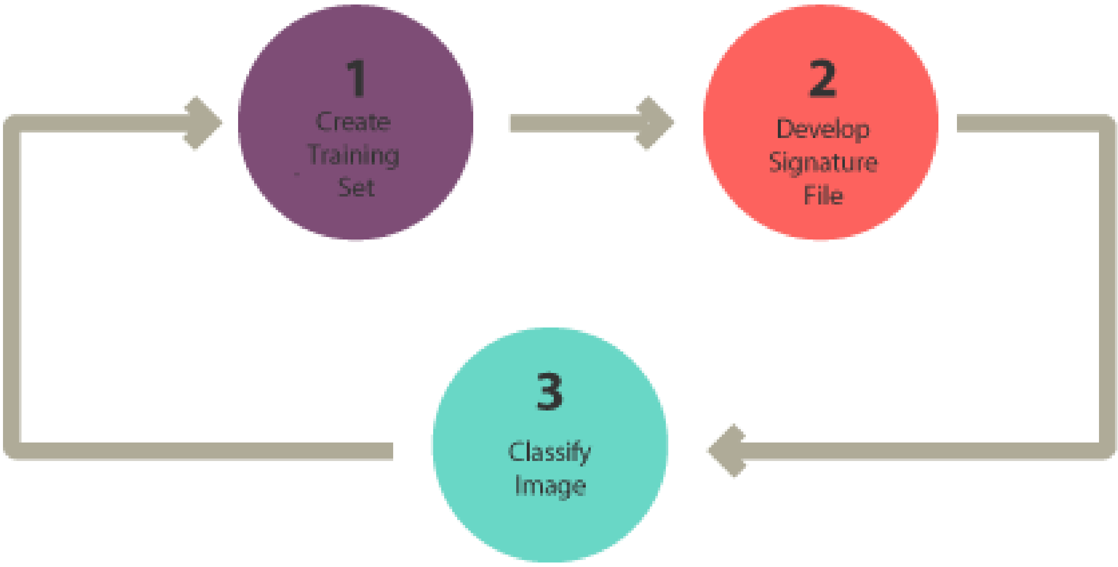
Supervised Classification Steps:

- Select training areas
- Generate signature file
- Classify



Supervised Classification Diagram

Object-Based (or Object-Oriented) Image Analysis Classification

Object-based Classification

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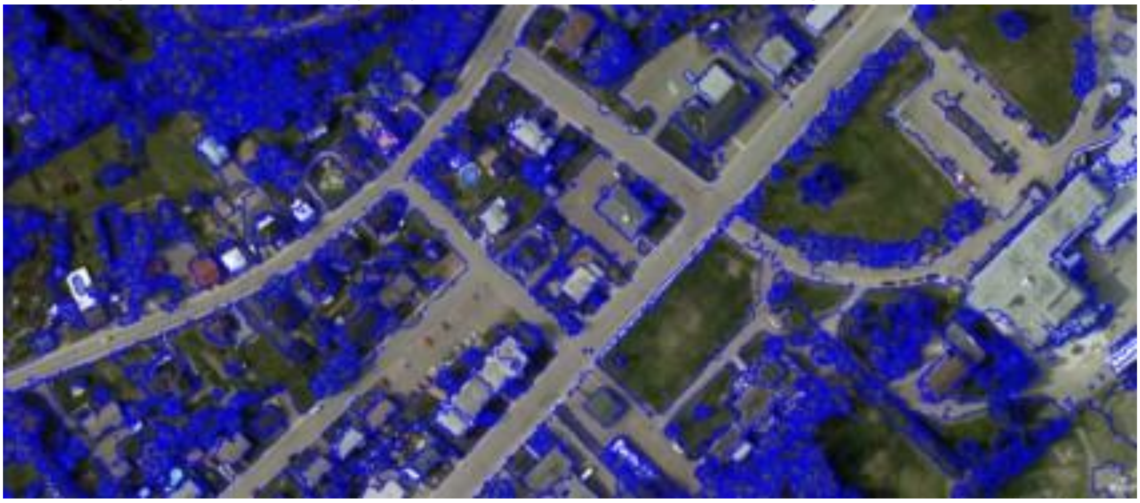
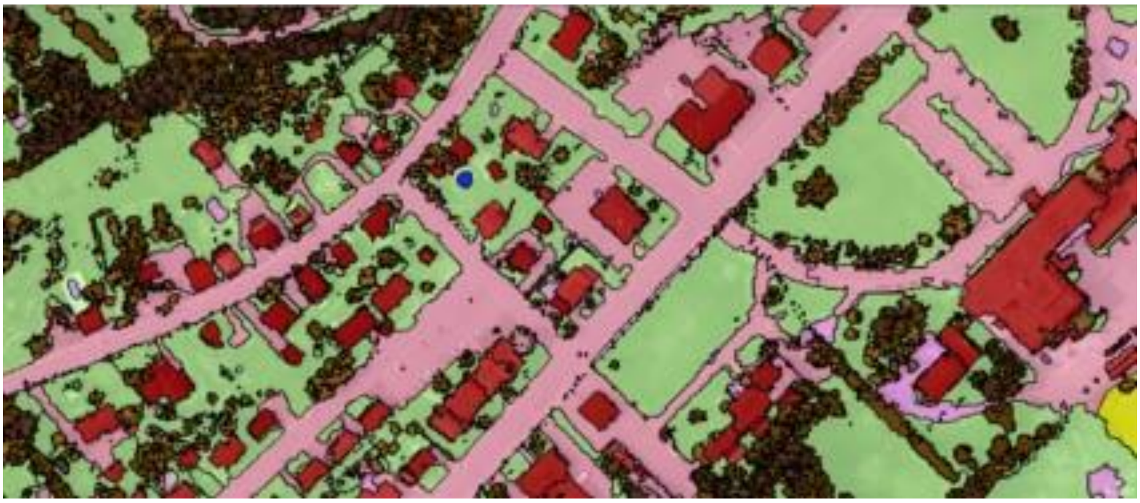
Supervised and unsupervised classification is pixel-based. In other words, it creates square pixels and each pixel has a class. But object-based image classification groups pixels into representative shapes and sizes. This process is multi-resolution segmentation or segment mean shift.

Multiresolution segmentation produces homogenous image objects by grouping pixels. It generates objects with different scales in an image simultaneously. These objects are more meaningful because they represent features in the image.



Object-Based Image Analysis (OBIA) segmentation is a process that groups similar pixels into objects

But most importantly, you can classify objects based on texture, context and geometry.



OBIA classification uses shape, size and spectral properties of objects to classify each object

In OBIA, you can use multiple bands to create objects and then classify them. For example, OBIA can take infrared, elevation or a shapefile to classify each object. Also, layers can have context with each other. For example, objects have proximity and distance relationships between neighbors.

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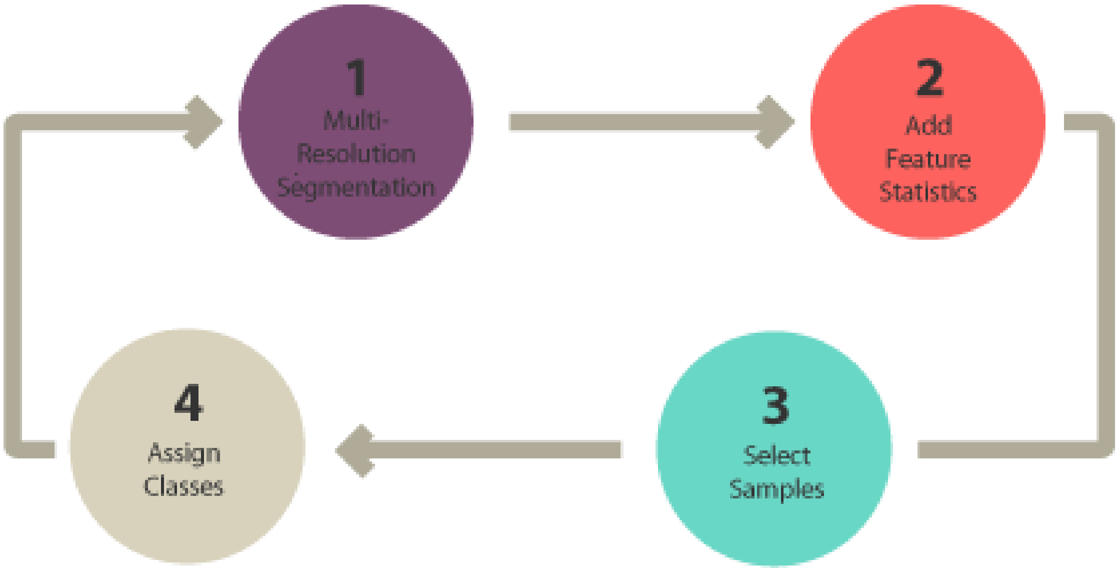
Nearest neighbor (NN) classification is similar to supervised classification. After multi-resolution segmentation, the user identifies sample sites for each land cover class. Next, they define statistics to classify image objects. Finally, nearest neighbor classifies objects based on their resemblance to the training sites and the statistics defined.



Object-Based Classification Diagram

Object-Based Nearest Neighbor Classification Steps:

- Perform multiresolution segmentation
- Select training areas
- Define statistics
- Classify

Remote Sensing Data Trends

In 1972, Landsat-1 was the first satellite to collect Earth reflectance at 60meter resolution. At this time, unsupervised and supervised classification were the two image classification techniques available. For this spatial resolution, this was sufficient.

However, OBIA has grown significantly as a digital image processing technique.

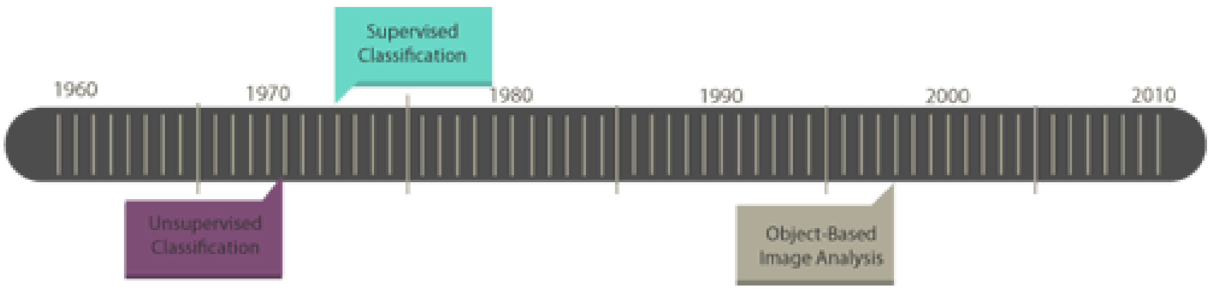


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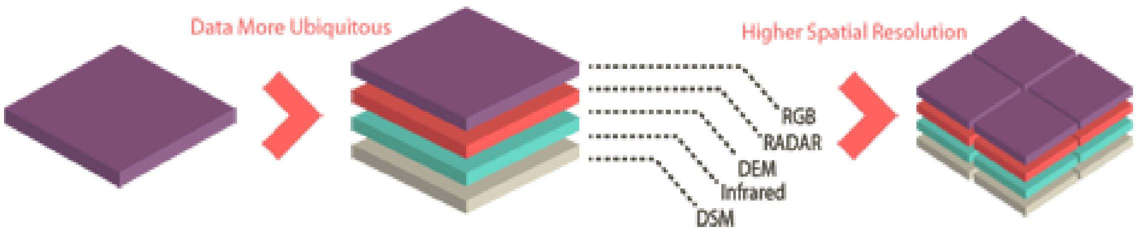
Image Classification Timeline

Over the years, there has been a growing demand for remotely sensed data. There are **hundreds of remote sensing applications** include food security, environmental concerns and public safety. To meet demand, satellite imagery is aiming at higher spatial resolution at a wider range of frequencies.

Remote Sensing Data Trends:

- More ubiquitous
- Higher spatial resolution
- Wider range of frequencies

But higher resolution images does not guarantee better land cover. The image classification techniques used are a very important factor for better accuracy.



Selection of Image Classification Techniques

Let’s say you want to classify water in a high spatial resolution image.

You decide to choose **all pixels with low NDVI** in that image. But this could also misclassify other pixels in the image that aren’t water. For this reason, pixel-based classification like unsupervised and supervised classification gives a salt and pepper look.

Humans naturally aggregate spatial information into groups. Multiresolution segmentation does this task by grouping homogenous pixels into objects. Water features are easily recognizable after multiresolution segmentation. This is how humans visualize spatial features.

- When should you use pixel-based (unsupervised and supervised classification)?
- When should you use object-based classification?

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Spatial Resolution: Low | Medium | High

As illustrated in **this article**, spatial resolution is an important factor when selecting image classification techniques.

When you have **low spatial resolution**, both traditional pixel-based and object-based image classification techniques perform well.

But when you have **high spatial resolution**, OBIA is superior to traditional pixel based classification.

Unsupervised vs Supervised vs Object-Based Classification

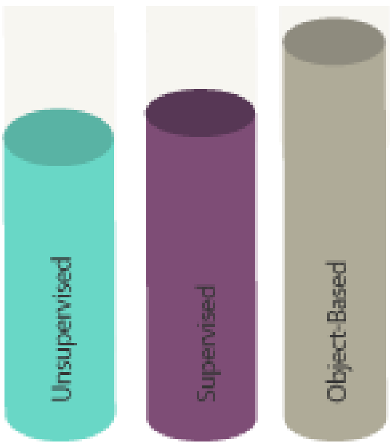

Image Classification Techniques Accuracy Assessment

A case study from the University of Arkansas compared **object-based vs pixel-based classification**. The goal was to compare high and medium spatial resolution imagery.

Overall, object-based classification outperformed both unsupervised and supervised pixel-based classification methods. Because OBIA used both spectral and contextual information, it had higher accuracy. This study is a good example of some of the limitations of pixel-based image classification techniques.

Daffodil International University
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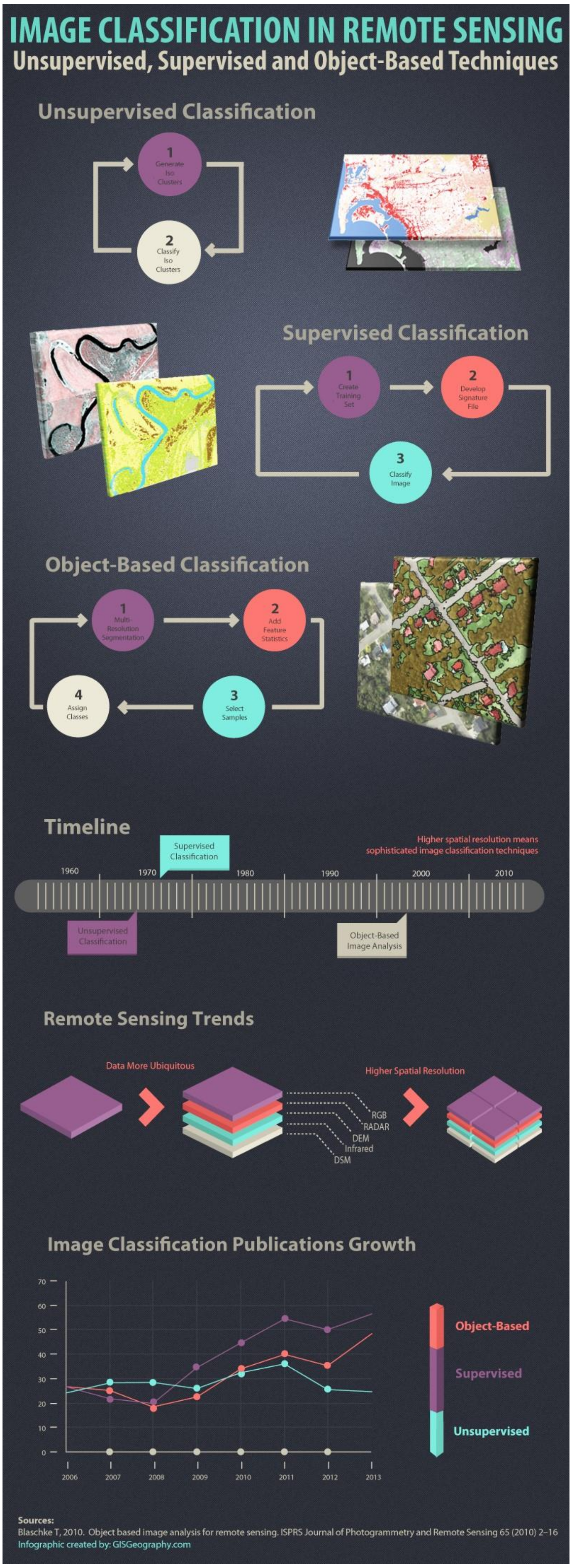

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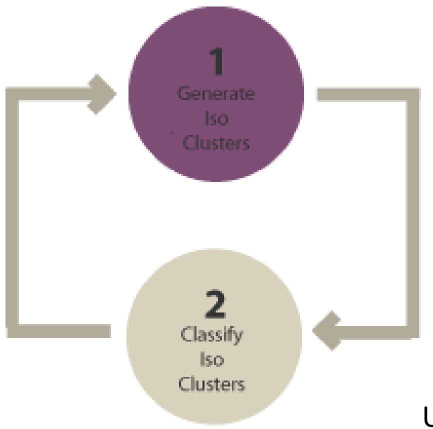
Unsupervised Classification in Remote Sensing

Unsupervised classification is different because it does not provide sample classes.

First, the user identifies how many classes to generate and which bands to use. Next, the software then clusters pixels into the set number of classes. Finally, the user then identifies the land cover classes.

Unsupervised Classification Steps:

- Generate clusters
- Assign classes



Unsupervised Classification Diagram

Step 1 Activate Spatial Analyst Extension

First, you have to activate the spatial analyst extension in ArcGIS (customize>extensions>spatial analyst).

Step 2 Generate clusters

In this unsupervised classification example, we use iso-clusters (spatial analysis tools>multivariate>iso clusters).

INPUT: The image you want to classifiy.
NUMBER OF CLASSES: The number of classes you want to generate during the unsupervised classification. For example, if you are working with multispectral red, green, blue and NIR bands, then the number here will be 40 (4 classes x 10).
MINIMUM CLASS SIZE: This is the number of pixels to make a unique class.

When you click OK, it will be form clusters/classes based on your input parameters. But you still need identify which land cover classes each cluster belongs to.

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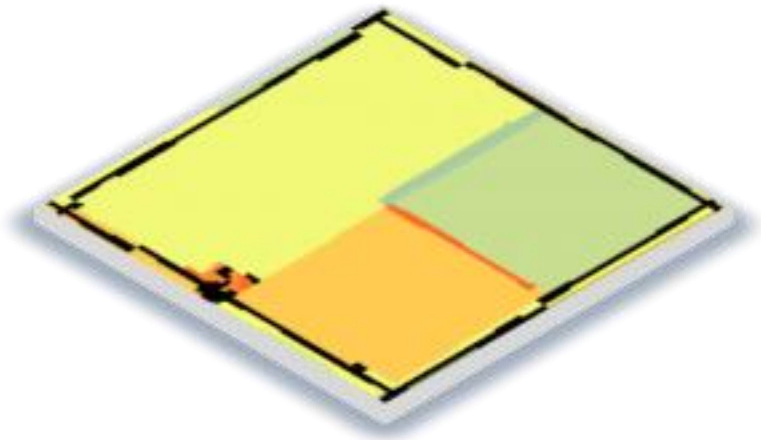
Step 3 Assign classes

The last step is to identify each class from the iso-clusters output. In general, it helps to select colors for each class. For example, set water as blue for each class. After setting each one of your classes, we can merge the classes by using the reclassify tool.



Unsupervised Classification Example

There will be some manual classification if classes appear in 2 land cover classes. For example, if vegetation was mistakenly classified as water (perhaps algae in the water), then user will have to manually edit the polygon.

In most cases, it helps to convert the raster to vector and use the editing toolbar. You can split polygons to help properly identify them.

Classifying Images with Supervised and Unsupervised Methods

This sums up some of the basics for unsupervised classification in remote sensing.

We generated unknown classes (isodata) using iso clusters. Next, the user identified each cluster with land cover classes.

Some manual editing may be necessary if there is confusion between classes.

Put these steps to practice and generate some land cover of your very own.

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What's the difference between a supervised and unsupervised image classification?

Classified tree canopy layer in the Virginia Urban Tree Canopy Mapper – http://www.utcmapper.frec.vt.edu

Two major categories of image classification techniques include **unsupervised** (calculated by software) and **supervised** (human-guided) classification.

Unsupervised classification is where the outcomes (groupings of pixels with common characteristics) are based on the software analysis of an image without the user providing sample classes. The computer uses techniques to determine which pixels are related and groups them into classes. The user can specify which algorism the software will use and the desired number of output classes but otherwise does not aid in the classification process. However, the user must have knowledge of the area being classified when the groupings of pixels with common characteristics produced by the computer have to be related to actual features on the ground (such as wetlands, developed areas, coniferous forests, etc.).