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Development was funded by the Department of Labor (DOL) Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant No. TC-22525-11-60-A-48; The National Information Security, Geospatial Technologies Consortium (NISGTC) is an entity of Collin College of Texas, Bellevue College of Washington, Bunker Hill Community College of Massachusetts, Del Mar College of Texas, Moraine Valley Community College of Illinois, Rio Salado College of Arizona, and Salt Lake Community College of Utah.

This workforce solution was funded by a grant awarded by the U.S. Department of Labor's Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warranties or assurances of any kind, express or implied, with respect to such information, including any information on linked sites, and including, but not limited to accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability or ownership.

Lesson 5: Remote Sensing and Image Classification

INTRODUCTION

In this lesson you will learn about image classification. The first section of the lesson focuses on what image classification and explains attributes, special features, and traditional image classification. You will gain an understanding of how spectral signatures are used, and evaluated. Supervised and unsupervised classification are also explained and demonstrated as well as the conversion process of spectral classes to information classes.

LESSON OBJECTIVES

By the end of this lesson, you will be able to:

1. Define image classification.
2. Explain supervised, object-based image classification techniques.
3. Perform image classification techniques such as supervised and unsupervised classification on remotely sensed data.

LEARNING SEQUENCE

Required Reading	Read the following: <ul style="list-style-type: none">• Online Lesson Material
Resources	Review the following: <ul style="list-style-type: none">• None
Assignments	Complete the following: <ul style="list-style-type: none">• Quiz• Lab: Unsupervised Classification• Lab: Supervised Classification

INSTRUCTION

Image Classification Overview

Image classification is one of the primary areas that some image analysts spend the majority of their time. This lesson will introduce some of the common image processing methods that



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are used in the industry. As one might imagine there are a number of ways that remotely sensed imagery can be used to develop land cover or land use maps. Image classification is a collection of methods that an image analyst can use to categorize (or “classify”) pixel values into land cover or land use types. Shown in the image below are many of the commonly used image classification methods. The unsupervised, supervised, and object-based image classifiers will be discussed in this lesson since these are the most often used methods. The other two, spectral un-mixing and the fuzzy classifier will not be discussed.

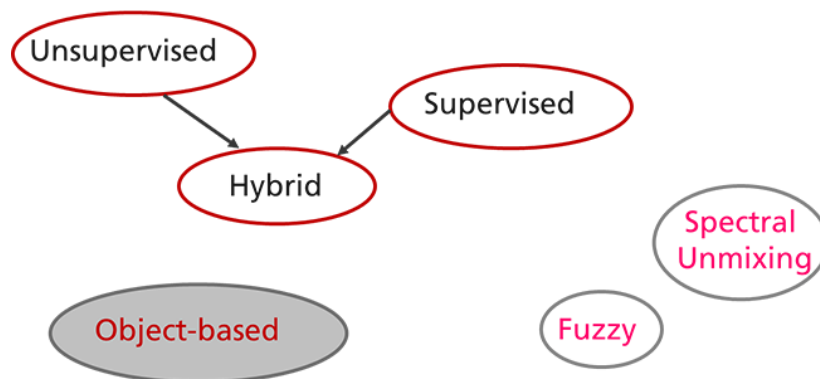


Figure 1 Image Classification Methods

Common Attributes

Some of the common attributes with all types of image classifiers are:

- The ability to auto categorize pixels into land cover or land use types.
- Although image classifiers can work on any kind imagery, they often work best when the image data set contains information from multispectral data that include both the true color and infrared band.
- The classifiers evaluate the spectral patterns across an image. Similar spectral patterns are often identified by how similar or different one or more pixels are to other pixels. Spectral pattern can be evaluated by the use of spectral signatures or areas identified on the image as containing the same spectral characteristics.
- Most image classification processes involve more than a single step and often include a “training phase, evaluation phase, and classification phase” each of which can involve multiple steps to complete. In addition, the classification is often iterative meaning that some of the steps need to repeat multiple times or the overall classification process needs to occur more than one time to obtain a reasonable and accurate result.



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- Image classification, although can be automated or semi-automated, there is still some human involvement to help train image classifiers, evaluate results, and to make judgments on how well an image classification exercise performed.
- An accuracy assessment is required to quantify how well the image classifications worked and how valid the output data set is. Image classification accuracy assessment is the subject of lesson six where it will be discussed in detail.

Special Features of Image Classification

Some special characteristics of image classification that will not be covered in this lesson are spatial pattern recognition and temporal analysis. However, they will be briefly outlined to provide you with a basic understanding of what they entail.

Spatial Pattern Recognition

Spatial pattern recognition is often used by some of the more involved image classification processes such as the object-based image classification methods. Specialized software is usually required to take advantage of spatial patterns as part of an image classification.

Temporal Analysis

Temporal analysis is often a “next step” in image classification where the results of two or more image classifications can be used to monitor change over time in the landscape that can be a factor of natural causes, human induced change, or natural disasters. Depending on the kind of change to identify and quantify, other special image processing software may be required.

No “Right Way”

As with many image processing activities, there is no single “right way” of performing image classification. Often times the image classification methods are based on the scope of a project, the kinds of land cover types needing identification, and project budget and resources. The processes are usually subjective since there is judgment that is required of the image analyst. Even though some statistical methods can be used to independently identify land cover types and quantify accuracy, the analyst is still heavily involved in creating and interpreting data and products that result from image classification protocols.

Traditional Image Classification

Figure 2 outlines the steps that are often used to perform a “traditional” image classification. Traditional refers to image processing methods that analyze only spectral content from the image and do not consider specific “spatial patterns”, shapes, or the context of specific objects. These traditional methods typically are applicable to medium and coarse image resolutions (that is, greater than 20m pixel sizes).



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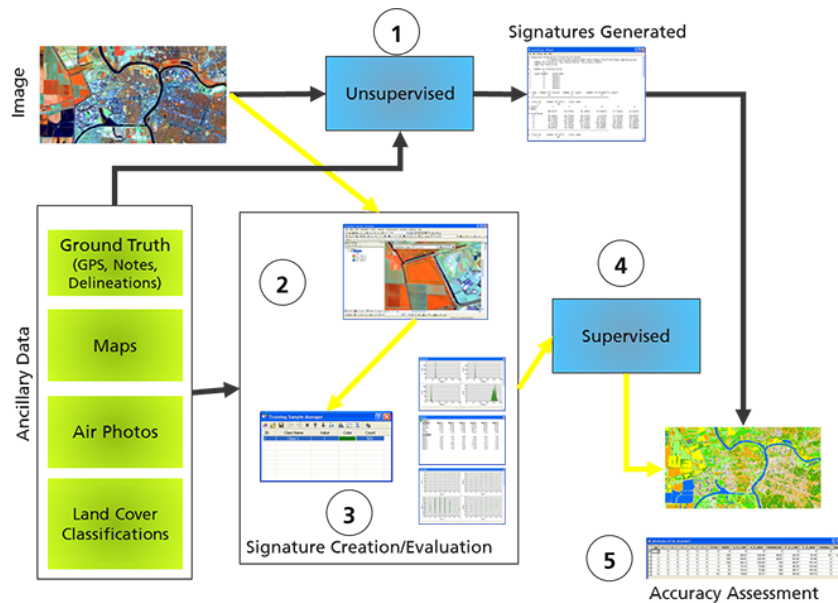


Figure 2 Traditional Image Classification Process

- The black arrows show the workflow for an “unsupervised” image classification. The yellow arrows show the steps for a “supervised” image classification.
- For the unsupervised approach, an image is automatically classified into broad groups of pixels that have similar “spectral” characteristics. The image analyst needs to spend time identifying the specific land cover types in the image. Often times, additional methods and time is required to identify areas that have more than one cover type present in the group.
- The supervised approach begins with the analyst identifying representative samples of the specific land cover types that are expected to be identified in the image classification. The samples often require field visits and/or photo interpretation or consulting other resources to identify the land cover types. Once these specific samples are identified then they can be used as the input to a supervised image classification algorithm that generates the output land cover map.

Traditional Image Classification Process: Hybrid Approach

Here is an example of the “hybrid” approach mentioned both methods are combined into a single process to generate an image classification output data set. The general steps are numbered.

Step 1

This step uses an unsupervised classification routine to segment the original remotely sensed image into unique groups of similar kinds of pixel values.

Step 2

Once the segments are identified “training” sites can be identified in each “spectral segment”. These are field verified using on ground surveys, air photo interpretation, and other image



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classification or maps to determine the specific land cover categories to be mapped in the output.

Step 3

Spectral signatures are created from the training sites then evaluated to make sure the spectral variability of each land cover category is represented.

Step 4

The spectral signatures are used to perform a supervised image classification that then generates the final image classification output.

Step 5

The image classification output data set is assessed for accuracy for each of the land cover categories. If some land cover classes have been poorly identified then some or all of the above steps may be performed multiple times to improve the land cover classification accuracy.

The accuracy assessment and methods are often written up in a formal document and contain the explanations of the methods and the interpretations of the results as well as a provision for recommendations of use and further action.

Object-Based Image Classification

Here is the basic process for object-based image classification. This is an over simplified workflow where each step usually requires a number of steps.



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de Jong, S.M. and F.D. van der Meer, Eds., *Remote Sensing Image Analysis Including the Spatial Domain*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2004.

Classification Scheme

All image classification projects begin with a classification scheme that identifies and defines the specific land cover types that are required for the project. Typically, the classification scheme is agreed upon by a project group that includes the client. The specific land cover types need to be exhaustive as to cover all of the expected land cover types within the project area. The project team must also agree to the specific definitions of each land cover type. These are usually discussed and then written definitions in addition to pictures and sample sites are described.

Many land cover classification schemes are based on work conducted by [Anderson, Hardy, Roach and Witmer \(1976\)](#). Object-based image classification schemes may include many other factors such as those described above, since they do not rely solely on spectral content from the image.

Hierarchical Classification Scheme

Most of the time the land cover classification scheme is hierarchical which begins with general land cover types and then identifies more specific land cover types. The land cover classification scheme is often shown as a decision tree that shows the relationships between the general and more specific land cover categories.

This image is an example of a hierarchical classification scheme and is based on the Anderson classification scheme which can be found in Developing the Classification System section outlined within [A Land Use and Land Cover Classification System for Use with Remote Sensor Data](#) (Anderson, et al 1976).

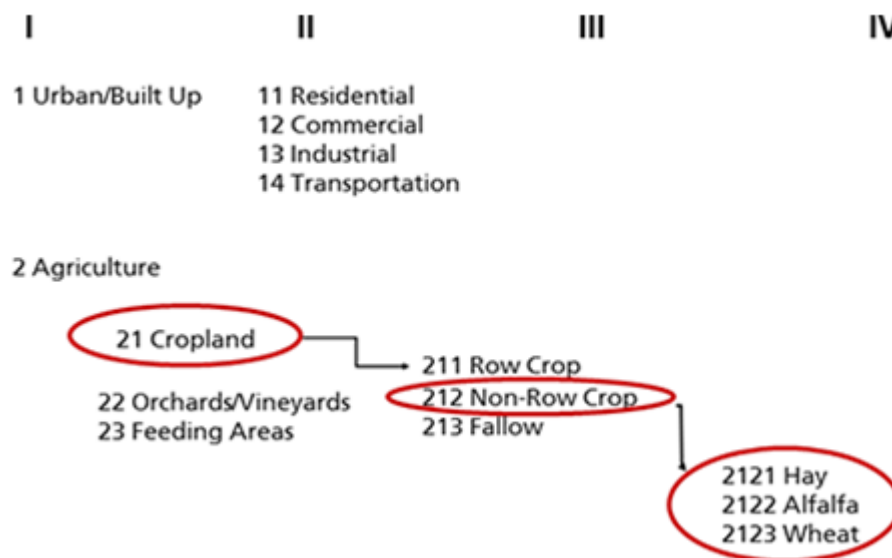


Figure 4 Hierarchical Classification Scheme



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At the top are four levels of detail with the most general land cover types on the left and moving to more specific levels of detail on the right.

In the example two major land cover types are shown, Urban/Built-up and Agriculture. Notice that the urban/built up category only has a second level of detail. The agricultural land cover type is broken down further into four levels of detail. The Cropland category and its respective hierarchy are shown in the red circles.

Tracing the Cropland category, this can further be broken down into Row Crops, Non-Row Crops, or Fallow fields. The Non-Row Crop can be further divided into specific crop types of Hay, Alfalfa, and Wheat.

The classification scheme itself is exhaustive for these cover types that would be expected in a typical land cover classification that contains an Agriculture land cover type and specific crop types. The classification scheme defines a level of detail provided the imagery and classification methods can identify the specific cover types. If the specific cover types cannot be identified, the next general level of detail can be used.

This kind of classification schemes allows for the flexibility of providing different levels of detail in the output image classification provided the information, image resolution, spectral content, and image processing methods are capable of identifying the most specific types. If they are not, then a more generalized depiction of the land cover type is provided in the image classification output.

Minimum Mapping Unit

The minimum mapping unit is important to identify as part of an image classification project because this can limit the level of detail found in the output image classification. In many image classification projects, individual pixel sizes do not represent the level of detail in the output image classification. More often, contiguous groups of pixels that form an area better represent the level of detail in an image classification product.

The minimum mapping unit represents the smallest mappable area that will be identified in the output image classification. The minimum mapping unit is defined based on a number of factors such as image resolution, scale of the project area, the number of bands in the image, the specific kinds of land cover types or features to identify as well as the time of year and any obstructions that may affect the ability to identify such features. Examples include clouds, shadows, shadows cast by buildings, building or vertical structure overlay, and others.

The minimum mapping units is agreed upon by the project team and client and is often expressed as an area (for example, 10 hectares). Once an image classification is complete, a “smoothing” algorithm is often used to aggregate the classified pixels into contiguous areas that meet the minimum mapping unit size.

Size depends on:

- Classification Scheme
- Purpose
- Types of features to ID
- Scale of image
- Pixel size of image



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- Time of Year
- Identifiable obstructions

ArcGIS 10

The lab exercises for this lesson will use some of the Spatial Analyst and Image Classification tools provided in ArcGIS as listed below. More details will be provided in the lab exercises.

Image Classification Toolbar

The Image Classification Tool bar will be used to perform the two common traditional unsupervised and supervised classification methods. In addition, the Image Classification Toolbar will be used to create and review spectral signatures that are used in the supervised classification tool.

Image Classification Toolbar includes the following:

- IsoCluster Unsupervised Classification
- Maximum Likelihood Supervised Classification
- Probability
- Principal Components

Spatial Analyst Toolbox – Multivariate Toolset

The Multivariate Toolset within the Spatial Analyst Toolbox will be used to evaluate spectral signature files. The classification tools can also be found in the Multivariate Toolset.

Multivariate Toolset includes the following:

- All of the Image Classification Toolbar +
- Dendrogram – spectral signature analysis
- IsoCluster – autogenerate spectral signatures
- Edit Signatures

Spatial Analyst Toolbox – Reclass Toolset

The reclassify tool can be found in the Reclass Toolset within the Spatial Analyst Toolbox and is used to create the final set of land cover classes in an image classification output. Provided below are a few references that you can refer to on your own to read about and study for additional information regarding the overview of image classification and object-based image classification methods.

Lillesand, Kiefer, and Chipman. *Remote Sensing and Image Interpretation*, 6th ed., Wiley & Sons, 2007. ISBN: 0470052457 and ISBN-13: 978-0470052457

de Jong, S.M. and F.D. van der Meer, Eds., *Remote Sensing Image Analysis Including the Spatial Domain*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2004.

Navulur, K., *Multispectral Image Analysis Using the Object-Oriented Paradigm*, CRC Press, Boca Raton, FL, 2007.



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Spectral Signatures

A spectral signature is a group or cluster of pixels that have similar spectral characteristics. What this means is for any given area of pixels that are considered to be similar, the pixel values for a given band are often similar and when statistical measures are computed for this area the following is often found:

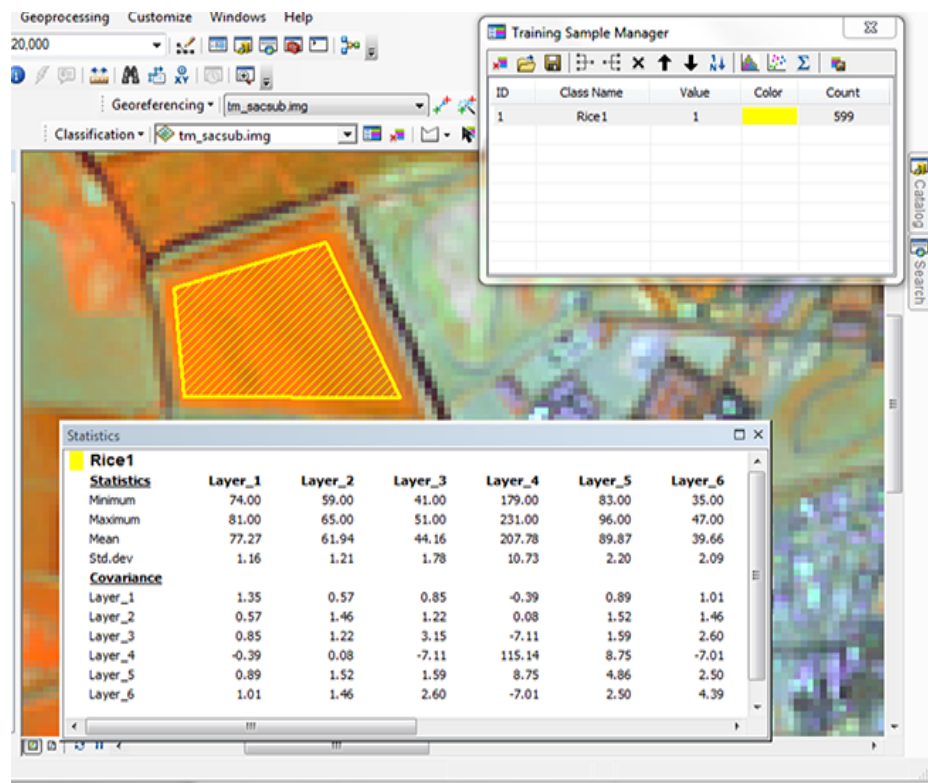
1. The mean or average value for the group of pixels is similar to individual pixel values
2. The standard deviation and variance for the area of pixels is often small, meaning that the different pixel value are similar to the mean value of the area

The spectral signature is the identified group of pixels and the statistics that can be computed for the group of pixels. That is the group of pixels and its statistical measures that make up the specific definition for the spectral signature.

Spectral signatures can be auto-generated through the use of the unsupervised classification method or can be manually defined by the analyst where specific areas are delineated on the image and individual statistics can be computed.

Spectral Signature – Manual Delineation

This image is an example of a spectral signature that has been delineated by an analyst. The area within the yellow polygon contains 599 pixels and at the bottom are the specific statistics computed for each band within this area of 599 pixels. The area delineated in addition to the specific statistics computed for this area represents a “spectral signature” for the Rice land cover type.



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Figure 5 Spectral Signature Example

Spectral Signature: Auto-generated

The image below is an example of an unsupervised classification routine creating an image output with only one spectral category shown. When the unsupervised classification method is performed a number of unique spectral areas are created. These are often broad groupings of pixels where each unique group contains a number of pixels and corresponding statistics. A spectral signature file can be generated from the unsupervised process that can be used in subsequent image classification procedures.

The yellow in the image is the geographic extent of Spectral Class 2. Note that this class contains a number of pixels that are scattered throughout the image. The bottom image of Figure 5 is the portion of the spectral signature file created from the unsupervised process. The image band numbers and spectral signature means are shown across the top. A "covariance" table is also shown. Covariance is a statistical measure of how the pixels values within the spectral signature area vary between the different image bands. The variance for a given band is the value along the diagonal of the covariance table. The variance is outline in red. Remember, the variance for a given band describes how different individual pixels within the spectral signature area are to the mean of the pixel values in the spectral signature area.

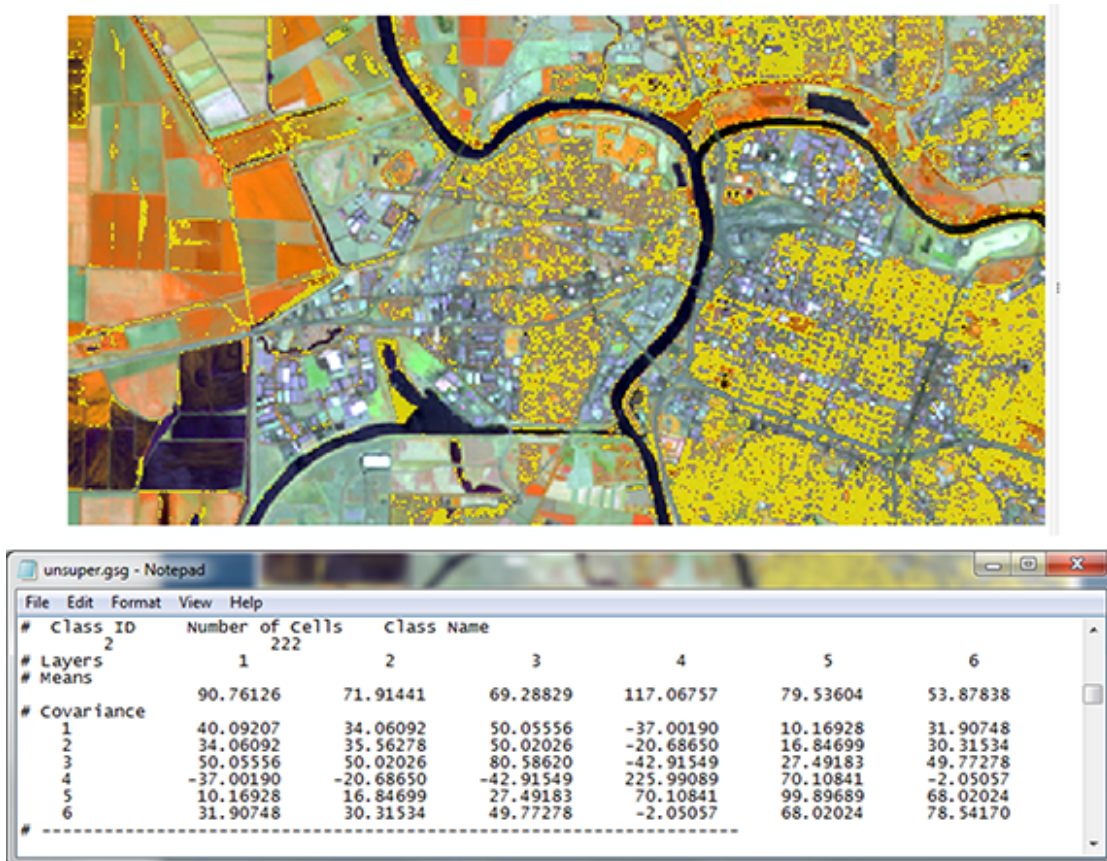


Figure 6 Unsupervised Classification Routine



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How are Spectral Signatures used?

In an image classification project all of the types of land cover that need to be identified in the image need to be sampled. Since not all specific land cover types look the same on an image, these land cover types must have spectral samples that cover the variability of the land cover type.

When identifying spectral signatures, whether automatically or manually, additional reference information is needed, field work or air photo interpretation may be required, in addition to having some specific knowledge of the geographic area. Image analysts can spend considerable time creating, evaluating, and modifying spectral signatures. Since obtaining high quality spectral signatures is an important part of image classification routines, analysts need to spend quality time developing these spectral signature sets.

In some sources spectral signatures may also be referred to as “training sites” or those spectral signatures that are used to “train” spectral classifiers.

Creating Spectral Signatures

Spectral signatures are often created as part of the supervised classification process and begin with drawing polygon areas on an image similar to the example shown in the previous figures. Identifying spectral signatures on an image often require using additional information such as conducting field visits for “ground truthing”, maps, air photo interpretation, and other land cover maps.

One of the goals of creating spectral signatures is to sample the variability of the land cover classes across the image because the same land cover types can different spectral characteristics in different parts of the image.

Samples: Three Types of Land Cover Types

The illustration shows (Figure 7) multiple samples of three different land cover types (noted with A, B, or C). Each of the individual spectral signatures has a mean, standard deviation, variance that describes the spectral characteristics of the land cover type. Each signature that represents the same land cover type may have slightly different spectral characteristics which will represent the variability of the land cover type.

The analyst will need to pay close attention to how spectral signatures are collected because this will be the information that is used in supervised classification methods. If spectral signatures are delineated or identified incorrectly, then the output image classification will likely have errors or issues.

High quality spectral signatures are those that represent only a single cover type based on the classification scheme, contain homogeneous pixel values, and have small standard deviations and variances for each image band. For some land cover types this is not always achievable, but the analyst should strive to sample single land cover types when creating spectral signatures.



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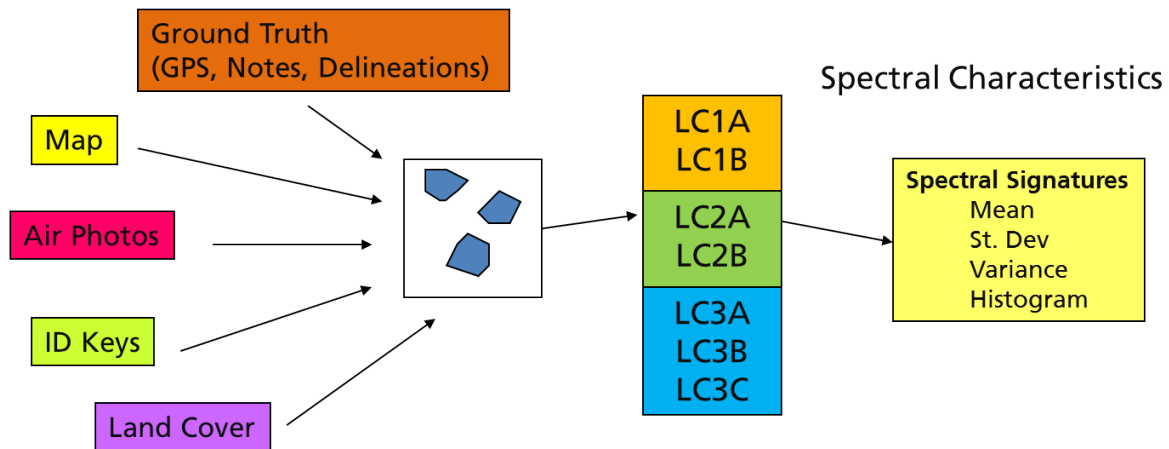
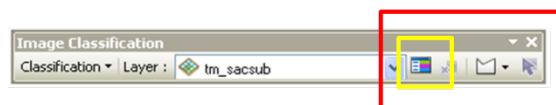


Figure 7 Multiple Samples of Different Land Cover Types. Each different land cover type is noted with A, B, or C.

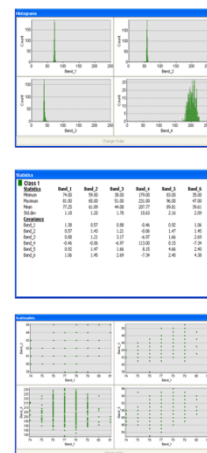
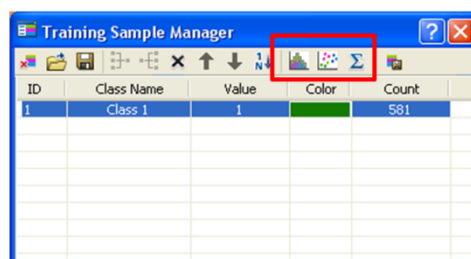
Creating Spectral Signatures in ArcGIS

Creating spectral signatures in ArcGIS is performed using the Training Sample Manager on the Image Classification Toolbar which can be seen in the image provided (Figure 8). When the user creates a spectral signature on the image, the individual spectral characteristics can be reviewed by using one or more of the spectral evaluation tools. Three tools are available: histograms, signature statistics, and scatter plots. Keep in mind that the histogram and the signature statistics are the most often used tools when reviewing specific spectral signature quality.

Image Classification Toolbar



Training Sample Manager



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Figure 8 Creating Spectral Signatures using ArcGIS:
Screenshots are included of the Image Classification Toolbar
the Training Sample Manager and the three tools available
(histograms, signature statistics, and scatter plots).

- **Histograms**

The histogram is a graph of the specific pixel values and the pixel count for each unique brightness value. A histogram can be created for each image band. A spectral signature that is delineated for a single land cover type will appear as a single curve on the histogram. If a spectral signature has multiple curves, this is an indication there may be more than one land cover type delineated in the spectral signature area.

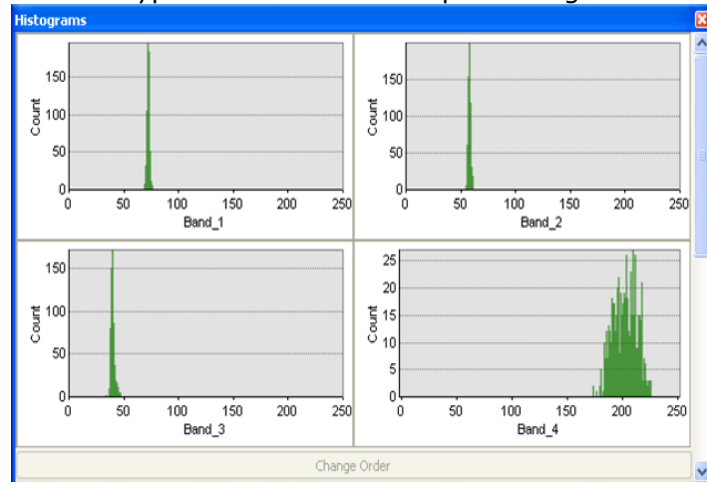


Figure 9 Histograms

- **Signature Statistics**

The spectral signature statistics tool is commonly used to review the means, standard deviations, and variances for a given signature. The analyst can easily see specific values and determine if a spectral signature seems to represent a single cover type.

If the standard deviations and variances are large across multiple bands, then the spectral signature may include multiple land cover types. A high quality spectral signature will often have small standard deviations and variances.



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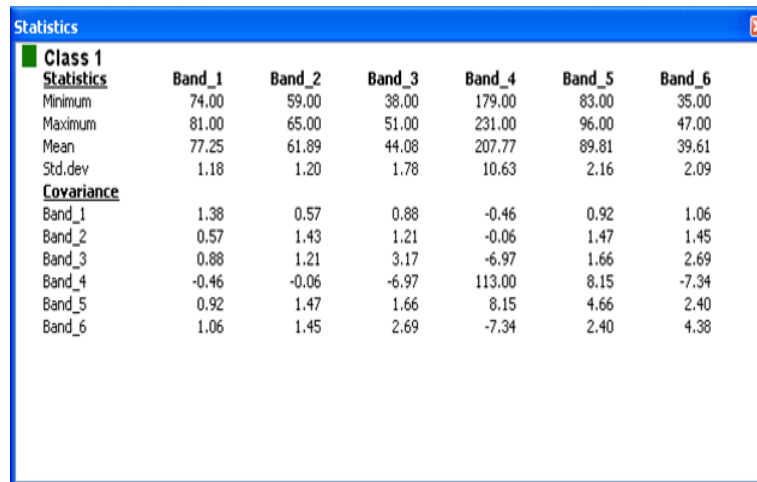


Figure 10 Signature Statistics

- **Scatter Plot**

Scatter plots are graphical representations that compare individual pixels within the spectral signature between two bands. For example, the pixel values found in band 1 are plotted against the pixel values found in band 2. The same can be done for band 2 to band 3, band 3 to band 4 and so on.

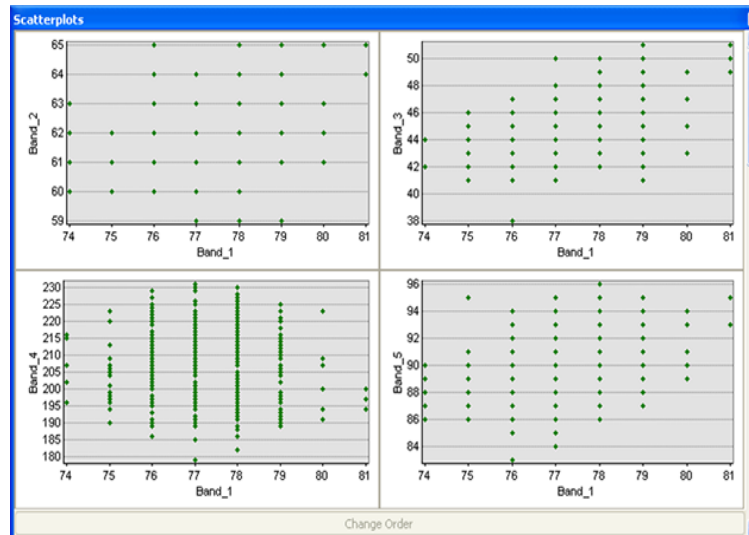


Figure 11 Scatter Plots

Training Sample Manager

To delineate a spectral signature using the Training Sample Manager, the analyst chooses the polygon tool and draws a polygon for a single land cover type. Care is taken not to delineate an area that represents more than one cover type. For example, in the Figure 12, the polygon is drawn within the field boundary of the image. Note the area delineated does not follow the edge of the field or include areas that are definitely not within the field itself.



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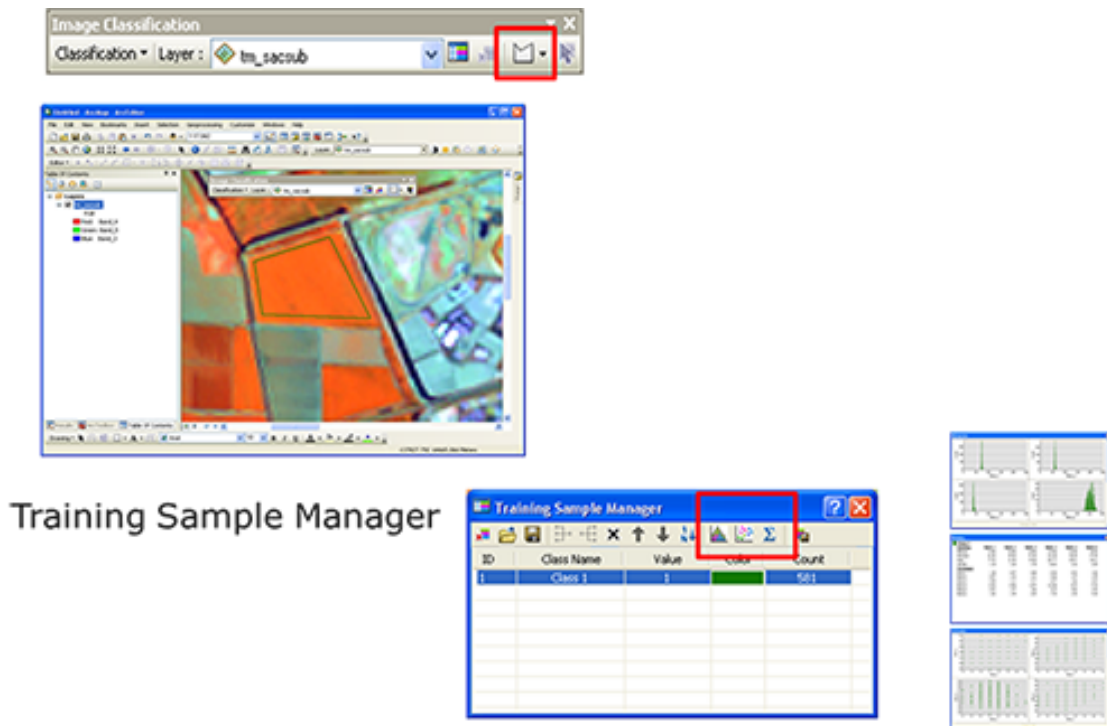


Figure 12 Screenshot of the Training Sample Manager being used to delineate a spectral signature as discussed under the Training Sample Manager heading above.

Evaluating Spectral Signatures

Once the signature is delineated the different spectral evaluation tools can be used to review the quality of the signature. The same process can be used to create new signatures for all of the different land cover types. When a full set of spectral signatures is created, a signature file can be saved.

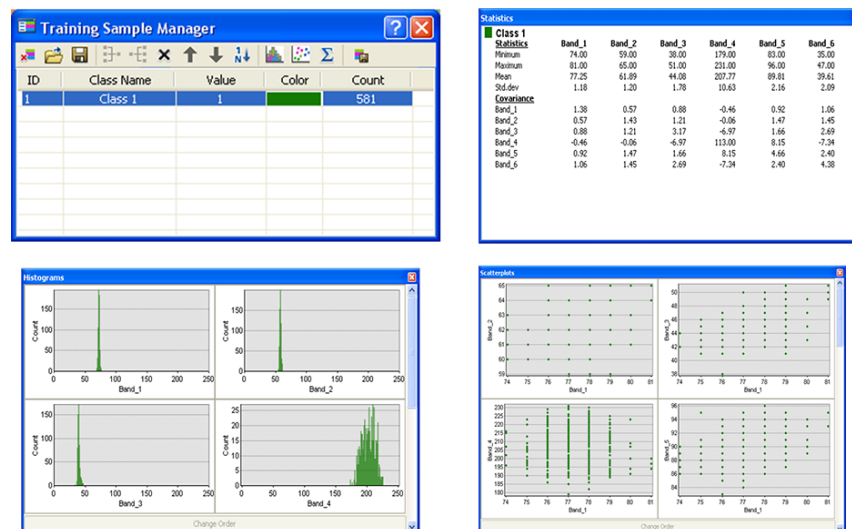


Figure 13 Spectral Signatures



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Dendrogram

Once a number of spectral signatures are created in the Training Sample Manager, the entire group of signatures can be evaluated by using the Dendrogram Tool in the Multivariate Toolset under the Spatial Analyst Toolbox. The input to this tool is the spectral signature file created when the spectral signatures are delineated.

The dendrogram tool runs and generates a text file that shows a series of connected lines. The left side of the file represents specific signature numbers. For each pair of signatures a horizontal line is shown and then a vertical line connects the two signatures together. The length of the horizontal lines determines how similar or different a pair of spectral signatures is from one another. Short horizontal lines indicate that a pair (or group) of signatures are similar. Longer horizontal lines indicate dissimilarity or an indication that two or more spectral signatures may represent different land cover types.

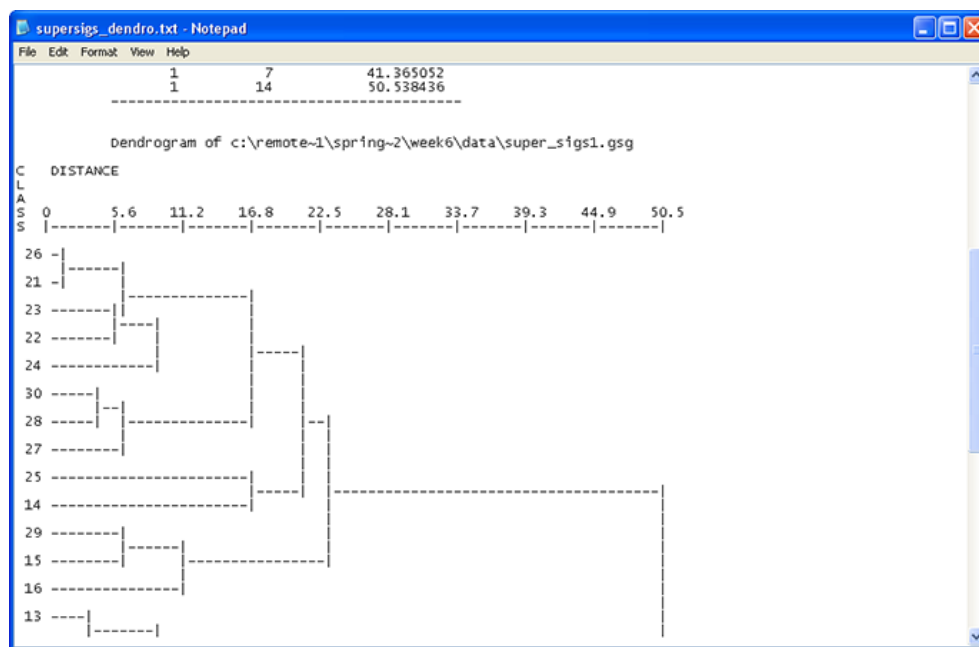


Figure 14 Dendrogram

Dendrogram Routine

The dendrogram routine is often run to check entire spectral signature sets where the analyst can then make decisions to make adjustments on individual spectral signatures and add or delete spectral signatures.

It is good practice to evaluate both individual and a full set of spectral signatures before implementing an image classification routine. The analyst should insure that the spectral signatures are high quality and the full set represent the land cover classes that are expected to be categorized in the image classification.



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Unsupervised Classification

The unsupervised classification method automatically categorizes image pixels into a specific number of “spectral classes” or categories that have similar spectral characteristics. These groups of pixels have the same kinds of pixel values and the standard deviations and variances are small. This, however, is all relative, since the number of classes assigned by the user may include multiple cover types that actually have similar spectral characteristics. This can be a problem for the analyst and can produce erroneous information in an output image classification.

A number of common unsupervised classification options exist in image processing software: ISODATA, IsoCluster, and K-Means are three such processes.

- **ISODATA** stands for Iterative Self Organizing Data Analysis). As the name indicates, this algorithm iterates multiple times to eventually create a categorized image and can optionally generate a spectral signature file that contains spectral characteristics for each spectral class identified in the image output.
- The **IsoCluster** is a slight modification of the ISODATA algorithm and is the version that is offered in ArcGIS.
- **K-Means** is another option for unsupervised classification where the analyst identifies a specific pixel for specific land cover types. This “seed” pixels serves to initiate the K-Means unsupervised algorithm.

Unsupervised Classifications in ArcGIS

Two unsupervised classification processes exist in ArcGIS. The IsoCluster Unsupervised Classification produces both an image and an optional spectral signature file. The IsoCluster Tool only generates the spectral signature file. The input parameters for each tool are nearly identical. For either model the IsoCluster operation requires a set of parameters. Each one is described within the Spectral Classes.

IsoCluster Unsupervised Classification Tool

Provided below is a description of the IsoCluster Unsupervised Classification tool. It is important to note that the IsoCluster Unsupervised Classification tool requires an image output.

IsoCluster Unsupervised Classification Tool (ArcGIS)

- **Input image data set** is the input multispectral image data set.
- **Number of output spectral classes** is the number of expected unique groups of pixels (i.e. spectral classes). The spectral classes represent pixels with similar spectral characteristics and may or may not refer to specific land cover types). A value of 2 or greater is required.
- **Minimum number of pixels in a class** refers to the minimum number of individual pixels used to create a spectral class. The default is 20 and is often used.
- **Sample interval** refers to how often input pixels will be evaluated for inclusion into a spectral class. The default is 10 and is usually used.
- **Output image** is the output image containing groups of pixels with a unique spectral class (often an integer data type).



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- **Output Spectral Signature File (optional)** is a file that can be used for further spectral analysis or for use with a supervised classification method

IsoCluster Tool

The IsoCluster Tool provides an option to have the analyst assign a specific number of iterations to run the IsoCluster process and does not produce an output image, but only an output spectral signature file. Provided below is a description of the IsoCluster Tool.

IsoCluster Tool

- **Input image data** set is the input multispectral image data set.
- **Number of output spectral classes** is the number of expected unique groups of pixels (i.e. spectral classes). The spectral classes represent pixels with similar spectral characteristics and may or may not refer to specific land cover types). A value of 2 or greater is required.
- **Number of Iterations** refers to the maximum number of iterations the IsoCluster Tool will run before stopping the process.
- **Minimum number of pixels** in class refers to the minimum number of individual pixels used to create a spectral class. The default is 20 and is often used.
- **Sample interval** refers to how often input pixels will be evaluated for inclusion into a spectral class. The default is 10 and is usually used.
- **Output Spectral Signature File** is a file that can be used for further spectral analysis or for use with a supervised classification method

Unsupervised Classification Process: 6 Step Process

The unsupervised classification process basically requires six steps to complete.

Step 1

The user sets up the algorithm with the required parameters. Often the number of spectral classes and a number of iterations are required, but can be different depending on the software used.

Step 2

Behind the algorithm, the first process that is implemented is to create a set of means for each specific spectral cluster (or spectral class) which contains a group of pixels. The initial set of classes is arbitrary.

Step 3

The image pixels are evaluated against the "spectral class" means. For a given pixel, if it is similar to one of the class means, then it is assigned to that specific spectral class. If the pixel does not meet any of the spectral classes, then it is not considered during this iteration.

Step 4

After the assignment of some of the pixels, the spectral class statistics are recomputed. If the statistics significantly change, then a new spectral class is created. If the spectral classes have similar statistics, then they can merge.

Step 5

Individual pixels are again checked again to see if they are similar to one of the spectral classes and then assigned one of the specific spectral classes. Essentially, steps 3 and 4 are



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iterated and repeated until the number of iterations is reached or the spectral class statistics do not change between subsequent iterations.

Step 6

The final step is to assign all of the pixels to one of the spectral classes and generate an output image and optionally a spectral signature file.

Unsupervised Example

Figure 15 shows an example of the classified image output and the associated spectral signature file. The output image is often initially displayed as a gray scale image. The analyst can assign colors to each output spectral class.

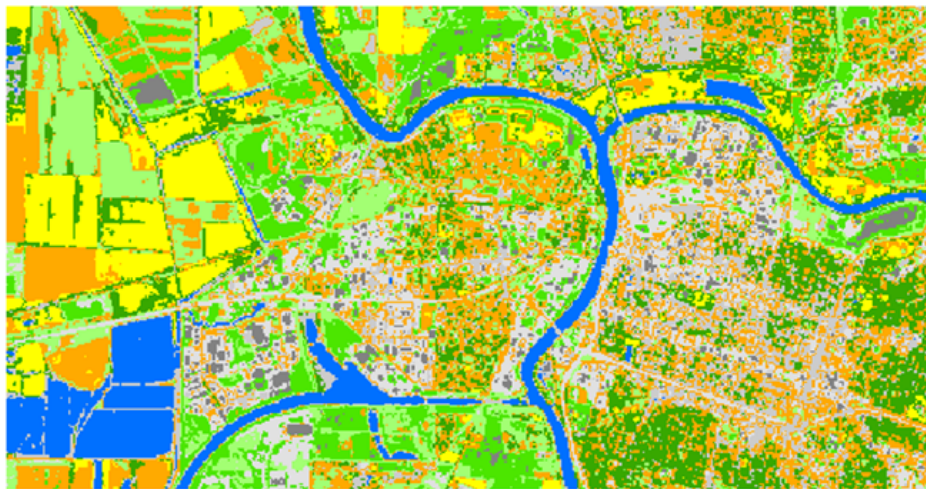


Figure 15 Output Classified Image



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```

isoclust10.gsg - Notepad
File Edit Format View Help
# Signatures Produced by Clustering of Raster
# c:\remote_sensing\spring2011\week5\data\image_classificationpt1.gdb\tm_sacsub
# number_of_classes=10 max_iterations=20 min_class_size=20
# sampling_interval=10

# Number of selected grids
# 6
# Layer-Number Band-name
# 1 Band_1
# 2 Band_2
# 3 Band_3
# 4 Band_4
# 5 Band_5
# 6 Band_6

# Type Number of Classes Number of Layers Number of Parametric Layers
# 1 10 6 6
# =====
# Class ID Number of Cells Class Name
# 1 78
# Layers
# Means
# Covariance
# 1 88.83333 69.75641 61.38462 45.06410 27.56410 22.41026
# 2 60.60823 60.75108 68.57143 1.45238 22.95238 28.80952
# 3 60.75108 75.43340 83.71828 26.78205 27.55478 26.72461
# 4 68.57143 83.71828 109.27872 47.53347 38.05295 35.91808
# 5 1.45238 26.78205 47.53347 204.94389 96.50882 45.99933
# 6 22.95238 27.55478 38.05295 96.50882 101.91142 66.83050
# 28.80952 26.72461 35.91808 45.99933 66.83050 52.86846
# -----
# Class ID Number of Cells Class Name
# 2 94

```

Figure 16 Optional Signature File

Typically, once an unsupervised classification is performed significant work is still required by the analyst. The output of the unsupervised classification is "spectral" classes and not "information" classes.

Remember a "spectral class" is a set of pixels that have similar spectral characteristics (irrespective of the actual land cover type). This is why a spectral signature file can be created from an unsupervised classification routine.

An "information class" is one that actually represents one of the land cover categories in a classification scheme. An information class can be represented by one or more spectral classes and often requires a subsequent processing step to "recode" spectral classes into information classes. This process will be discussed more depth further in this lesson.

Spectral classes derived from an unsupervised classification can and often do contain pixels from one or more specific land cover types. The analyst will not know which land cover type (or types) each spectral class represents. Additional field work, air photo interpretation, and/or additional image classification processes are required to properly identify unique land cover types in the resulting classification output data set.

Supervised Classification

This segment of the lesson discusses another traditional image classification process, the supervised classification. The object-based image classification method will not be discussed in this lesson since there are not methods within ArcGIS that where this can be used. The general process has already been identified and students are encouraged to review the references provided in the Overview of Remote Sensing lesson.

Supervised Steps

As the name implies the image classification requires supervision by the analyst. This comes in the form of creating spectral signatures for the different expected land cover classes in the



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geographic area. The analyst will know or be able to determine the specific land cover type for each spectral signature. The supervised classification process can be illustrated in three steps.

Step 1 - Training

The analyst creates “training” sites for the different land cover classes expected in the output. The analyst will create spectral signatures that cover the variability for each land cover type. The collection of spectral signatures represents the “knowledge” that is needed by the supervised classification to “train” the classifier to identify the specific land cover types in the output image.

Step 2 - Classification

Once the spectral signature file is created, it will be used as the primary input to perform the image classification.

Step 3 - Output

The last step (or really, the result of the classification step) is to create the actual output image. In addition to the output image, there may be associated tables of quantities of land cover types, an accuracy assessment, and a report.

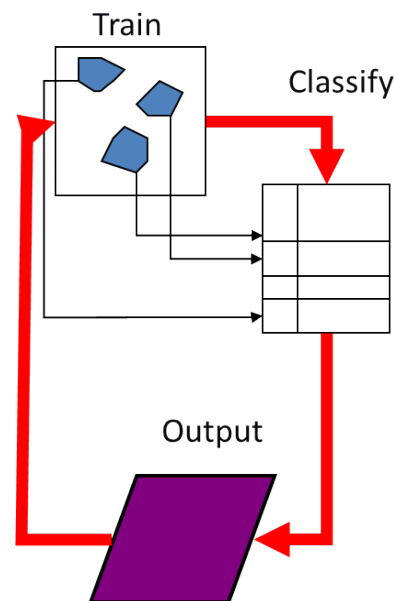


Figure 17 Supervised Classification Process

Creating Spectral Signatures

The key to the success of the supervised classification is the quality of the spectral signature file and the individual spectral signatures that make up the file. Each land cover type should have a number of spectral samples that represent the spectral variability of the class. Being able to properly identify these will often require field visits, air photo interpretation, and reviewing other land cover maps.

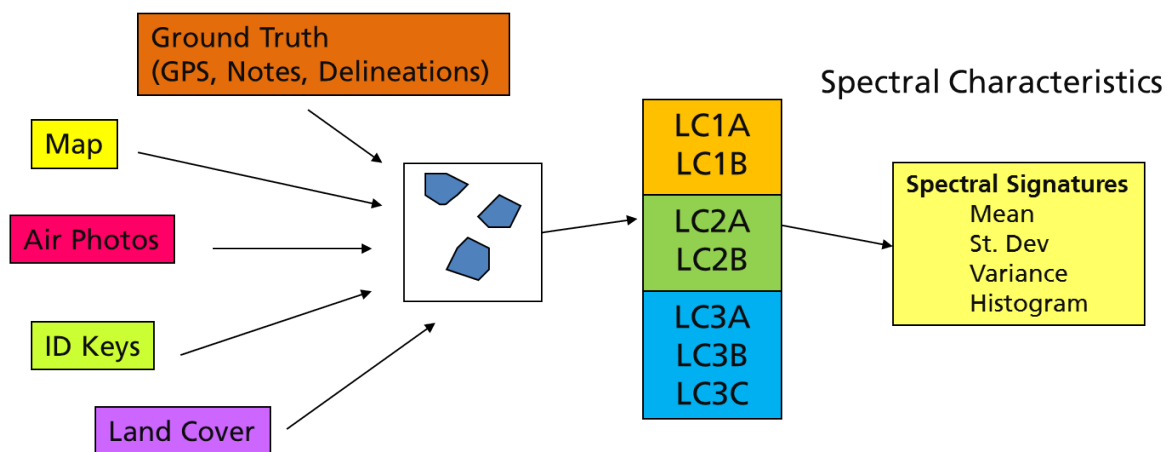


Figure 18 Example of Spectral Characteristics



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Evaluating Spectral Signatures

Once the spectral signatures are created, they need to be individually and collectively evaluated to make sure each signature represents one and only one land cover type and the entire set of the spectral signatures represents well-grouped signatures that represent all of the land cover types expected in the resulting land cover classification data set. Spectral evaluation tools are often available in digital image processing software that is capable of performing image classifications.

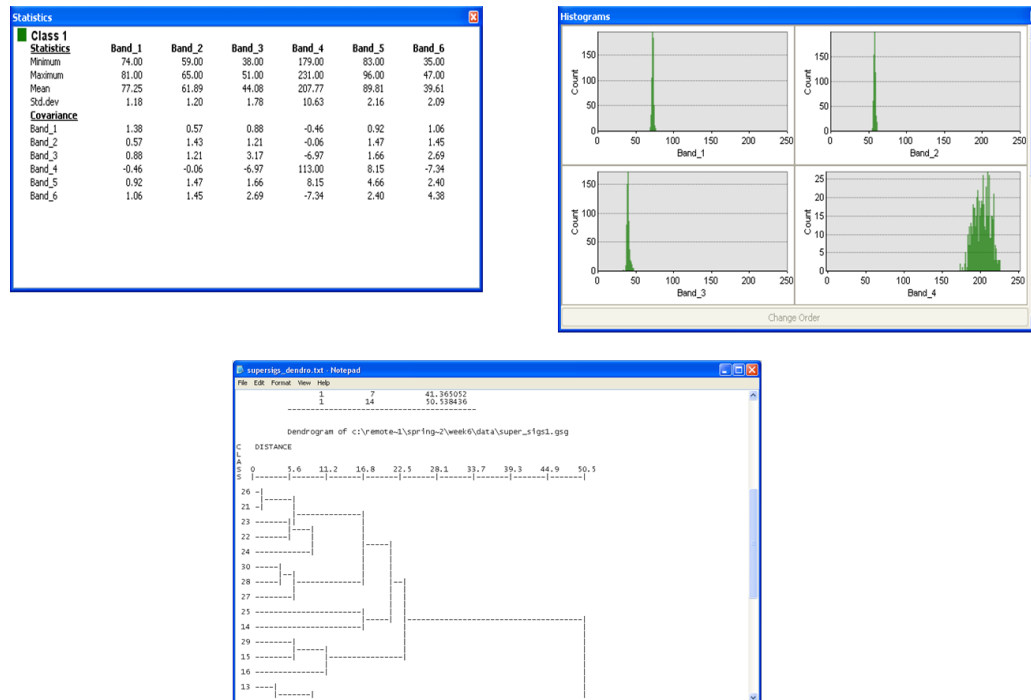


Figure 19 Digital Image Processing: Evaluating Spectral Signatures

Supervised Classification Example

Once a high quality spectral signature file is created and has been evaluated and tuned to contain the best set of spectral signatures of each land cover type, it is used in the supervised classification algorithm (often the Maximum likelihood algorithm) which then generates the output classified image.

The result of the supervised classification does contain the individual spectral classes where each category in the output supervised classification represents one of the spectral signatures from the spectral signature file. Since the signature file contains multiple signatures for each land cover type, the resulting image classification needs to be further refined into "information classes." This will be the subject of the next segment of the lesson titled, Spectral Classes to Information Classes, and will represent the final stage of the image classification process.

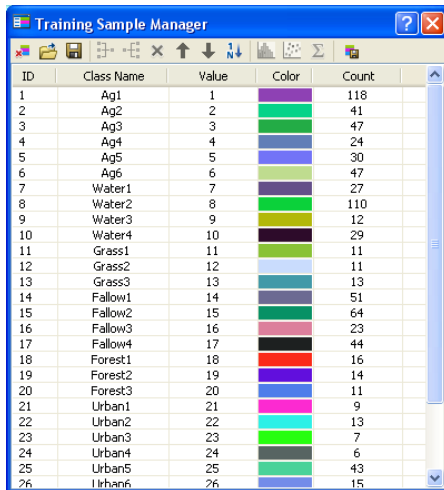


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ID	Class Name	Value	Color	Count
1	Ag1	1		118
2	Ag2	2		41
3	Ag3	3		47
4	Ag4	4		24
5	Ag5	5		30
6	Ag6	6		47
7	Water1	7		27
8	Water2	8		110
9	Water3	9		12
10	Water4	10		29
11	Grass1	11		11
12	Grass2	12		11
13	Grass3	13		13
14	Fallow1	14		51
15	Fallow2	15		64
16	Fallow3	16		23
17	Fallow4	17		44
18	Forest1	18		16
19	Forest2	19		14
20	Forest3	20		11
21	Urban1	21		9
22	Urban2	22		13
23	Urban3	23		7
24	Urban4	24		6
25	Urban5	25		43
26	Urban6	26		15

Figure 20 Required Signature File

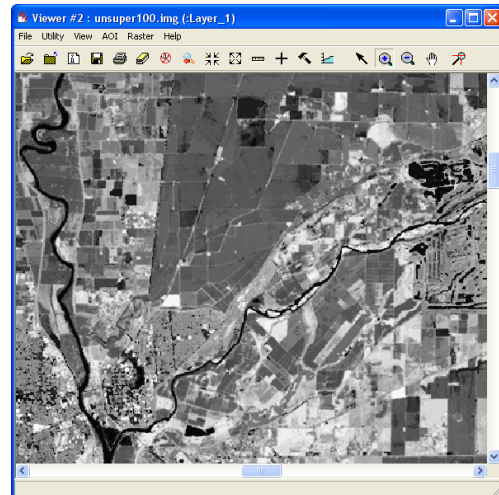


Figure 21 Output Classified Image

Recommended References: The following text is recommended for further study of spectral signatures.

Lillesand, Kiefer, and Chipman, 2007. *Remote Sensing and Image Interpretation*, 6th ed., Wiley & Sons, ISBN: 0470052457 and ISBN-13: 978-0470052457

Spectral Classes to Information Classes

This segment of the lesson covers the conversion of spectral classes to information classes. In many of the traditional image classifier routines the output image data set represents spectral classes, that is, each output class represents a unique set of pixels that have similar spectral characteristics. Since many spectral classes represent a single land cover type (or information class), a reclassification process is required to convert the spectral classes to the specific information classes that represent the land cover types in the final classification data set.

Conversion Process

A simple classification scheme (Figure 22) is shown on the left and a representation of the spectral signature file that was created to generate the image classification.

An output image classification is shown at the bottom of Figure 22 and the corresponding spectral class categories shown above it. Note that each unique spectral class is represented by a number which also corresponds to the signature number in the table on the left side of Figure 22. The groups of spectral classes have been outlined in colored boxes that represent the different land cover types.

The arrows in the spectral class list are pointing to the individual information classes or the specific land cover types that the spectral will be reclassified. Once the spectral classes have been reclassified or recoded to the information class, which is from the spectral class numbers 11 through 55 to the information classes 1 through 5, the final land cover classification is complete.



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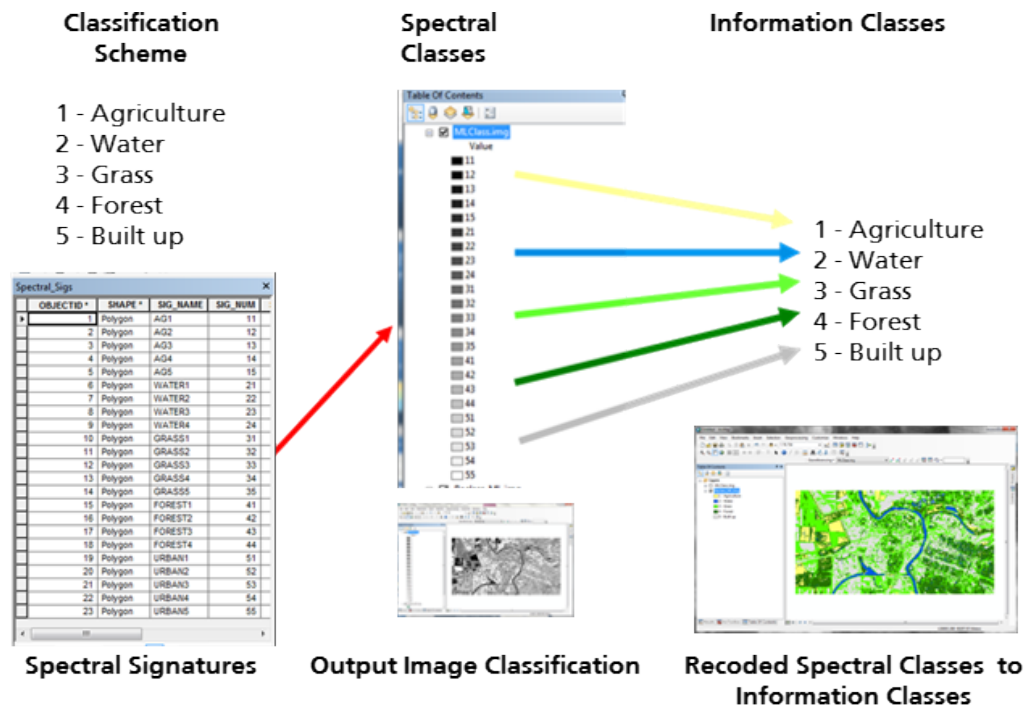
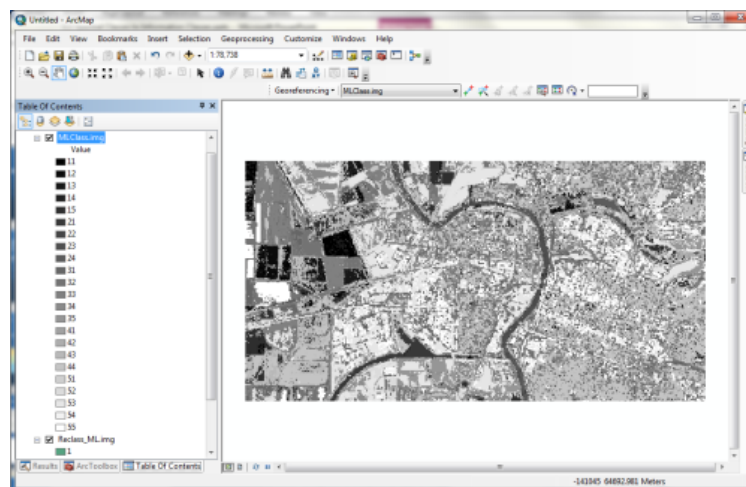


Figure 22 Conversion Process: Simple Classification Scheme

Spectral Class

This image is a more detailed representation of the original output from an image classification that shows the spectral classes. Note that this output image is normally depicted with gray scale values and then are assigned meaningful colors after the spectral classes have been recoded to information classes. You will note that the spectral classes range from 11 to 55, where each number represents a specific spectral class. See the previous Figure 22 and look at the spectral signature table to see the respective spectral signature names are that relate to the spectral class numbers.



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Figure 23 Output Classified Image

Information Classes

The image provided shows the final classification data set where the spectral classes have been recoded to the information classes. Colors have also been applied to make the resulting image more meaningful. Note also that the land cover names are showing in the table of contents of the ArcMap window.

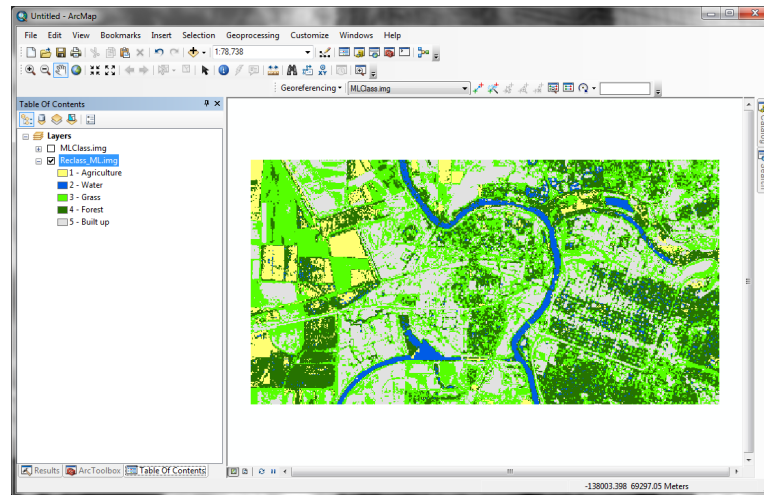


Figure 24 Recode Spectral Classes to Information Classes

Recode Spectral Classes to Information Classes

The recoding process is performed by using a tool to convert the spectral classes to information classes. In the case of ArcGIS, the Reclassify tool is used. The spectral classes 11 through 55 found in the output image from the supervised classification process are re-assigned to the values 1 through 5 to match the number corresponding to the specific land cover types (that is information classes) found in the classification scheme. Once the recoding process is complete, the image final image classification is complete. Appropriate colors can be assigned and the specific land cover names can be added to a table associated with the image file or can be renamed as part of a legend on a land cover map. Review Figures 25-27.



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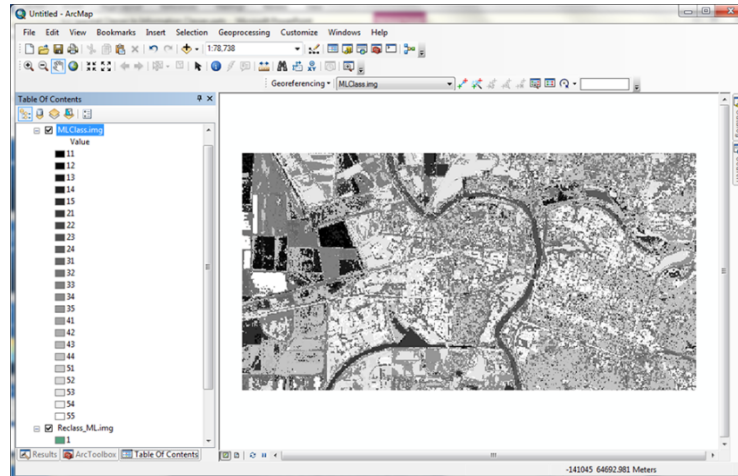


Figure 25 Output from Image Classification

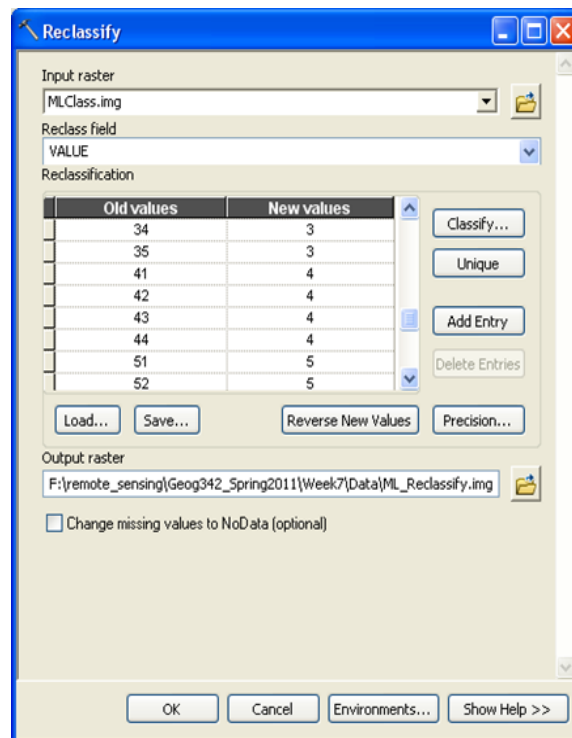


Figure 26 Screenshot of Reclassify box



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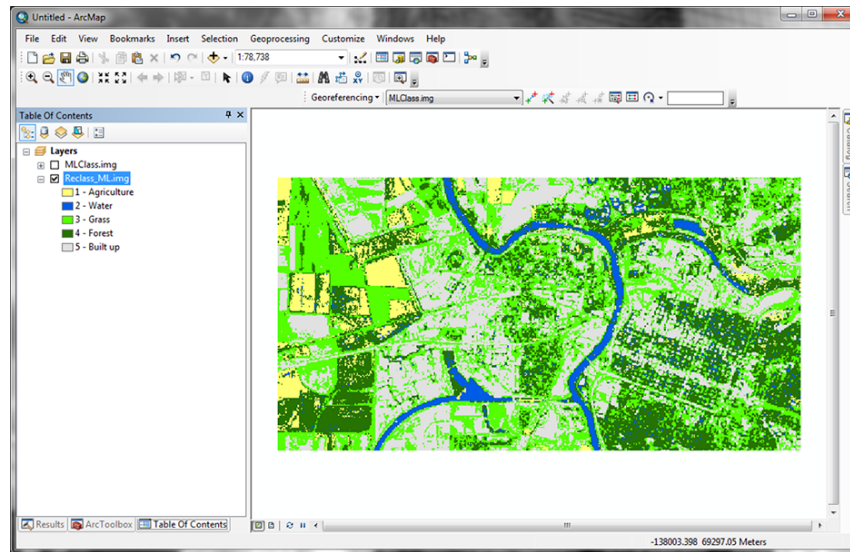


Figure 27 Recoded Spectral Classes to Information Classes

SUMMARY

In this lesson you learned about image classification. The first section of the lesson focused on what image classification and explains attributes, special features, and traditional image classification. You gained an understanding of how spectral signatures are used, and evaluated. Supervised and Unsupervised classification were also explained and demonstrated as well as the conversion process of spectral classes to information classes.

ASSIGNMENTS

1. Quiz
2. Lab: Unsupervised Classification
3. Lab: Supervised Classification



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