

ArcView Image Analyst

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C H A P T E R 1

Introduction to the ArcView Image Analyst

This book will introduce you to new ways to process and evaluate your images using ArcView® Image Analyst. Image Analyst provides the capability to display, enhance, and analyze remotely sensed imagery through a new theme type, IATheme. With Image Analyst, you can import images from numerous data types, and you can both read and write multiple data formats. Using Image Analyst tools, the data you import can be visually manipulated using histogram stretching options, rectified to a map projection system, and categorized to map various cover types.

The Image Analyst helps you process your images in a number of ways:

Import satellite and raster data into the ArcView environment with the option of calculating pyramid layers.

Change the appearance of images by applying contrast and brightness tools so that certain areas become more prominent.

Align images with standard map coordinate systems for precise area location.

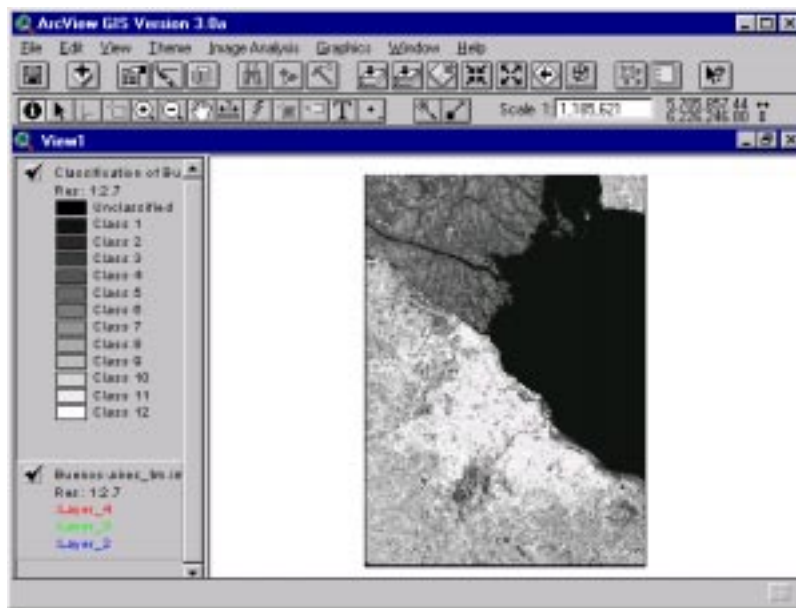
Evaluate areas at different time periods and identify small examples of a cover type to find like areas throughout images.

Classify areas based on their components, such as vegetation.

What you can do with the Image Analyst

The Image Analyst helps you manipulate images to extract meaningful information. You can perform unsupervised classifications of unfamiliar data to begin analysis. Image analysis can also be greatly enhanced by applying histogram stretches as well as Smooth and Sharpen features in an image. To compare images, you can use Image Analyst's Image Difference tool. The Image Analyst provides you with a Vegetative Index to target areas whose land cover class is difficult to distinguish. In the following examples, you will see how you can use Image Analyst to extract more information from your images.

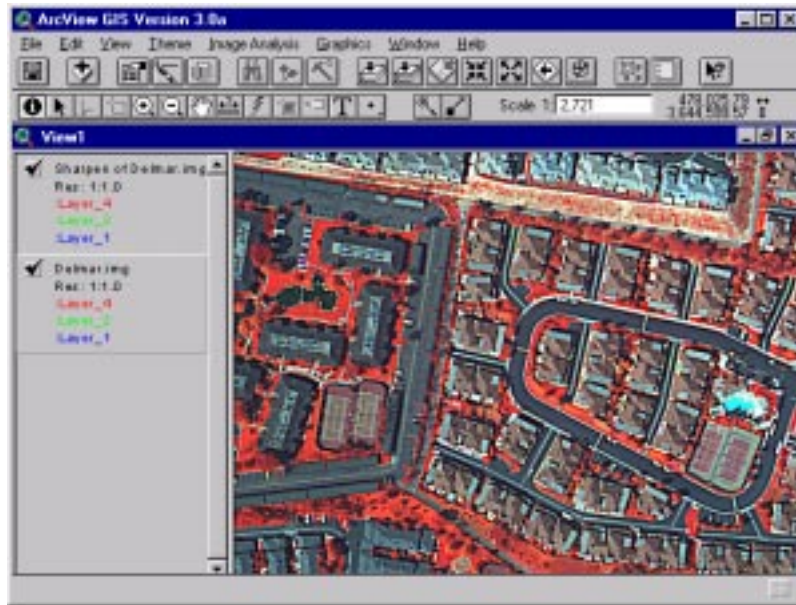
Consider the image of Buenos Aires below which, when it was first drawn in the View, had only three obvious classes. Image Analyst provides you with a Categorize tool which rapidly groups values in your image into a designated number of classes – however many classes you choose. Once you perform an initial classification of your data, it is easier to isolate specific areas for further analysis. In this example, you may wish to study areas which fall into the Class 5 designation.



This picture shows an image of Buenos Aires. The original image had only three visibly discernible classes, but the categorize option breaks the image into as many classes as you wish, in this case, 12.

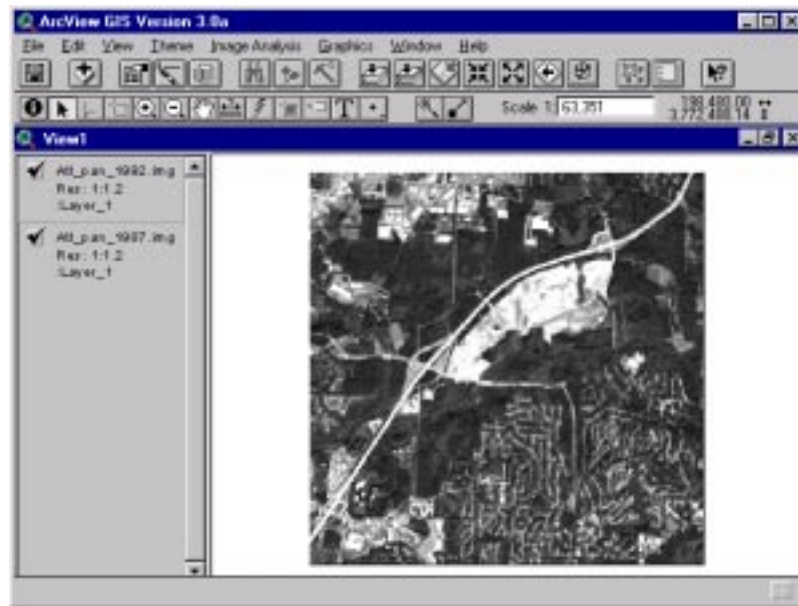
Suppose you are working with an image, like the image of Moscow below, which contains a lot of detail. Even if you are zoomed in significantly, certain features of the image are difficult to distinguish, especially their boundaries. The Image Analyst provides you with both histogram stretching options which make your data display in

many different ways, and Smooth and Sharpen features which greatly enhance your images. By applying the Sharpen tool to an image, you can see much more detail.



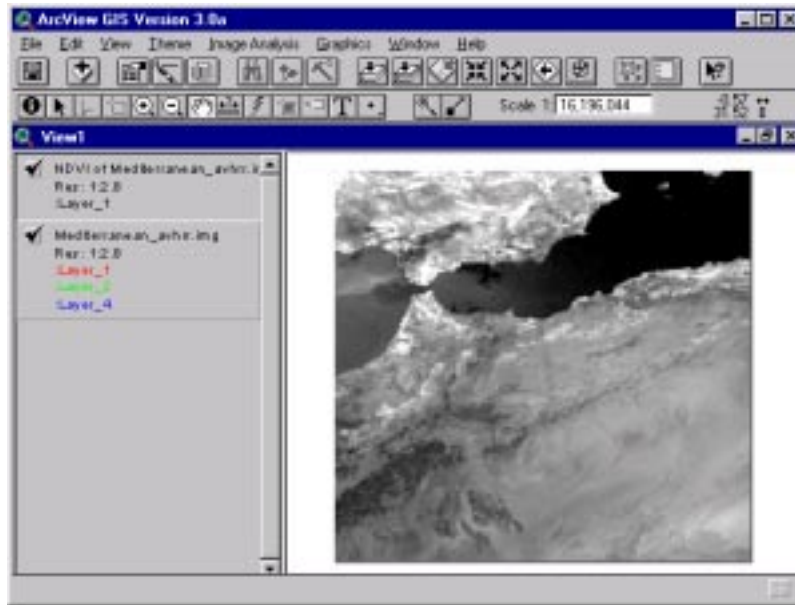
This example illustrates the use of the Sharpen tool on an image of Moscow. The result is an theme with much finer detail.

If you want to compare two images of the same area over time, Image Analyst is able to easily perform that comparison for you. A good example involves development of an area, in this case, North metro Atlanta. You can set the parameters to be considered in determining the amount of change. In the following example, the areas of change are 25% or greater. The result is that areas in the Northeastern portion of the image, highlighted in green, have undergone the most construction and development during the intervening 5 years.



This picture illustrates the amount of change in the North metro Atlanta area between 1987 and 1992.

In the example below, The Vegetative Index was applied to an image of the Mediterranean Sea and surrounding land mass so that you can clearly discern areas of thriving dense vegetation. These areas were difficult to distinguish in the original image. The Vegetative Index allows you to choose which bands of data you wish to consider for vegetative analysis. Once you have clearly defined areas, it is easier to classify and assign names to all the areas which make up your image.



The image above illustrates the use of the Vegetative Index tool on an image of the Mediterranean Sea and surrounding land mass. Areas of vegetation are bright.

These examples illustrate just a few of the tools you can apply to your images using the Image Analyst. For detailed instructions on how to apply the tools, see Chapter 2, 'Quick start tutorial.'

Tips on learning the Image Analyst

The more you know about ArcView, the better prepared you are to use the Image Analyst. We assume that you are already familiar with the way ArcView works, and that you have worked through the 'ArcView Quick Start Guide.' We also assume you have spent time exploring the software. If you are unfamiliar with the software, you should refer to *Using ArcView* to familiarize yourself with the ArcView user interface and ArcView capabilities.

What to read next

If you are just discovering the Image Analyst, a good place to start learning about what you can do with the Image Analyst is to read the 'Quick start tutorial,' Chapter 2 of this book. This chapter gives you a brief overview of the types of information you can obtain using the Image Analyst. You will also learn basic steps and techniques to process an image using the Image Analyst by following an analysis of an image from start to finish.

How to get on-line help

You can use ArcView's on-line help to get information about various components of the Image Analyst extension, including: button, tool, and menu functions; dialog box functions; and an index of the complete on-line help.

To find out what a button, tool, or menu choice does

Move the cursor over it, but do not select it. A short description appears in the status bar.

To get help about a button, tool, or menu choice

1. Click the Help button.
2. Click the button, tool, or menu choice you want to get help about.

To get help about a dialog box

Press the F1 key on your keyboard when the dialog is displayed. Some of the more complex dialogs also provide a Help button equivalent to the F1 key.

To browse the contents of the ArcView help

1. From the Help menu, choose Help Topics.
2. Click the Contents tab.

To search the index of the ArcView help

1. From the Help menu, choose Help Topics.
2. Click the Index tab.

To search the ArcView help for a particular word

1. From the Help menu, choose Help Topics.
2. Click the Find tab.

Getting technical support from ESRI

The product registration and support card that came with ArcView and the "Obtaining technical support" section of ArcView's on-line help provide further information.

Visit ESRI and ERDAS on the web

For more information on ESRI® products and services, visit ESRI's web home page at www.esri.com. For more information on ERDAS® products and services, visit ERDAS' web home page at www.erdas.com.

CHAPTER 2

Quick start tutorial

To complete this tutorial, you should already be familiar with ArcView software. If you would like to review the functions of ArcView, we suggest you consult the ‘Quick start tutorial’ in *Using ArcView GIS*. The tutorial will refresh your memory on basic terminology and interface concepts. This book shows you how to expand on those concepts using Image Analyst.

This chapter contains exercises which give you basic instructions on how ArcView’s Image Analyst extension works. You may have selected Image Analyst for specific functionality such as import of various file formats, refinement of imagery, rectification, or image analysis and feature extraction. This tutorial shows you how to apply some of those tools to process images.

As you work through the exercises, you can obtain additional information about the concepts and techniques by reading the side notes. You can learn more about these topics in the other chapters of this book and in the ArcView on-line help.

This chapter leads you through the following exercises using Image Analyst:

Exercise 1: Working with Image Analyst themes.

Exercise 2: Adjusting histogram (lookup table) stretches.

Exercise 3: Performing image analysis.

Exercise 4: Evaluating thematic change.

You can simply read through this tutorial, or you can use your computer to follow the exercises step-by-step. To follow along, the Image Analyst extension and tutorial files should already be loaded on your system. If you installed the tutorial files, they are located in the directory /AVTUTOR.

Exercise 1: Working with Image Analyst themes

In the first exercise, you will import and analyze an Image Analyst theme. Image Analyst creates a new theme type, the IA Theme, which is supported by ArcView Version 3.0a.

In this exercise you will learn:

How to load the Image Analyst extension.

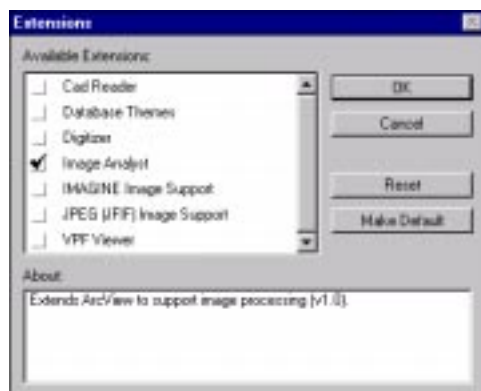
How to view an Image Analyst theme.

How to zoom to image resolution.

How to incorporate feature themes.

How to remove an Image Analyst theme from a view.

Start ArcView




You can load ArcView extensions easily by accessing the Extensions dialog. If you wish, you can click the Make Default button so that Image Analyst is automatically loaded every time you start ArcView.


Load the Image Analyst extension

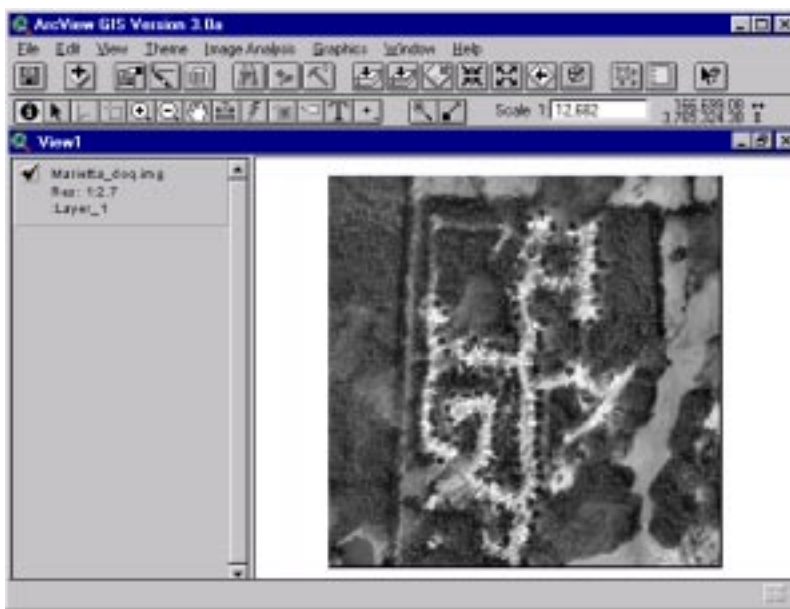
1. From the File menu, choose Extensions.
2. Click in the check box labeled Image Analyst. Click OK in the Extensions dialog.

Open a new view

1. Choose Views  at the left of the project window.
2. Click New to open a new view.

Add and draw a new IA theme



1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double click on marietta-nw_doq.img to add it as a theme.
5. Click the check box in the legend to draw the theme.




This is the image of Marietta as it was drawn in the view.

Change image display scale

You can easily change the scale in which the image is depicted by typing a new value in the Scale field.

1. Type the value “24000” in the Scale field (located in the ArcView tool bar).
2. To set the image to a full resolution, click the Zoom to Image Resolution button .
3. Click the Pan tool  and move the image in the view.

Add a vector feature theme

1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Feature Data Source.
4. Double click on marietta_rds.
5. Click the check box to draw the theme in the view.



This is the image of Marietta with the road shapefile.

Identify a feature

1. Click the Identify button .

2. In View1, click to choose a road.



3. Close the Identify Results dialog box.

Cut themes from the view

1. Make both themes active in the view.
2. From the Edit menu, choose the Cut Themes option to remove all themes from View1.

Exercise 2: Adjusting histogram (lookup table) stretches

One of the benefits of Image Analyst is that it allows you to display the same data in many different ways. Histogram stretching enables you to manipulate the data to make areas of your image easier to interpret and evaluate.

In this example, you will work with an image of Moscow. With this image, you can apply different histogram stretches to make drastic changes to the way the image is output to the display. You can also reverse that output by applying an Invert Stretch.

In this exercise, you will learn:


How to apply different histogram stretches.

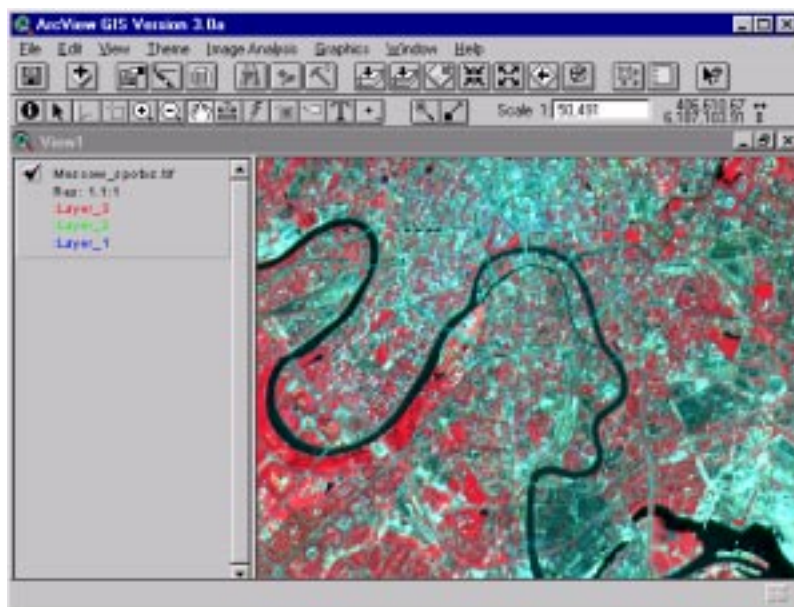
How to use the Brightness and Contrast slider bars.

How to apply the Invert Stretch button.

How to use the Sharpen function.


Add and draw a new IA theme

1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double click on moscow_spot.tif to add it as a theme.
5. Click on the check box in the legend to draw the theme.

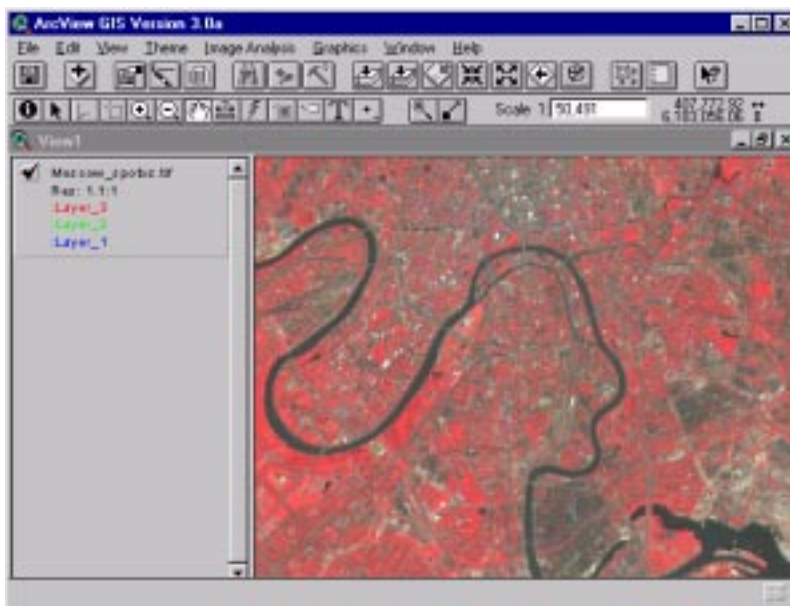


The theme Moscow_spot.tif draws in the view.

Apply a histogram stretch to an image

1. Click the Edit Legend button  to display the Image Analyst Legend Editor dialog.
2. Click the Stretch dropdown list and choose Minimum-Maximum. Click Apply.

3. Use your mouse to move the Brightness and Contrast slider bars slightly to the right. Click Apply.
4. Repeat the application of the Brightness and Contrast slider bars until the image is clear.

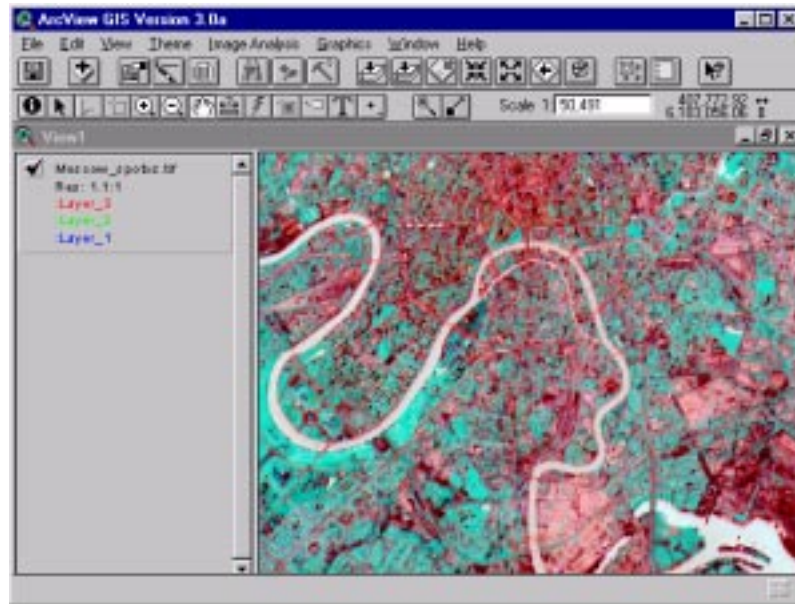


The Minimum-Maximum contrast stretch greatly affects the appearance of the image. Apply the Brightness and Contrast slider bars to enhance the image.

5. From the Image Analyst Legend Editor, click the Stretch dropdown list and choose Standard Deviations. Click Apply.

Apply an Invert Stretch to an image

1. From the Image Analyst Legend Editor, click the Invert Stretch button.




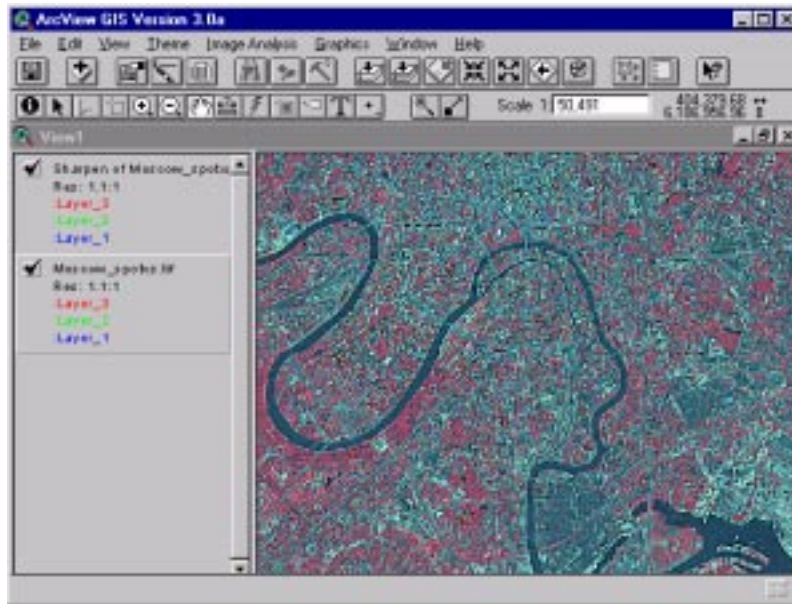
This picture illustrates the use of the Invert Stretch option. The result is a color negative of the original image.

2. Click Undo in the Image Analyst Legend Editor.
3. Close the Image Analyst Legend Editor.

Zoom to image resolution and sharpen

Before you can apply the Sharpen tool, you must first zoom to the image resolution. This ensures that you see a marked improvement in the display of your image after the tool is applied.

1. Click the Zoom to Image Resolution button .
2. From the Image Analysis menu, choose Sharpen.
3. In the legend, click the check box of Sharpen of Moscow_spot.tif to draw the theme.



The resulting theme from the use of the Sharpen tool is drawn in the view. This example shows how the Sharpen tool can considerably improve some of the visible detail in the image.

4. Make both themes active in the view.
5. Click the Edit menu and choose the Cut Themes option which removes all themes from View1.

How does the Sharpen tool work?

To adjust the sharpness of an image, Image Analyst applies standard *convolution filtering techniques*. Convolution techniques average small groups of pixels within an image and make changes in spatial frequency. *Convolution kernels* are applied by the Sharpen function so that pixel values are averaged.

Note For more information on the Sharpen application, see Chapter 4, 'Displaying and enhancing Image Analyst themes.'

Exercise 3: Performing image analysis

The Image Analyst extension to ArcView is designed to provide you with image enhancement and feature extraction tools which are easy to apply. The tools unique to the Image Analyst extension are Vegetative Index, Seed, Find Like Areas, Image Difference, and Categorize. With these tools, you can analyze many elements of your images.

In this exercise, you will learn:

How to use the Vegetative Index.

How to use the Seed tool.

How to find like areas within an image.

How to perform an Image Difference calculation.


How to perform an unsupervised classification.

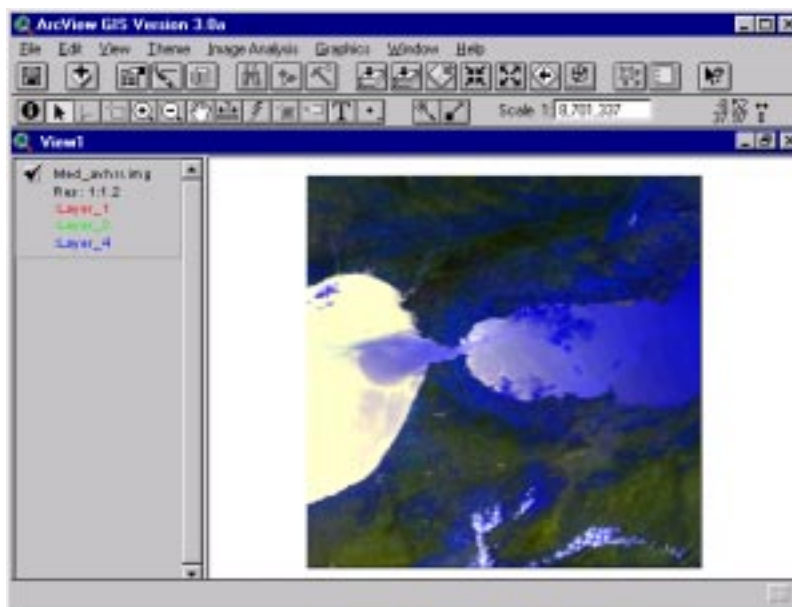
Vegetative Index

The Normalized Difference Vegetation Index (NDVI) calculates areas of vegetation in your image. With the Vegetative Index, you are able to discern the healthy and highly vegetated areas in an image.

In the following example, you will work with an image of the Mediterranean Sea and surrounding land mass. In the image, areas of water and land are obvious. The different kinds of vegetation, however, are more difficult to pick out. By applying the Vegetative Index, you can select specific areas of vegetation for further analysis.

Add and draw a new IA theme

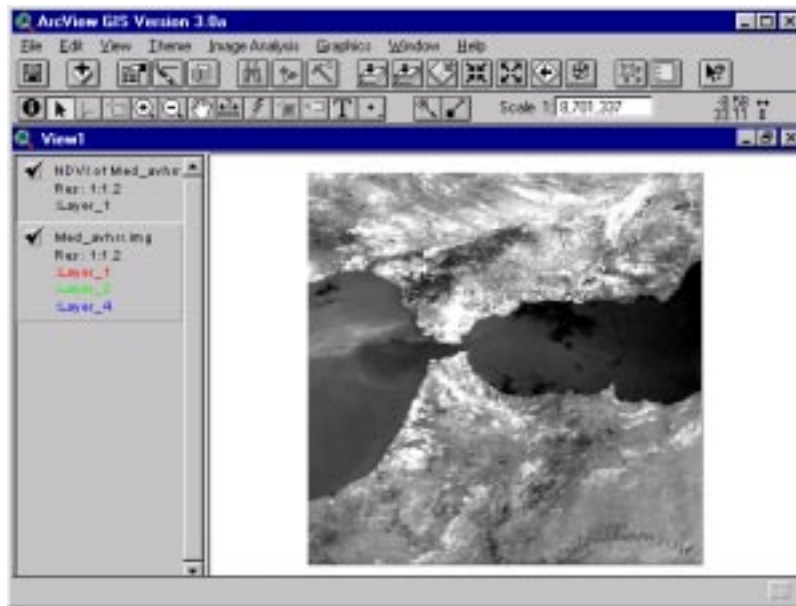
1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double click on med_avhrr.img to add it as a theme.
5. Click the check box in the legend to draw the theme.



This is an AVHRR image of the Mediterranean Sea and surrounding land mass.

Use the Vegetative Index on an image

1. From the Image Analysis menu, choose Vegetative Index.
2. In the Vegetative Index dialog, confirm that Layer_2 is the Near Infrared Layer and Layer_1 is the Visible Red Layer. Click OK.
3. Click the check box for NDVI of Med_avhrr.img in the legend to draw the theme.



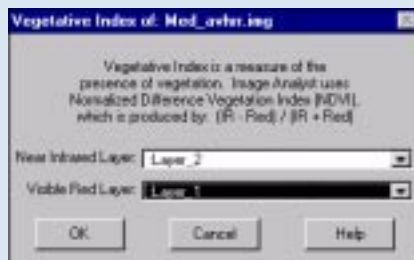
The result of the Vegetative Index operation is a grayscale theme. This example shows the dense vegetation as very bright areas.

Cut themes from the view

1. Make both themes active in the view.
2. Click the Edit menu and choose the Cut Themes option to remove all themes from View1.

Choosing layers in the Vegetative Index dialog

The Vegetative Index returns default Near Infrared and Visible Red layers based on the type of data you are working with. This example uses AVHRR data, so the defaults are Layer 2 and Layer 1, respectively.



If you wish to choose layers other than the defaults provided for analysis, you may do so by clicking the dropdown lists for both the Near Infrared Layer and Visible Red Layer.

Near infrared properties

Vegetation is particularly reflective in the near infrared region of the electromagnetic spectrum. This region is also referred to as the short wave infrared region (as opposed to the long wave infrared region which emits radiation). In AVHRR data, as used in this example, Layer 2 is well suited to vegetation detection and emphasizes the contrast between vegetation and water.

Visible red properties


The visible portion of the spectrum reflects healthy vegetation. For AVHRR data, this visible red portion is especially prominent in Layer 1. Used in combination with the near infrared region, you can discern the vegetated areas in an image.

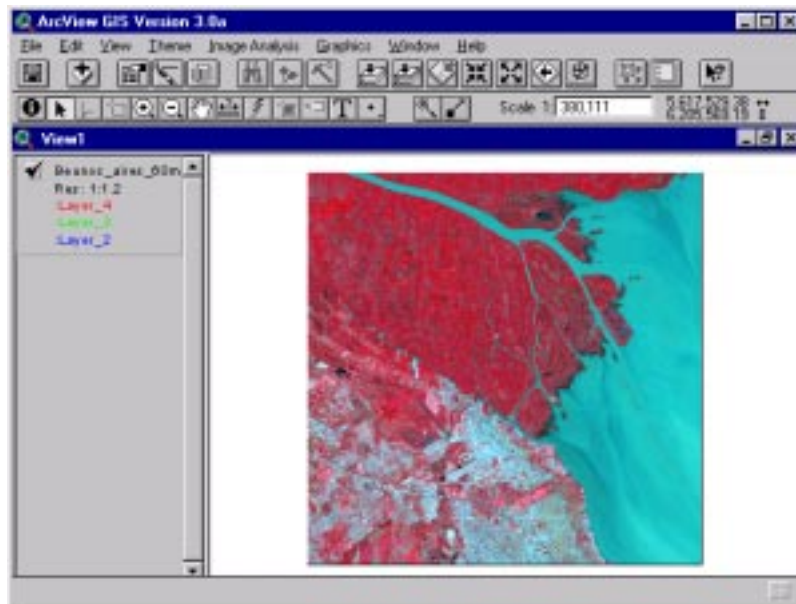
Use the Seed tool

The Image Analyst offers you the Seed tool which can quickly identify areas with the same or similar characteristics. The Seed tool is able to function in two distinct ways. You can click a point to grow a polygon around it that contains pixels with same values within a certain radius. You can also click and drag a rectangle to incorporate larger areas with similar characteristics.

In the example which follows, you will practice using the Seed tool in both ways to see how they work on an image of Buenos Aires. The Seed tool is particularly useful for isolating different areas of the water.


Add and draw a new IA theme

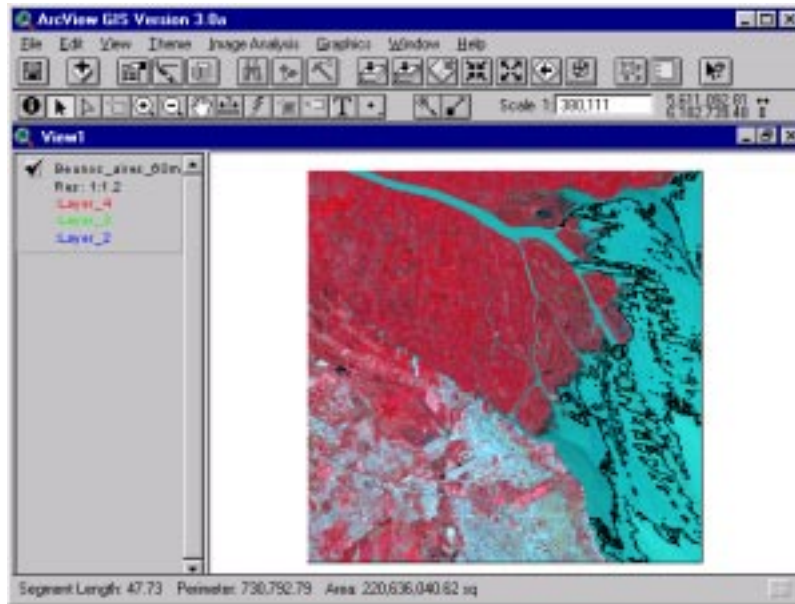
1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double click on buenos_aires_60m.img to add it as a theme.
5. Click the check box in the legend to draw the theme.




The areas of water in this image of Buenos Aires have distinct color changes which can be defined using the Seed tool.

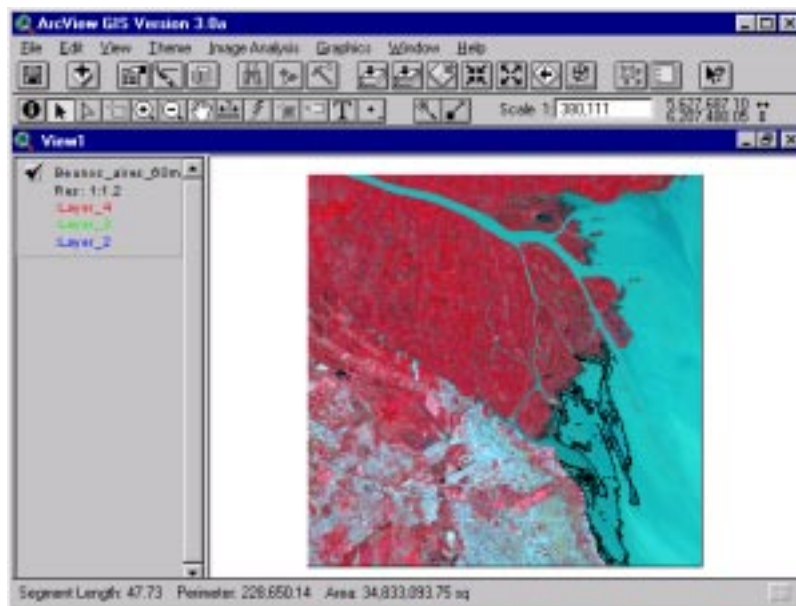
Apply the Seed tool

1. From the Image Analysis menu, choose Seed Properties.
2. Change the Seed Radius to “5” and click OK.
3. Click the Seed tool  and click a point in the water.



The outlined areas are both the same as and contiguous to the pixel you selected with the Seed tool.

4. Use the Pointer tool  to select the polygon created by the Seed tool.
5. From the Edit menu, choose Cut Graphics.
6. Click the Seed tool again and click and drag a rectangle in the water.



When you use the Seed tool to drag a rectangle, Image Analyst considers all pixels in the area. The result in the example above is that the tool outlines all areas of water in the image.

7. Use the Pointer tool to select the polygon created by the Seed tool.
8. From the Edit menu, choose Cut Graphics.

As these examples show, you can use the Seed tool in two different ways to extract different kinds of information from your images. By clicking, you can select only areas of a specific value which is of interest to you. By dragging a rectangle, you can select a larger area composed of pixels of similar values which interest you.

Find Like Areas

Note This tool is not yet operational.

Image Analyst provides you with the Find Like Areas tool which allows you to find areas with similar characteristics within an image which may not necessarily be contiguous. This tool helps you rapidly scan large images for certain characteristics.


In the following example, you will take results from the use of the Seed tool and use them to find like areas in the rest of the image.

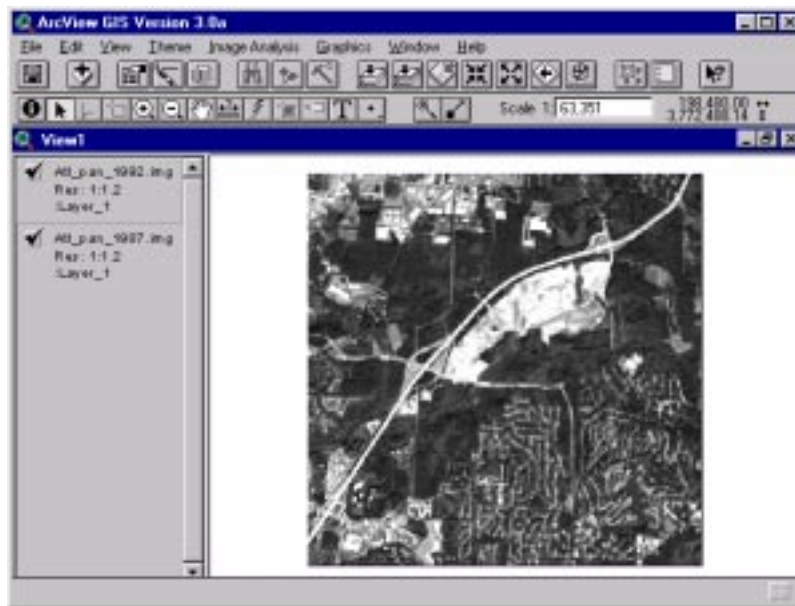
Image Difference

The Image Difference option is useful for analyzing areas which may have changed over time. You can use the Image Difference option only with continuous data. By using the Image Difference operation on multi-temporal images, you can clearly see which specific areas changed over time. You can specify the amount of change you would like to highlight either as Percent or Value.

In the following example, you will work with two images of the North metro Atlanta area. Between the years of 1987 and 1992, there was much clearing and subsequent development of areas.

Add and draw new IA themes

1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Press the SHIFT key and click on atl_pan_1987.img and atl_pan_1992.img. Click OK.
5. Click the check box for Atl_pan_1987.img and Atl_pan_1992.img to draw the themes.



Once both images have drawn in the view, you can make both of them active and perform the Image Difference calculation.

6. Make both themes active in the view.

Compute the Image Difference

1. Click the Image Analysis menu and choose Image Difference.
2. In the Image Difference dialog, set the Before Theme to Atl_pan_1987.img and the After Theme to Atl_pan_1992.img.
1. Change both the Increases more than and the Decreases more than options As Percent to "25." Click OK.
2. In the legend, click the check box of Difference theme to draw the theme.
3. In the legend, click the check box of Highlight Difference theme to draw the theme.



When you draw the Highlight Difference theme, change is evidenced by the red and green areas. In this example, the large contiguous area of Increase (in green) in the Northern part of the image is due to commercial construction. That area changed by 25% or more.

Cut themes from the view

1. Make all of the themes active in the view.
2. Click the Edit menu and choose the Cut Themes option to remove all themes from View1.


Note For information on performing a change detection on thematic data, see Chapter 6, 'Analyzing Images.'

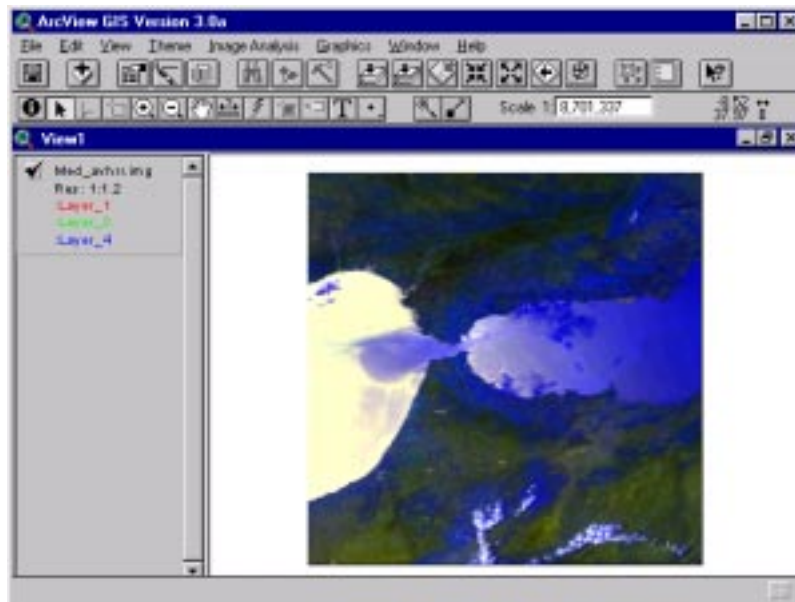
Perform an unsupervised classification (Categorize)

To perform an unsupervised classification of your data, Image Analyst allows you to categorize your data. The Categorize option allows you to change your continuous data into thematic or categorical data. By selecting the number of classes the image will be divided into, you are able to pick specific attributes from your image to analyze further.

The next example illustrates how the Categorize option can be used on an image of the Mediterranean Sea and surrounding land mass. When the image is initially brought into the view, it has only two obvious classes: land and water.

Add and draw a new IA theme

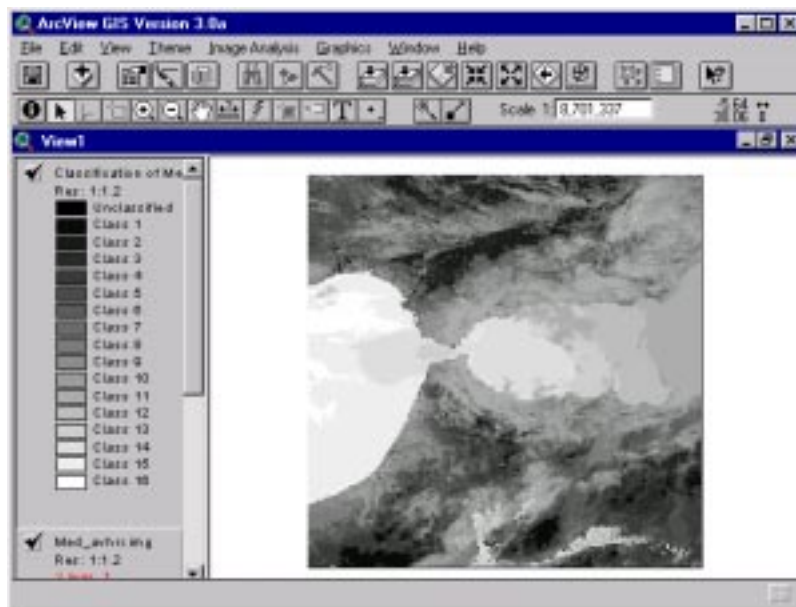
1. Click the Add Theme button .
2. Navigate to the AVTUTOR directory. Double click on the IA_data folder under the AVTUTOR directory.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double click on med_avhrr.img to add it as a theme.
5. Click the check box in the legend to draw the theme.



This is the original image composed of continuous data. The two obvious classes are land and water.

Choose the number of classes

1. From the Image Analysis menu, choose Categorize.
2. In the Categorize dialog box, confirm the number of classes is "16." Click OK.
3. Image Analyst adds the theme Classification of Med_avhrr.img to the top of the legend. Draw the theme by clicking the check box.



This Categorize operation produced 16 separate classes in the Med_avhrr.img file. The differences in the values which make up the image are more apparent.

Cut themes from the view

1. Make both themes active in the view.
2. Click the Edit menu and choose the Cut Themes option to remove all themes from View1.

How does the Categorize tool work?

The Categorize tool works by using an *Iterative Self-Organizing Technique (ISODATA)*. *ISODATA* performs an entire classification (outputting a thematic raster layer) and recalculates statistics. The technique is self-organizing because clusters of data are created without input from you. The advantage to the *ISODATA* method is that it does not favor values at the extremes of the spectrum.

Exercise 4: Evaluating thematic change

Image Analyst is especially useful for evaluating changes over time. You can perform this type of analysis on either continuous data using the Image Difference calculation, or thematic data using the Thematic Change option.


The next example uses two images of the X area both before and after hurricane Hugo came ashore in 1989. Suppose for this example, you are the executive of a paper company which owns a parcel of land caught in the hurricane's path. With the Image Analyst, you can see exactly how much of your forested land has been destroyed by the storm. With this information, you can make plans to obtain trees from another source in order to fill orders.

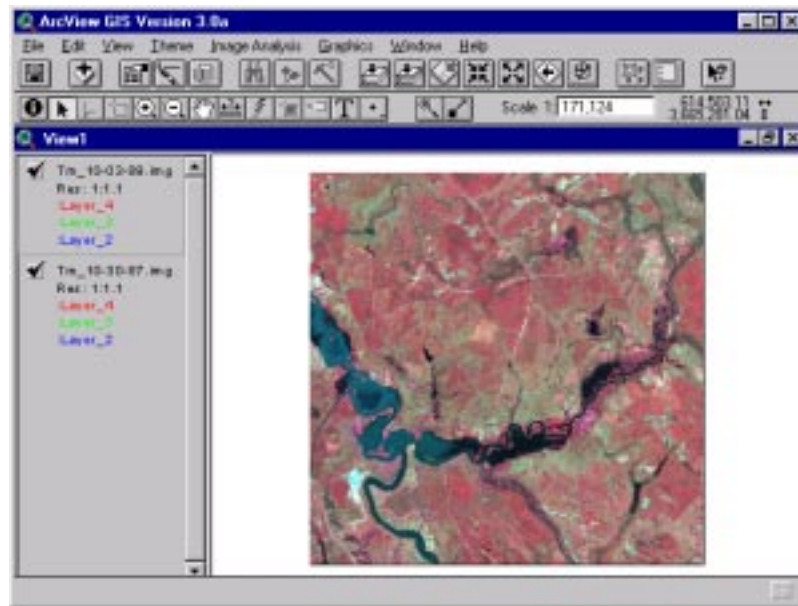
In this exercise, you will learn

How to perform a Thematic Change calculation on thematic data.

How to Summarize Areas using a feature theme.

Add and draw new Image Analyst Themes

1. Click the Add Theme button .
2. Navigate to the directory. Double-click on the IA data folder.
3. Click the Data Source Types dropdown list and choose Image Analyst Data Source.
4. Double-click on tm_10-30-87.img to add it as a theme.
5. Click the Add Theme button again.
6. Double-click on tm_10-03-89.img to add it as a theme.
7. Click the check boxes of both themes in the Table of Contents to draw them in the View.



This picture illustrates an area of X both pre- and post hurricane Hugo.

Perform a classification of a theme

1. Click the title Tm_10-30-87 to make the theme active.
2. From the Image Analysis menu, choose Categorize.
3. In the Desired number of classes text box, type the number “3.” Click OK.
4. Click the check box to draw the theme Classification of Tm_10-30-87.img in the view.
5. Widen the Table of Contents so that you can read all of the title.

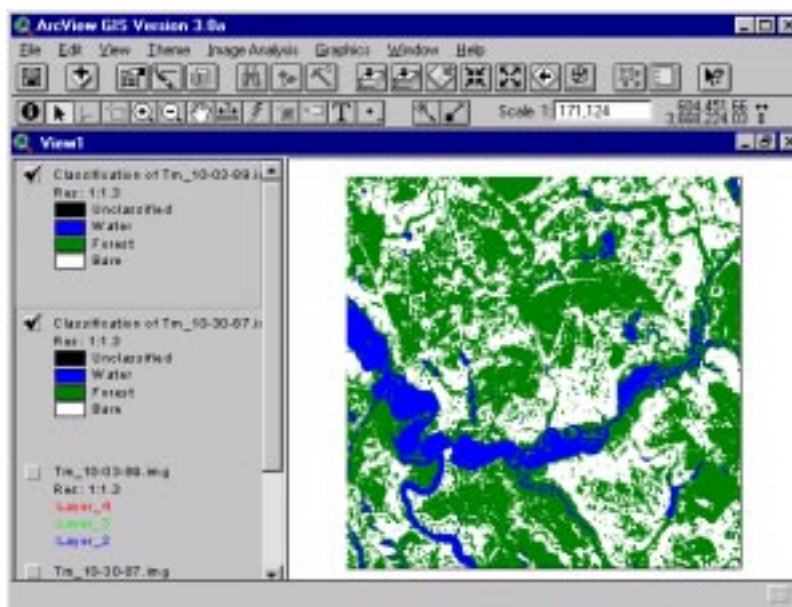
Edit the legend of classification

1. Double-click on the Classification of Tm_10-30-87.img to access the legend editor.
2. Double-click the Symbol next to the Value of 1 and choose the color blue.
3. Click in the Label field and type “Water.”
4. Click the Symbol next to the Value of 2 and choose the color green from the color palette.
5. Close the Color Palette.
6. Click in the Label field and type “Forest.”
7. Click in the Label field next to the Value of 3 and type “Bare.” Click Apply.

8. Close the Legend Editor.

Perform another classification

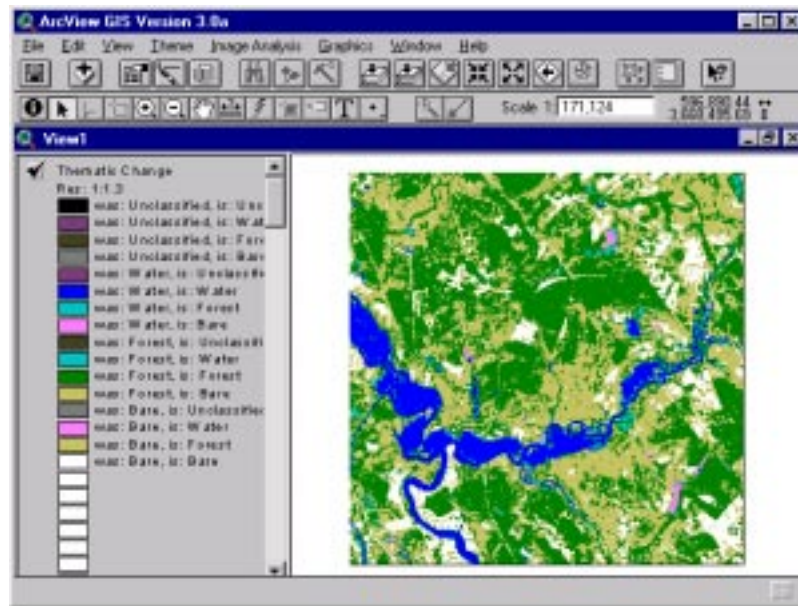
Using the steps provided for the theme Tm_10-30-87.img, perform a classification and change the Legend Editor for Tm_10-03-89.img, then draw the theme in the view.



This image shows the result of the classification of the images.


Perform a thematic change

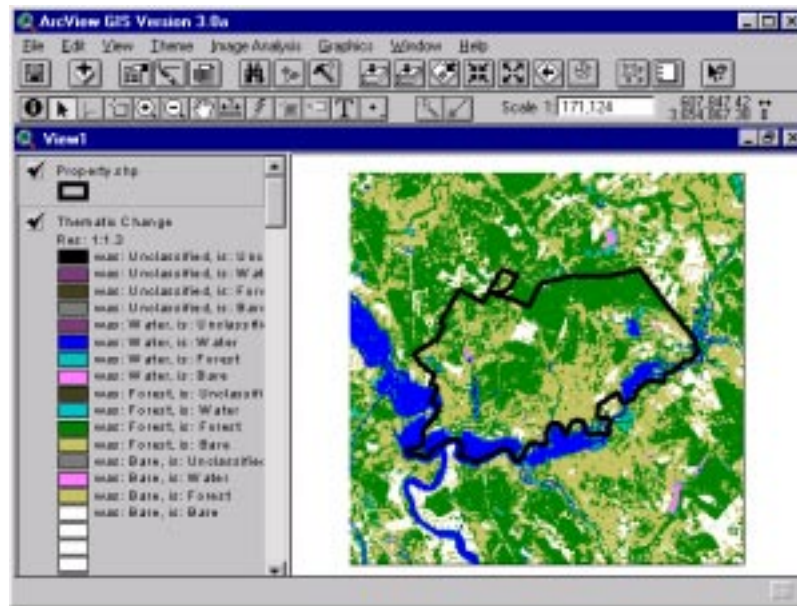
1. Make both Classification of Tm_10-30-87.img and Classification of Tm_10-03-89.img active in the view.
2. From the Image Analysis menu, select Thematic Change.
3. Confirm that the Before Theme is Classification of Tm_10-30-87.img and that the After Theme is Classification of Tm_10-03-89.img. Click OK
4. Click the check box next to Thematic Change to draw the theme.



Note the amount of area which falls into the was: Forest, is: Bare increased dramatically.

Add a feature theme

1. Click the Add Theme button .
2. Navigate to the directory. Double-click on the IA data folder.
3. Click the Data Source Types dropdown list and choose Feature Data Source.
4. Double-click on Property.shp to add it as a theme.
5. Click the check box in the Table of Contents to draw the theme.



The use of the shapefile enables you to summarize areas.

Summarize areas

1. Make the themes Thematic Change and Property active in the View.
2. From the Image Analysis menu, choose Summarize Areas.
3. In the Zone Theme text field, use the dropdown list to select Property.shp.
4. In the Class Theme text field, use the dropdown list to select Thematic Change. Click OK.

Class Name	Count	%	Area
Water: Water	12163	7.41%	2706.322131
Water: Forest	1195	0.73%	265.761866
Water: Bare	59	0.04%	13.121297
Water: Unclassified	0	0.00%	0
Forest: Water	2502	1.52%	556.431956
Forest: Forest	70633	43.01%	15706.416608
Forest: Bare	44463	27.08%	9888.342951
Forest: Unclassified	0	0.00%	0
Bare: Water	792	0.48%	176.136734
Bare: Forest	13094	7.97%	2912.036382
Bare: Bare	15308	11.76%	4294.000083
Bare: Unclassified	0	0.00%	0

Note the amount of forested area which was lost due to hurricane Hugo.

As this example shows, you can use the Image Analyst to evaluate areas of your image within certain parameters, such as the property boundary of the paper company's land. This information allows you to make operational decisions based on hard data.

What Next?

Since you have worked through the tutorials, you now know about the types of enhancements to and comparisons of data you can make using the Image Analyst. From here, you can continue to read this book to get more detailed information on the way the Image Analyst components work and the type of information you can get from each of them. You can also use this book as a reference as you use the Image Analyst to complete your own work. If you have questions while you work, the on-line help also provides information.

C H A P T E R 3

Data types and Image Analyst

The ‘Quick start tutorial’ shows you how to complete basic image analysis processes to give you an idea of how Image Analyst works. This chapter gives you details on how Image Analyst categorizes data types and how you can refine that data, even before actual analysis.

Image Analyst works with two broad categories of data, continuous and thematic, each of which has specific characteristics. Continuous and thematic data can come from many different sources which must be brought into the Image Analyst environment through importers; other data are treated as direct sources. You can then choose to create pyramid layers or subsets of data depending on how you intend to use that data.

In this chapter you will learn:

How to differentiate between continuous and thematic data.

How to access different data types.

How to work with native data.

How to use pyramid layers to display data rapidly.

How to subset data from the original file.

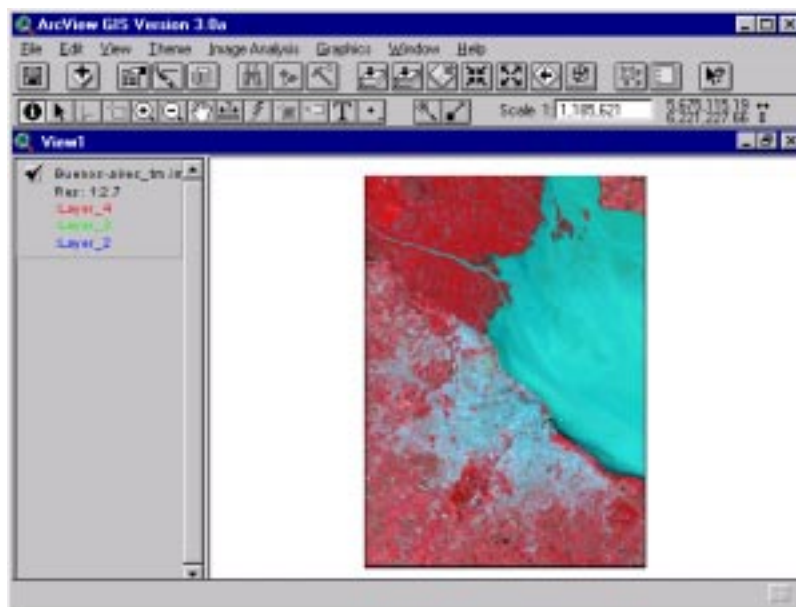
Comparing continuous and thematic data types

Image Analyst treats data as either continuous or thematic. Each data type has traits which lend it to different types of analysis. The following examples illustrate the properties of both data types.

Properties of continuous data

Continuous data are quantitative and the result of some kind of measurement. Continuous data can be displayed as both single and multiband. For multiband continuous data, each pixel has multiple file values, depending on the band you are analyzing. It is possible to display only selected layers of data and discount others from analysis.

Consider the example of Buenos Aires below. In this example, a multiband image of Buenos Aires is displayed exactly as it was initially drawn in the view. The Landsat TM image is made up of seven layers, and three of those layers are assigned to red, green, and blue as depicted in the theme's legend. Each pixel which makes up the image has its own individual value, relative to the band you choose for analysis. You can see all of these values by using the Identify tool and selecting various points in the image.

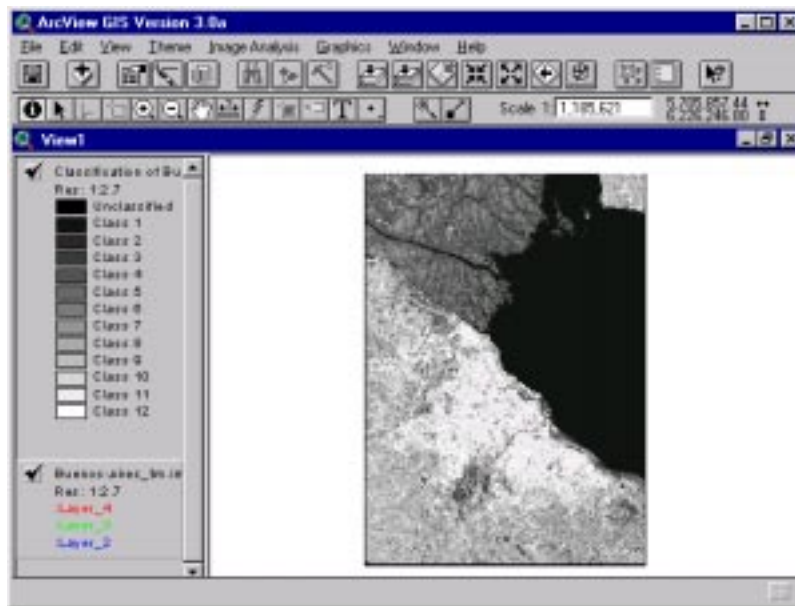


This example shows Buenos Aires as an example of continuous data.

Properties of thematic data

Thematic data are qualitative and deal with categorical information about an area. Thematic data are usually the result of an assignment or classification of pixels which make up the image. Classification of pixels in an image results in pixels of the same value being grouped together and assigned a *class value*. Only one value is stored for each pixel, therefore thematic images have only one layer.

Consider the same image of Buenos Aires below after a classification has been performed on the image. As you saw in the previous example, each pixel that made up the original image had a different value depending on which layer you considered. In this example, each pixel has one class value only, in this case Class 1 through Class 12. With continuous data, a pixel's color is determined by the pixel values. However, with thematic data, the color may be chosen for each pixel or class value.



This example shows Buenos Aires as thematic data.

Import different types of data

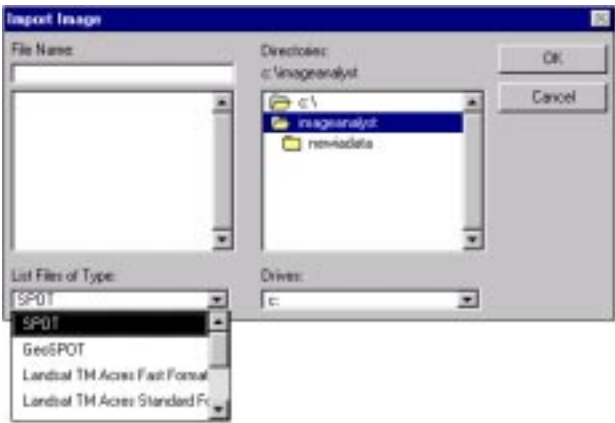
As you work with Image Analyst, you might receive data such as satellite imagery from another source which you want to import into the ArcView environment. These data were likely obtained from one of many different sensors. Image Analyst provides you with the capability to import data from many different sources easily. All you have to do is select the source of data you will be working with and Image Analyst does the rest.

The formats supported by Image Analyst at the import level include *Landsat*, *RPF* and *SPOT* as follows:

Import Data Types

Landsat	RPF	SPOT	IRS	DOQ
TM Acres Fast Format	Raster Product Format	SPOT		
TM Acres Standard Format		SPOT (GeoSpot)		
TM EOSAT Fast Format				
TM EOSAT Standard Format				
TM ESA Fast Format				
TM ESA Standard Format				
TM IRS Fast Format				
TM IRS Standard Format				
TM RADARSAT Fast Format				
TM RADARSAT Standard Format				

All of these data types are selected by scrolling through the List Files of Type dropdown list in the Import Image dialog box. You simply choose the format which corresponds to your data.



The Import Image dialog box has a List Files of Type dropdown list to scroll and choose the type of data you wish to import.

Note The Image Analyst only supports disk formats, including CD-ROMs. Support for tape media is not included.

How to import data

By following these basic steps, you can easily import data into the Image Analyst environment...

Select the type of data

1. Insert the disk or CD which contains the data you wish to import.
- 2.

Use the Source Manager to manage data files

Because of the comprehensive nature of ArcView's file storage architecture, files cannot simply be copied, renamed, deleted and moved at will. In the past, these tasks have been accomplished by using the operating system to find primary files and all the files associated with them. Image Analyst uses the Source Manager to greatly simplify file management.

The Source Manager is designed to copy, rename and delete data sources by accessing a single dialog box. This dialog box allows you to make changes to ERDAS IMAGE .img files, GRIDs and TIFF files. The Source Manager automatically copies, renames, or deletes the main file you designate along with all of the associated files such as .aux and .rrd (pyramid layers). You can easily access the Source Manager from the File menu.

Using direct read/write data

There are three data formats which can be treated natively by the Image Analyst extension in a direct read/write manner. These types of data do not require you to access the import mechanism.

With Image Analyst, you are able to both read and write each of the formats. These three formats, through the use of the direct read/write DLL capability, provide flexibility for storing additional information about the imagery in auxiliary (.aux) files. This means that information such as class names may be stored with a GeoTIFF file, or map information may be stored with a file whether the format supports it or not. The direct read/write data types include:

Native Data Types

ERDAS IMAGE	GRID	TIFF
IMAGE .img ¹	GRID	TIFF
	Grid Stack	GeoTIFF

¹IMAGINE .img files include calibrated imagery

Raster DLL capabilities

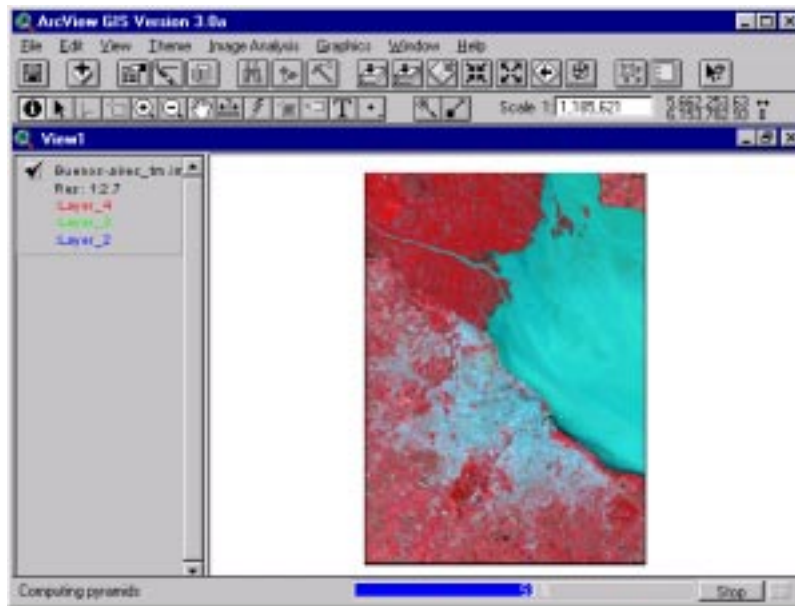
You have great flexibility with native data through the use of Raster Dynamically Loaded Libraries (DLLs). Raster DLLs are objects/libraries which are loaded by an application at run time.

The auxiliary information which can be both read and written to includes georeferencing, geocoding, image statistics, contrast and color. The benefit of Raster DLLs is that they can be used without recompiling or relinking at the system loader level.

Using pyramid layers to display images quickly

As you saw in the previous example, when you import an image into the Image Analyst environment, *pyramid layers* of the data are created. You may also know pyramid layers as Reduced Resolution Data Sets (RRDS's). This allows your images to display in the view more rapidly. Files created using the Image Analyst, however, are automatically assigned pyramid layers. If you are currently working with an .img, GRID or TIFF file without pyramid layers, you have the option of creating pyramid layers to make your image easier to manipulate.

Suppose you have received data from another source such as X data, depicted below. The file is so large that it takes most of your system's resources to completely display the data; however, to complete your analysis, you must use all of the data. Pyramid layers enable you to preserve all of your data, yet display and manipulate it much faster at any scale.



If you choose to calculate pyramid layers, the pyramid layers progress meter displays at the bottom of the project window tracking the process of the calculation. The use of pyramid layers makes your images display faster.

How do pyramid layers work?

Pyramid layers are image layers that are copies of the original layer that have been successively reduced by a power of 2 and then resampled. When you are working with GRID and TIFF files, the pyramid layers are stored in a separate file in the same directory as the image. If your image is read only, the pyramid layers are stored in the project and not with the image itself.

The type of data you are working with determines the type of resampling which occurs to create pyramid layers. With thematic data, like land use, the nearest neighbor method is used. If your data are continuous, like elevation values, then cubic convolution method is used.

Nearest neighbor interpolation

The *nearest neighbor* method of interpolation produces an output file value which is the same as the file value it was closest to before resampling. The output pixel inherits its value from its nearest neighbor.

Cubic convolution interpolation

The *cubic convolution* method of interpolation considers sixteen pixels in a 4 by 4 window to create an output file value. The output file pixel inherits a weighted average of the sixteen pixels which surround it.

Working with subsets of data

Once you import the file, you may elect to use the whole file in analysis, or you may select a subset of the area for analysis. To specify the area of the data that you wish to consider, choose the Image Analysis menu, then Properties. In this manner, the image may be clipped with a simple rectangle or a complex polygon. Null values will be represented as zeroes.

The advantage of working with subsets of data is that your system resources are not as constrained. You can also limit your analysis of the image to a more specific area of the image.

Screen Capture with values

The Image Analysis Properties dialog box enables you to define the corners of the image you wish to work with.

C H A P T E R 4

Displaying and enhancing Image Analyst themes

The Image Analyst extension creates a new type of theme which can be added to the ArcView environment, the IATheme. Like other themes, you can display the theme in a view and change basic properties like theme name. The benefit of the Image Analyst theme, however, is that you can make more advanced changes to the way your themes display in a view, drastically altering their appearance.

With the Image Analyst, you can display and enhance the themes in many different ways, simply by accessing one dialog. The tools provided to accomplish this include histogram editing, contrast and brightness adjustment, invert stretch, and level slice. These options are available on both multiple and single band imagery. An additional feature provided by Image Analyst includes sharpening of images.

In this chapter you will learn:

How to change the properties of a theme.

How to work with single and multi-band images.

How to adjust the brightness and contrast of an image.

How to apply histogram stretches to obtain specific visual results.

How to work with background values and null data.

How to access the advanced histogram editing features.

How to work with thematic data.

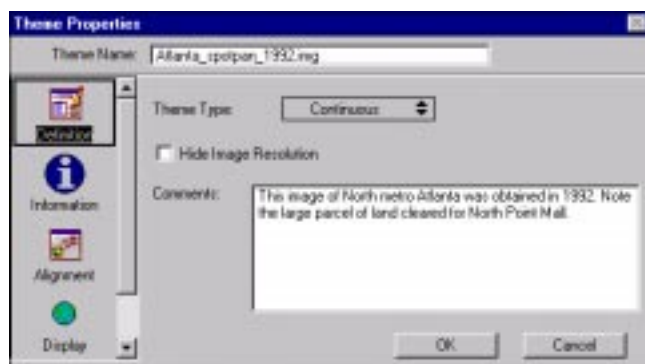
How to adjust the sharpness of an image.

Change theme properties

Like other themes in ArcView, Image Analyst theme properties are accessed by choosing the Theme menu, then selecting Properties. Two new tabs unique to the Image Analyst extension have been added: Information and Alignment.

Defining a theme

The Definition tab contains basic information about a theme which may be changed or edited.



The Definition section allows you to change theme names and make notes about the image.

This dialog box provides information about the type of image and data you are working with. You can use this dialog box to change continuous data to thematic. Since thematic data is categorical and has one class per pixel, multi-layer or floating point continuous data may not be changed to thematic without first using Categorize. You can also rename your theme from this dialog box. A Comments section is provided for you to make notes about the theme.

Note For more information on Categorize, see Chapter 8, 'Image classification and post classification analysis.'

Getting information about a theme

To obtain information about a theme, access the Information tab.



The Information dialog box gives information about the image in the active window. With the exception of theme name, it is not editable.

The information dialog box gives you a ready reference to attributes of the theme you are displaying. This information includes data such as file location and image boundaries in the form of Left, Top, Bottom, and Right coordinates. From this dialog box, you can determine cell sizes, data types and if pyramid layers are present. The data in the text boxes are not directly editable.

Alignment properties of a theme

The Alignment tab defines the properties of the Align tool for the active theme.



The Alignment dialog box assigns default parameters for the collection of control points in the image.

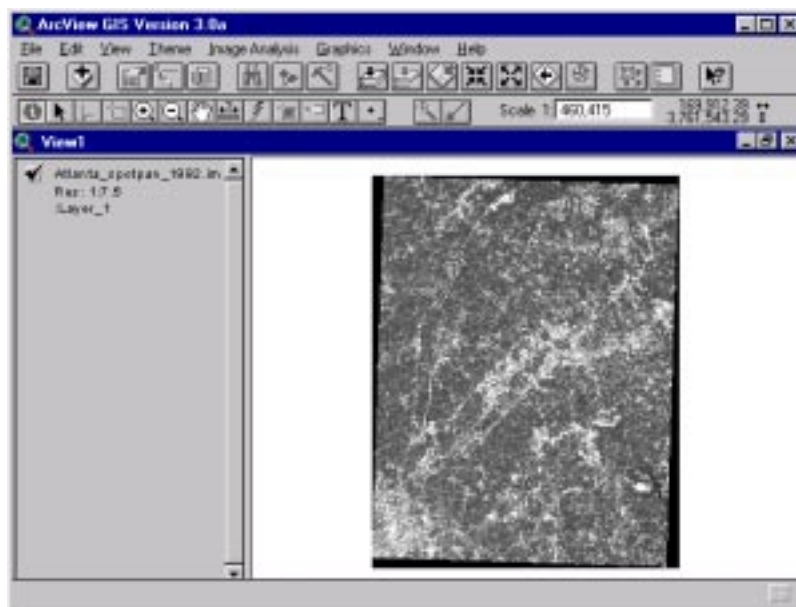
This screen assigns the default parameters for use with the Align tool located on the tool bar. In the Alignment dialog box, you can set the default to draw a line between your

From and To points. You can also custom set your cursor color and snapping tolerance. The parameters you select are only applicable to the active theme, they are not established as the default for the Image Analyst extension.

Working with single band imagery

A single band image can be either continuous or thematic. The default depends upon the data in use. Single band images are typically displayed in gray scale and only have one lookup table to alter. The lookup table still allows you to add, delete, and shift breakpoints.

The following image is an example of a single band continuous data image.



This is a single band continuous data image. The Legend Editor you access from an image like this allows you to adjust Contrast and Brightness as well as edit the lookup table by working with breakpoints.

The legend editor associated with the image of Atlanta is depicted below.

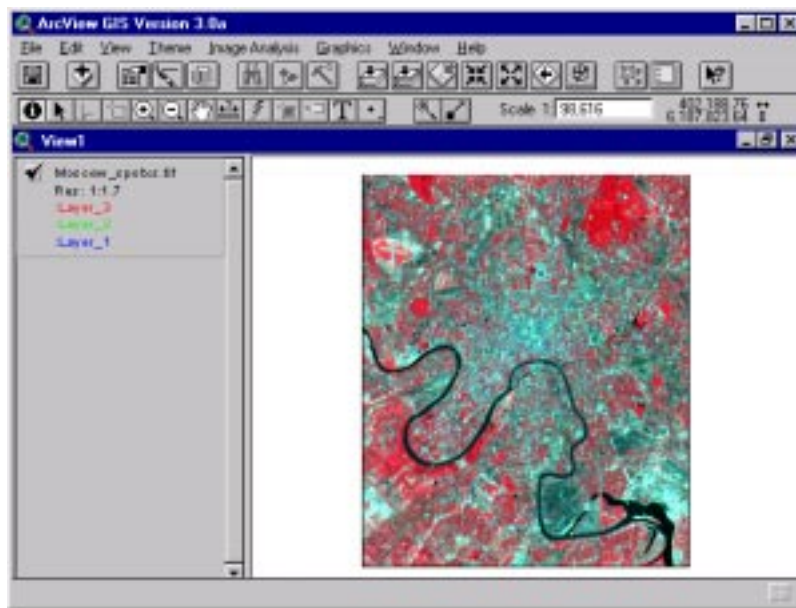


This is the type of Legend Editor you will work with if your data is continuous, regardless of whether it is made up of single or multiple bands.

Working with multi-band imagery

Like single band imagery, you can also enhance the display of multi-band imagery. The example below is an image of Moscow. With Image Analyst, you can perform numerous operations on the image to enhance its appearance.

Note For more information on changing band layer combinations, see 'Changing band combinations.'

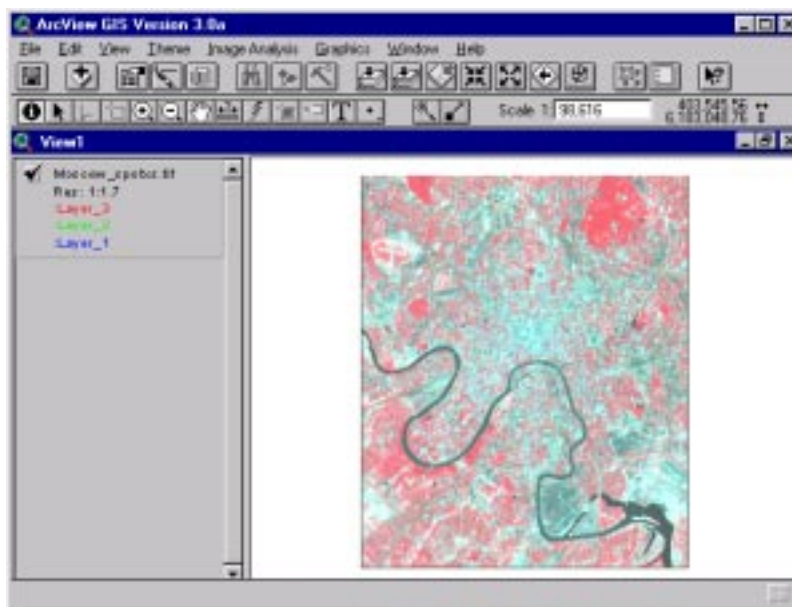


This image of Moscow will be used to demonstrate all the image enhancement techniques you can apply to multiband continuous data.

Adjust the brightness and contrast of an image

To allow you to enhance continuous data, like the image of Moscow above, Image Analyst has *Brightness* and *Contrast* slider bars which are easily accessible from the Legend Editor.

Brightness and Contrast are adjusted using slider bars, or, for fractions of change, the arrow buttons. The bars are useful for making minimal changes to the way an image is displayed. You can adjust either or both slider bars. If you do not like the results, simply click the Undo button at the bottom of the dialog. Any changes you make to the image using the Legend Editor are saved both with the project and the image.



This example started with the original image of Moscow. The Brightness was drastically increased in the image to produce this effect.

Brightness and Contrast slider bars work in conjunction with the Stretch options. Brightness and Contrast tools are used to indirectly alter the breakpoints of the lookup tables. If the breakpoints are edited, however, the Brightness and Contrast slider bars are set to their midpoints.

Note See Changing band combinations

Much of the data you work with using the Image Analyst is made up of many layers of information (depending on the source of the data number of layers vary). Each layer has file values for a certain portion of the electromagnetic spectrum. You can change the combination of layers assigned to the Red, Green and Blue bands to produce different effects on your data.

The Image Analyst legend editor offers you two places where you can select the color bands of data which are displayed in the view. From the main Legend Editor panel, you can alter band and layer combinations as well as deselect bands from output to display. If you wish, you may also access the lookup tables by clicking the Advanced button to disable certain bands.

Altering lookup tables and managing breakpoints on page 15 for information on lookup tables.

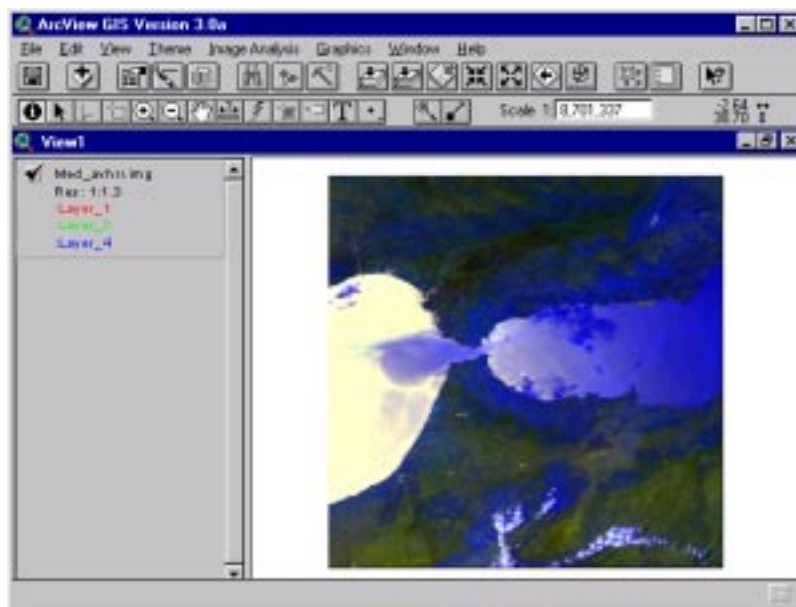
Applying histogram stretch options

Because the range of raw data file values are usually not the same as the range of brightness values of the display, a contrast stretch is applied, which stretches the range of values to fit the range of the display. You may wish to alter the appearance of your data to emphasize a particular area or de-emphasize another – simply by changing band combinations and color displays.

The Stretch dropdown list is provided so that initial breakpoints are standardized using recognized techniques; however, the breakpoints can be altered by accessing the Advanced options. Stretch options you can apply to images include Standard Deviations, Histogram Equalize, and Minimum-Maximum. You can also choose to maintain the original look of your data and elect not to perform a stretch at all. Some types of stretch require additional parameters.

Applying Standard deviations stretch

Standard Deviations is the default histogram stretch applied to images by the Image Analyst. This type of stretch produces an average histogram with most values falling in the mean range and few data points falling at the extremes. Standard Deviations requires you to type the number of standard deviations to be stretched. The default value is 2.0.



This image of the Mediterranean Sea and surrounding land mass has had a standard deviations stretch applied to it.

Choosing a number of standard deviations

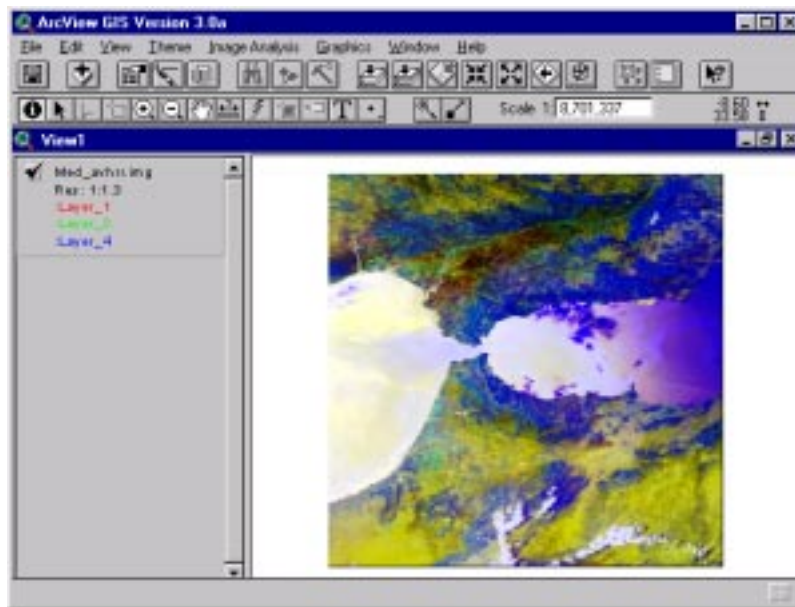
The variance of the data is expressed in units squared; standard deviation is defined as the square root of that variance. The default value of 2 standard deviations from the mean assumes that the data have a normal distribution and that the range output to the display includes most of the data. Change the number of standard deviations to assign a different percentage of variance from the mean.

Applying Histogram Equalize stretch

This Histogram Equalize option is applied by accessing the legend editor. Consider the image of the

Display an image

1. Double-click the theme's legend.
2. Click the Stretch dropdown list and choose Histogram Equalize.
3. Click Apply.



The image above illustrates the application of the Histogram Equalize option.

Histogram Equalize redistributes the data so that there are roughly the same number of data points of each display value. The resulting histogram has no real variance in contrast, it is essentially level. The histogram equalize function assigns pixels to bins

where they receive a new value. Image Analyst performs a simple division to obtain the appropriate number of pixels per bin.

What is a bin?

A bin is a numbered container which holds pixels of the same input value. Based on the bins in which the pixels fall, they are assigned new values. To calculate the number of pixels to be assigned to each bin, the total number of pixels that make up the image is divided by the number of bins.

Applying Minimum-Maximum stretch

Sometimes you want to display an image at the farthest extremes. The Minimum-maximum option will stretch the original values which make up the image so that they appear to fit within the minimum and maximum display values.

Display an image in Minimum-Maximum values

1. Double click the theme's legend.
2. Click the Stretch dropdown list and choose Minimum-Maximum.
3. Click Apply.

The image above illustrates a Minimum-Maximum stretch of the Moscow image.

Minimum-Maximum stretch displays the input data so that the input minimum and maximum pixel values are automatically displayed as extreme values (0 – 255) when output to the display. The input values are stretched or scaled to fit the range of the output display.

Applying no stretch to an image

If you choose the None option from the Stretch dropdown list in the Legend Editor, the data file values are displayed exactly as they were imported into the Image Analyst. No stretching of the data file values is performed.

Choosing other options to apply to an image

Image Analyst offers you other image processing tools to apply to your image: Level Slice and Invert Stretch. You can also choose how background areas and no data are treated in your image analysis.

Using the Level Slice option

By applying the *Level Slice* button, the lookup table is put into equal levels. The Level Slice stretch requires that you define the number of levels to be used in the stretch. A brightness value is assigned to each level. The Level Slice option is not applied based on the statistics of the image, but on the current state of lookup tables.

Screen Capture here

Using the Invert Stretch option

The image of the Mediterranean Sea illustrates the use of the Invert Stretch option. You use the Invert Stretch option in cases where. . .

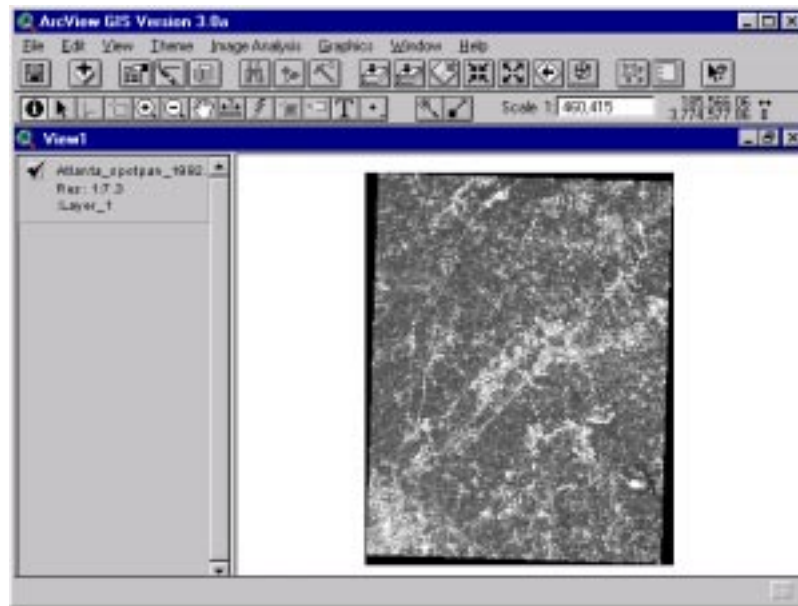
This image of demonstrates the Invert Stretch operation.

Like the Level Slice option described above, the *Invert Stretch* option is based on the current state of the lookup tables. With the Invert Stretch option, the data file values are reassigned so that the lightest become dark and the darkest become light – simply swapping values. The resulting image is, essentially, a color negative of the original image.

Displaying background as transparent

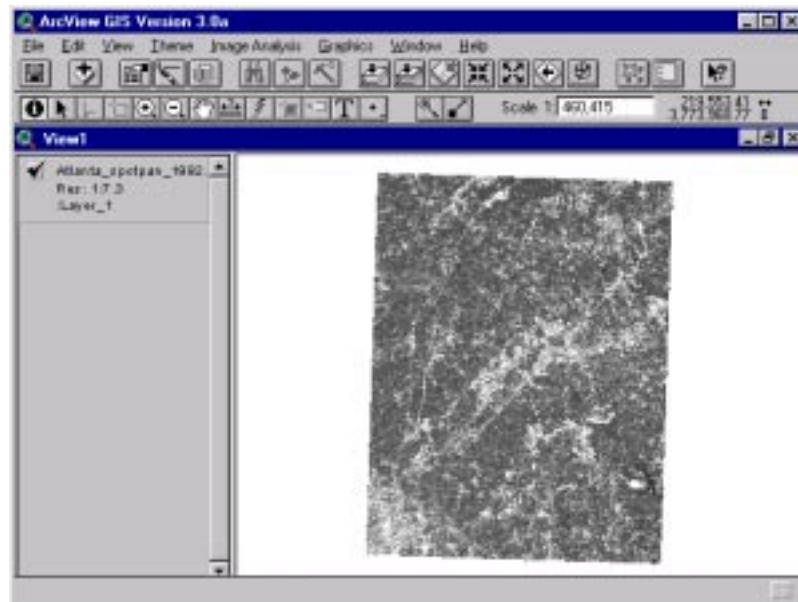
The display background as transparent option allows values to be transparent (usually the values 0 or 255). In many cases, values that fall at the extremes of the image display as black wedges.

Take the example image of Atlanta below. The black areas behind the actual image can be removed from the view by enabling the Display background as transparent option. This option is particularly useful if you have two images which overlay each other covering approximately the same area.



This image of Atlanta could be considerably improved by removing the black wedges which surround it. You simply enable the Display background as transparent check box in the Legend Editor.

The picture below illustrates the same theme drawn in the view with the background displayed as transparent.



With the background displayed as transparent, you can use an image such as this with other images which cover the same approximate area.

Displaying no data as transparent

This option is used primarily with GRID data. Similar to display background as transparent, the display no data as transparent option takes the largest negative number in the file and displays it as transparent.

Accessing advanced features from the Legend Editor

The Advanced button of the Image Analyst Legend Editor allows you to change the lookup tables and associated breakpoints that define the look of the image. The result is that the contrast of certain pixels is increased, and decreased in others – lookup tables simply depict this contrast in a graphic manner.

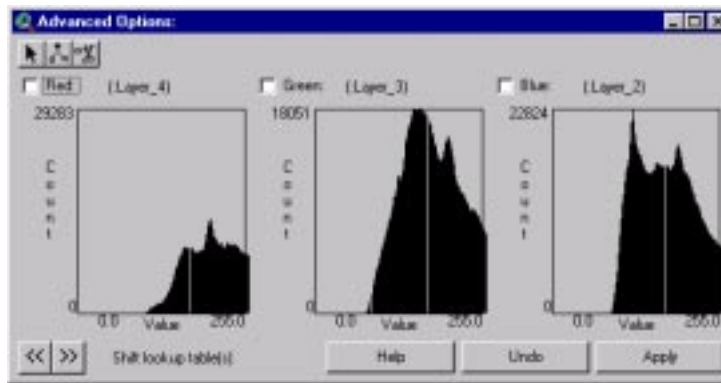
Changing band combinations

Much of the data you work with using the Image Analyst is made up of many layers of information (depending on the source of the data number of layers vary). Each layer has file values for a certain portion of the electromagnetic spectrum. You can change the combination of layers assigned to the Red, Green and Blue bands to produce different effects on your data.

The Image Analyst legend editor offers you two places where you can select the color bands of data which are displayed in the view. From the main Legend Editor panel, you can alter band and layer combinations as well as deselect bands from output to display. If you wish, you may also access the lookup tables by clicking the Advanced button to disable certain bands.

Altering lookup tables and managing breakpoints

Lookup tables illustrate the transformation of data file values into display brightness values. The lookup table can be deselected for any single or combinations of layers.



This lookup table comes from an image of Buenos Aires. From this table you can change the appearance of the image by altering breakpoints.

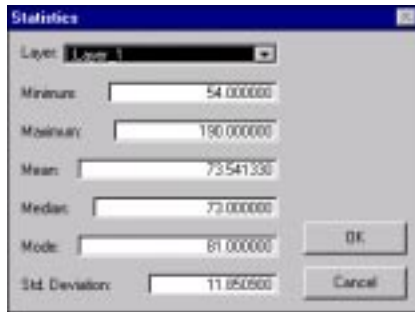
The breakpoints which define the lookup tables can be shifted using your mouse. They can also be added, deleted and removed using the breakpoint tools. The breakpoints of the lookup tables are located in accordance with both the Stretch option and any changes made to the Brightness and Contrast slider bars.

Image Analyst enables you to perform nonlinear stretches on your images through nonlinear stretch. In the most general terms, a lookup table changes the way the values that make up your original image are displayed on your monitor. You can alter the way your image is displayed by applying standard stretches such as standard deviations minimum maximum and something else as described earlier In this chapter. You also have the option of manually adjusting the breakpoints which dictate how the image is output to the display via the lookup tables.

A lookup table is defined based on the input data file values which make up the image, the breakpoints of a nonlinear stretch which dictate how the values will be output to the third component, the output brightness values. Typically, the non linear stretch which decides how values are displayed is divided into three regions of low, middle, and high and called a piecewise linear contrast stretch. With this type of stretch, any change you make to one segment of the stretch will affect the other two. For your advanced image analysis needs, however, Image Analyst allows you to both add and delete breakpoints to the nonlinear stretch. However you choose to alter the lookup tables, the Brightness and Contrast bars change accordingly.

Evaluating statistics of the image

The Statistics button of the Image Analyst Legend Editor allows you to access information about each of the spectral bands of data. This information includes maximum, minimum, mean, and standard deviation values. The text boxes you access from this button are not editable, but are for information purposes only.



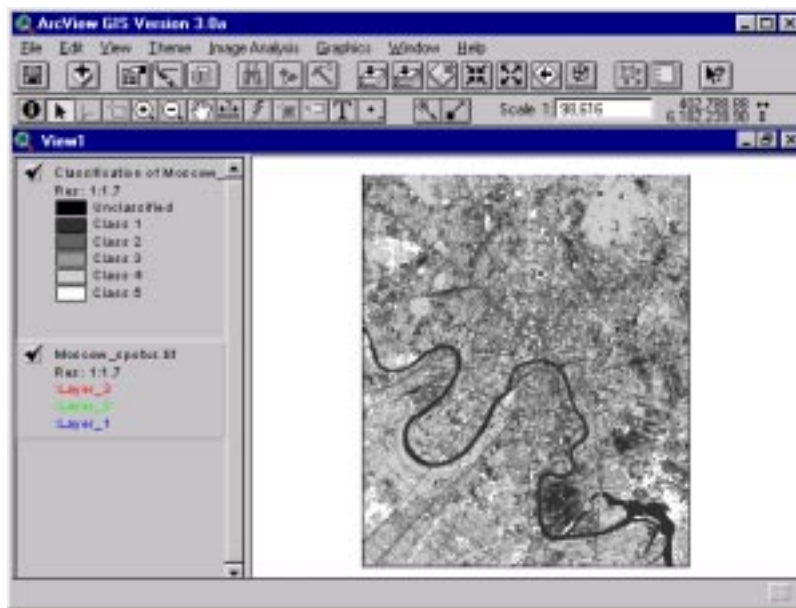
This Statistics dialog box gives details on continuous data. You can select which layer of data you would like to obtain information about by clicking the Layer dropdown list.

Working with thematic data

Image Analyst can also improve your thematic data. The legend editor you access when working with thematic data is not as complex as that of continuous data. Your primary capabilities when working with thematic data are changing the color schemes which display in the theme's legend. You can also change the names which correspond to each class.

With Image Analyst, you can perform a special operation on thematic data, Thematic Change. This option is accessed through the Image Analysis menu. For more information on Thematic Change, see Chapter 6, 'Analyzing images.' You can also use the Summarize Areas option to mark specific areas in your image.

The following image is an example of a single band thematic data image.



This is an example of single band thematic data. You can still access a Legend Editor for this type of data to change class colors and class names.

This is the legend editor you access when working with thematic data. This legend editor should be familiar to you since it is used in ArcView.

This legend editor should be familiar to you from working with thematic data.

Note For more information of working with thematic data, see Chapter 8 'Image classification and post classification analysis.'

Statistics of thematic data

You can obtain statistics for thematic data by accessing the legend editor.

The Statistics for thematic data are similar to those for continuous data, but you only have one Field, Value, to view.

Sharpen image appearance

To adjust the sharpness of an image, standard *convolution filtering techniques* are applied to images processed by the Image Analyst.

What is convolution?

Convolution techniques average small sets of pixels across an image, making changes in spatial frequency. *Convolution kernels* are applied to both the Sharpen option so that pixel values are averaged in a specific manner. The size of the convolution kernel takes into account the number of pixels surrounding the target pixel.

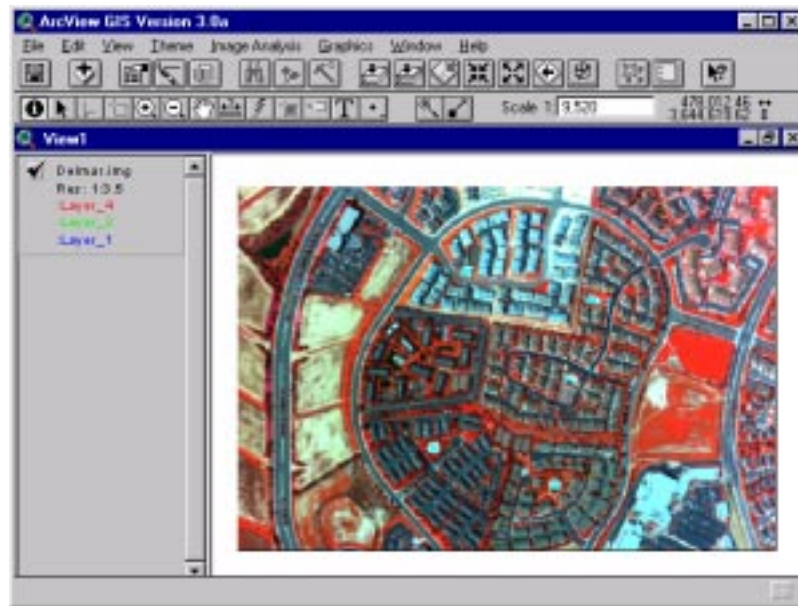
Applying a Sharpen filter to an image

The Sharpen option is accessible from the Image Analysis menu. Sharpen uses a three by three high pass convolution kernel. To achieve the effect of a higher pass or larger kernels, you may apply the Sharpen option multiple times. The Sharpen option is only active when the image is zoomed at least to the resolution of the image.

Take the following image of Moscow for example. There is a great amount of detail in this image. The boundaries which make up individual structures, however, are not very apparent. To help you analyze images such as this, you can follow the steps below.

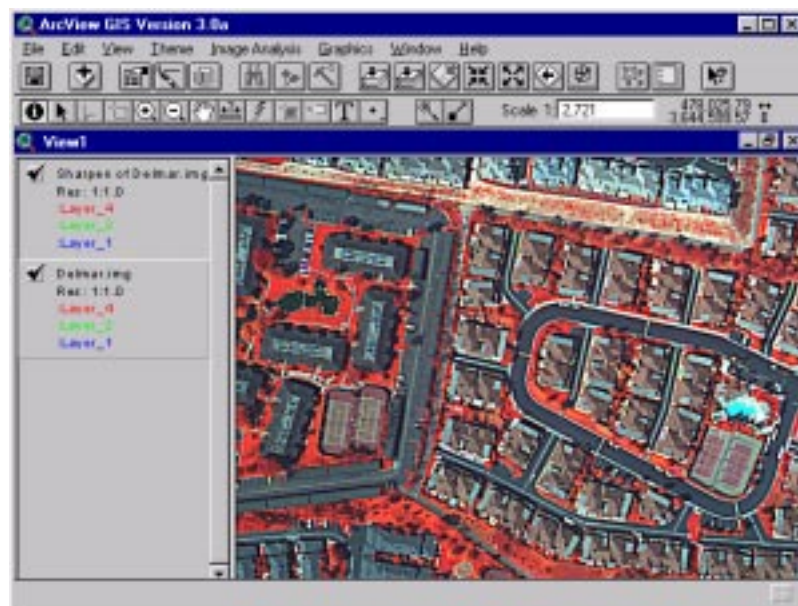
Sharpen an image

1. Make the theme Delmar.img active in the view.
2. From the View menu, select Zoom to Image Resolution.



This is the image as it was originally drawn in the view.

3. From the Image Analysis menu, select Sharpen.
4. Click the check box of Sharpen of Delmar.img to draw the theme in the view.



The picture above illustrates the use of the Sharpen tool on an image. The details of the area are much clearer than those of the original image.

CHAPTER 5

Image rectification

Rectification of an image is the process of transforming it from a sensor coordinate system to a map coordinate system specified by you. To obtain an accurate map coordinate position, Image Analyst performs a polynomial transformation, automatically selecting the order of the polynomial transformation based on the number and distribution of control points selected in the image and the map. This process is normally complex, but with Image Analyst, you just select known features and Image Analyst does the rest.

In this chapter you will learn:

How to use the Align tool step-by-step.


How to apply the Align tool to images and maps.

How to use other tools to help you align an image.

How to either calibrate or resample an image.

How to store From and To points.

Why use the Align tool?

The Image Analyst offers the Align tool , which is accessible from the ArcView tool bar, to aid you in rectifying an image to a map coordinate system. Typically, you use this

tool after drawing two themes, such as an image and a map or vector layer, which do not align properly.

With the align tool, you can easily select points in the image which correspond with your map so that the image can be reprojected into a map coordinate system. You simply select points, Image Analyst does all the calculations behind the scenes. Other capabilities of the Align tool include saving your control points as a shapefile, and a choice of either calibrating or resampling an image once you have applied the tool.

A step-by-step example

The best way to show the features of the Align tool is to go through a step-by-step example.

Applying the Align tool to an image with a map

As you saw in the step-by-step example, to begin using the Align tool, you must have both an image which is currently in a pixel or satellite coordinate system, and a map or shapefile which has the projection system you wish to apply to the image. If both your themes are active in a View, you may notice, if you apply the Zoom to Full Extent button that the two are nowhere close to one another. To remedy this situation, you simply need to begin collecting From and To points.

The initial application of the Align tool rescales the image and moves it within the extent or bounding box of the map. The Align tool is then used to select control points which may be seen in the image and the map.

How to select From and To points

The Align tool is designed to create control points in an image (From) and on the ground (To) so that the image may be rectified to a map projection system.

First, you must make the image needing a projection system active in the Table of Contents. To select From and To points, click the Align tool located on the tool bar. As you move the mouse around the image, the image coordinates are displayed in the status area of the ArcView window.

Click to select a location in the image. After you select the point, a rubber banding line is drawn to the cursor's location. This indicates you are supposed to select a corresponding location on the map. At this time, the map coordinates are being shown in

the status area of the ArcView window. Once you select the corresponding map location, a Root Mean Square (RMS) error is calculated for the point. You continue to select points in this manner until you have an even distribution of points throughout the image.

RMS error

RMS error is calculated when control points are taken. RMS error is the distance between the input location (or From point) and the rectified location (or To point). The RMS error is expressed in terms of horizontal (X and Y) components.

You can view the RMS error for any link (a From and To point pair) by clicking that link. To obtain the total RMS error for the calibration or rectification. The lower the RMS error, the more accurate the resampling.

There are other tools to help you

While you are collecting your control points, you may need some additional tools to help you. If you have the Align tool active, there are quick choices that you can select by clicking your right mouse button. These tools are briefly described below.



Zoom In

The Zoom In choice functions like the one found on ArcView's button bar. It zooms in upon a smaller area of the image.

Zoom Out

The Zoom out choice functions like the one found on ArcView's button bar. It zooms out so that a larger area of the image is in the view.

Pan

The Pan option is useful if you find that you need to select a To point which is currently outside of the display area. You can select the Pan choice and move the image so the corresponding point is visible, then continue to take your To point.

Pan to Next Link

The Pan to Next Link option not only enables you to see the links (a combination of a From and a To point) you have selected between the image and a map, it also enables you to see the RMS error associated with those links in the status area in the lower left hand corner of the ArcView window. If you already have a link selected when you choose this option, it pans to the next link you chose. If no link is selected, it starts at the first link you chose.

Image to Top

This option is particularly useful if you are working with two images which may obscure each other during the correction process. Simply choose this option to bring the active theme in the Table of Contents to the top.

Image to Bottom

Like the Image to Top option, the Image to Bottom option is also useful when you are working with two images which may obscure each other during the correction process. Simply choose this option to send the active theme in the Table of Contents to the bottom.

Enter 'To' Coordinate

You use the Enter 'To' Coordinate if you have a source of To points other than a map displayed in a view. A good example of this is if you have an image and a corresponding set of Global Positioning System (GPS) coordinates. By selecting this option, you can enter those GPS coordinates directly into a dialog as your To points.

Adjust Snap

The Adjust Snap option works just like the Snapping Tolerance which you can set from the Theme Properties. This option snaps your To point when it is within a certain distance of a specific point, for example a GPS point or a road intersection. The snapping tolerance ensures that the vertices snap when within a certain distance.

What happens behind the scenes?

After the first control point is taken, the image is shifted so the From and To locations line up. After the second control point is taken, the scale of the image is adjusted so that both the first two points line up. With the third point, an Affine transformation is calculated and the image adjusted so that all three points line up. Starting with the fourth point, the RMS error is calculated and displayed for each control point.

As each control point is selected from the image and the map, the polynomial transformation is calculated. The calculation is automatic and the image is re-displayed. With each point, the accuracy of the image is improved.

Editing control points

If you wish to edit control points, you must do so using the Graphics tools. With these functions you can delete control points which may actually have increased RMS errors as you continue to collect points. You may also use the Pointer tool to click and move both single control points and links large or small distances in your image. As when you first selected the control point, the RMS error is displayed in the ArcView status area.

Calibrate or resample the image

Once all the points have been collected, you have two options of how to save the image.

If you choose the Theme menu and then Save Image, the image is calibrated. This avoids producing a second copy of the image. The disadvantage of simply saving a calibrated image is that not all data formats keep the calibration node associated with the image for import into different GIS processing software.

Note Files in the ERDAS IMAGINE .img format keep calibration associated with an image.

Alternately, you may choose to Save Image As to produce a resampled image. This option is particularly useful for TIFF and Grid images which do not support calibration nodes.

Store From and To points

At this time, if you wish, you can also save the control point links as a shapefile. This shapefile can be loaded into a view like any other theme and serves as a record of the points that were taken and the resulting RMS errors.

.gcc files and their usage

The Ground Control Coordinates file has a .gcc extension. Files with the extension .gcc are used to store From points collected by using your mouse, entered with the keyboard, or digitized using the digitizing tablet. If you feel that you may need to consult these values at a later time, saving them is easy. They cannot, however, be loaded back into the original image, they are strictly coordinate values.

C H A P T E R 6

Analyzing images

The two major types of analysis provided by the Image Analyst extension are change detection and greenness mapping. Both allow you to isolate certain types of information in your images for analysis.

Change detection can be performed when you have two images of the same area at different points in time. Because change detection is such an important part of image analysis, the Image Analyst extension provides you with tools for exploring change in either continuous or thematic data. Image Analyst provides the capability to consider all possible combinations of change when working with thematic data. You can also select the amount of change to highlight when using continuous data..

Like change detection, greenness mapping is also an important part of image analysis. Image Analyst uses the Normalized Difference Vegetation Index to evaluate the vegetative make-up of an image.

In this chapter you will learn:


How to identify pixel attributes.

How to perform change detection between images.

How to perform greenness mapping of an image.

Identify pixel attributes

When you first draw a theme in a view, you may start your analysis by determining the values of certain pixels which make up the theme. This type of initial analysis may help you decide how to further analyze your image.

The Identify Results tool  provides information for all of the layers of a selected pixel. This information includes X and Y coordinates and values for the pixel in each layer of the image. Information accumulates in the Identify Results dialog box until you click the Clear or Clear All button. This option is useful for rapidly comparing areas within the image. This option is also useful when analyzing the results of the Categorize tool since class means are stored as attributes.



The Identify Results dialog box gives information for a selected pixel in every layer of the image.

Detect the amount of change between images

The use of change detection differs depending on what kind of data you are working with, either continuous or thematic. If your data are continuous, you use the Image Difference option. If your data are thematic, you use the Thematic Change option.

Image to image comparison

The image to image comparison menu choice is particularly useful for multi-temporal imagery which depicts the same area at different points in time. Typically, you want to find out what has changed over time. The Image Difference dialog box allows you to set the parameters which determine that change. Alternately, you may also choose to compare changes between bands of data of the same image.



The Image Difference dialog box allows you to select before and after themes and how the changes are depicted, either as percent or value.

Two themes are generated from image to image comparison: a grayscale containing the results of the subtraction and a thematic image consisting of five categories.

The grayscale image is composed of continuous data. This image is the direct result of subtraction of the two images. Brighter areas are in the higher reflective aspect. Dark areas are in the less reflective aspect.

The Highlight Difference theme depicts areas of change between images. By default, the areas of decrease are depicted in red, and the areas of increase are depicted in green. The first class represents areas of positive change greater than the threshold selected and is green in color. The second depicts areas of positive change, but less than the threshold and is transparent. The third is areas of no change and is also transparent. The fourth designates areas of negative change but less than the threshold selected and is transparent. The fifth class holds areas of negative change greater than the threshold and is red in color.

From an image to image comparison with the parameters in the dialog box pictured above, you obtain a result as follows:

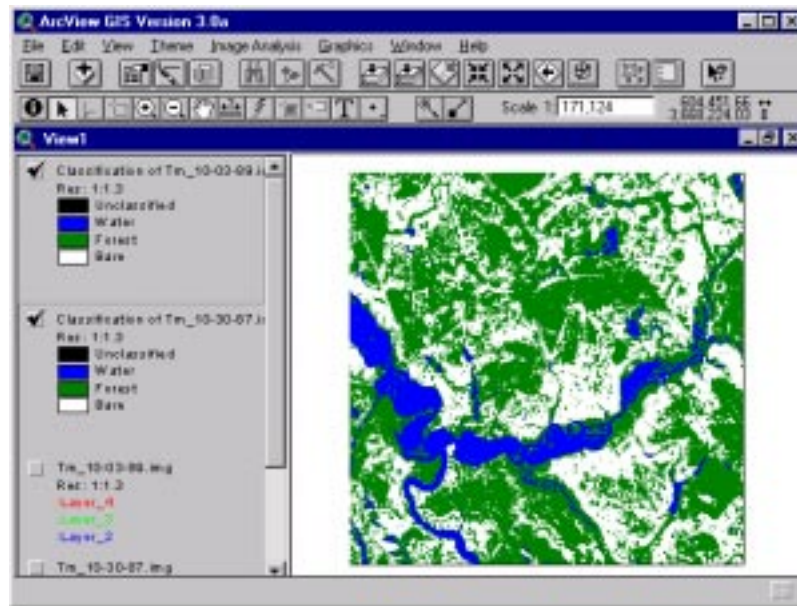


This image shows areas of >25% change in the North metro Atlanta area between the years of 1987 and 1992.

Classification to classification comparison

Before and after classifications allow you to quantify the amount and type of changes that have taken place over time. The two tools used to assess the change in condition are Thematic Change and Summary (Summarize Areas).

In the following example, you will see how two images of an area affected by hurricane Hugo can be used with both the thematic change option and the summarize areas option. The picture below illustrates how the Categorize option was used to produce two thematic data themes from the continuous data themes which were originally drawn in the view.



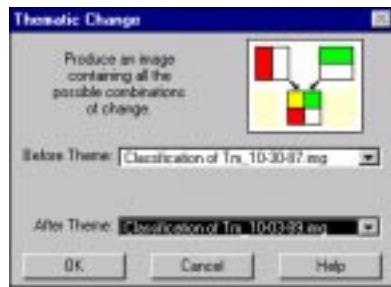
This picture illustrates how the categorize option is used to create thematic data from continuous.

Thematic change

Thematic Change produces a thematic image which has all the possible combinations of change which occurred using both before and after classifications.

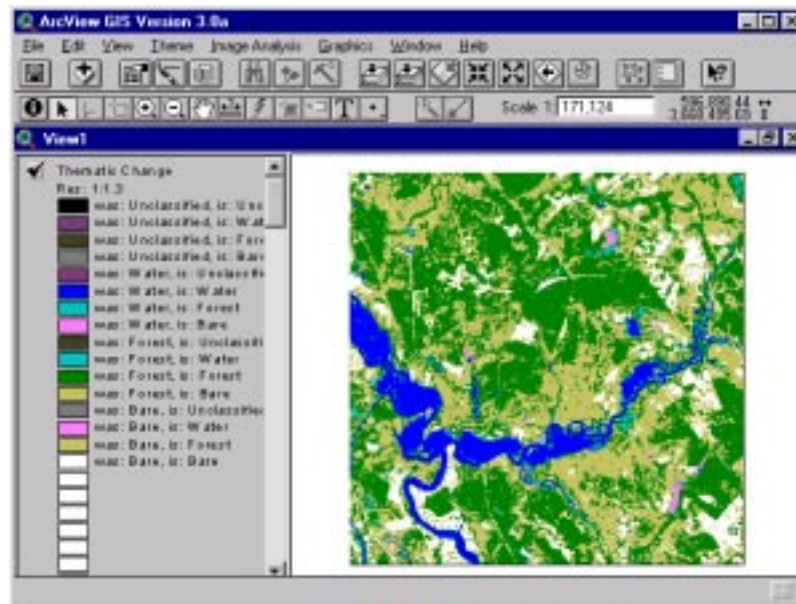
Perform a thematic change

1. Make both Classification themes active in the view.
2. From the Image Analysis menu, choose Thematic Change.
3. Click the dropdown list for Before Theme and choose Classification of Tm_10-30-87.img.
4. Click the dropdown list for the After Theme and choose Classification of Tm_10-03-89.img.



You can use the dropdown lists to select the Before and After Themes easily.

5. Click OK in the Thematic Change dialog.
6. Click the check box to draw the Thematic Change theme in the view.



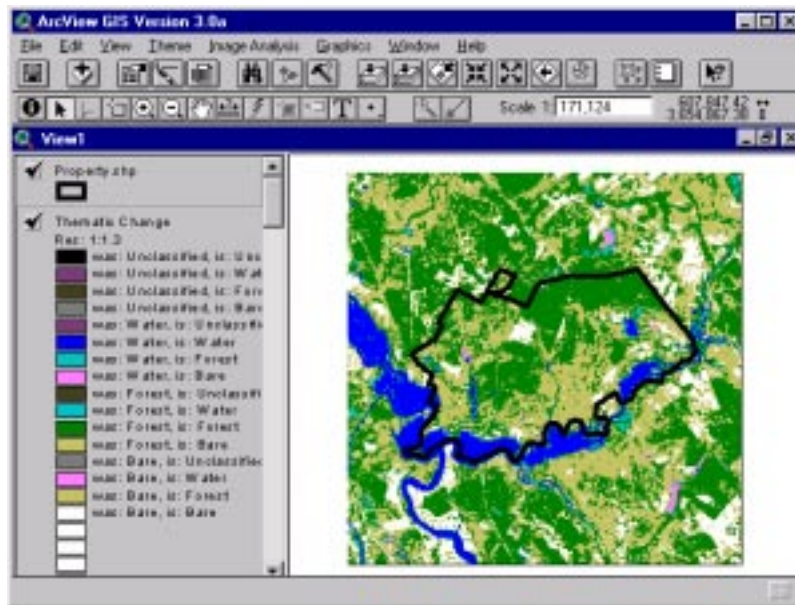
Use of the Thematic Change depicts all the combinations of change from comparing two themes. In this example, a matrix was made comparing classification of the Atlanta images from 1987 and 1992.

The result is a new theme with 16 distinct classes - the product of 3 times 3 classes plus the unclassified areas included in each of the two thematic images you used in the Thematic Change operation.

Summarize areas

The use of the Summary tool provides a more focused output by summarizing one theme by another. The initial dialog box looks like the one below. If you wish, you can export the data resulting from a Summary analysis to a table in your project.

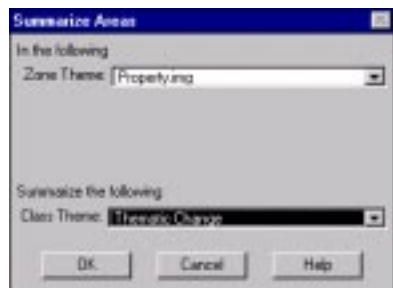
The example below continues to work with the example of the area affected by hurricane Hugo. You will now add a feature theme so that you can perform the Summarize Areas function.



This picture shows the theme generated from the Thematic Change operation as well as a feature theme, Property.shp. You can use these two themes to Summarize the areas specifically within the property boundaries.

Summarize areas within the boundary

1. Click to make both the Thematic Change and Properties.shp active in the view.
2. From the Image Analysis menu, choose Summarize Areas.
3. Click the Zone Theme dropdown list and choose Property.shp.
4. Click the Class Theme dropdown list and choose Thematic Change. Click OK in the Summarize Areas dialog box.



- When the Summarize Areas Results dialog opens, scroll to see all the values.

 A screenshot of the 'Summarize Areas Results' dialog box. It has a title bar 'Summarize Areas Results'. At the top, there are fields for 'Zone Theme:' (Property.mxd), 'Attribute:' (Class Name), and a 'Value:' dropdown. Below these are 'Class Theme:' (Thematic Change) and 'Area units:' (Acres). The main part of the dialog is a table with four columns: 'Class Name', 'Count', '%', and 'Acres'. The table contains 11 rows of data. At the bottom are three buttons: 'Close', 'Export to Table...', and 'Help'.

Class Name	Count	%	Acres
Water: Water, is: Water	12169	7.41%	2706.322131
Water: Water, is: Forest	1195	0.73%	265.761866
Water: Water, is: Bare	59	0.04%	13.121297
Forest: Forest, is: Unclassified	0	0.00%	0
Forest: Forest, is: Water	2502	1.52%	556.431956
Forest: Forest, is: Forest	70633	43.01%	15708.416608
Forest: Forest, is: Bare	44463	27.08%	9888.342951
Bare: Bare, is: Unclassified	0	0.00%	0
Bare: Bare, is: Water	792	0.48%	176.136734
Bare: Bare, is: Forest	13094	7.87%	2912.036382
Bare: Bare, is: Bare	15308	11.76%	4294.000083
	0	0.00%	0

You can use the scroll bars to select information which is most important to you.

- Click the Export to Table button to open the Export Table to DBASE dialog box.
- Type the name "Hugosummary" and click OK.

Map greenness of images

The greenness mapping option works by using the *Normalized Difference Vegetation Index (NDVI)* to measure the amount of vegetation in an image. This index is created by calculating a ratio of the DN values of different bands. Bands are directly influenced by the absorption and reflection properties of vegetation.

NDVI equation

The equation used to calculate NDVI is as follows:

$$\text{NDVI} = \frac{\text{IR} - \text{R}}{\text{IR} + \text{R}}$$

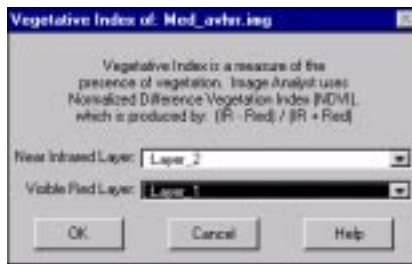
How are DN values determined?

A digital number (DN) value is a value assigned to a band of data. DN values are influenced by the amount of incident radiation absorbed by the atmosphere.

Pixels are positioned according to their DN values in each band of data.

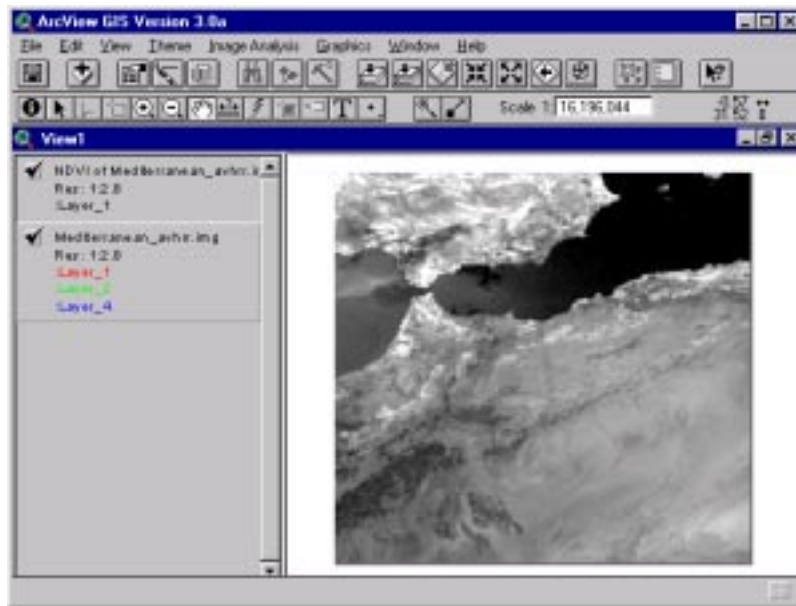
The use of the Vegetative Index produces a theme. The resulting theme clearly depicts the vegetation properties. Typically, bright areas represent more dense and healthy areas of vegetation, and darker areas represent less healthy or undervegetated areas.

To access the Vegetative Index dialog box, click the Image Analysis menu, then choose Vegetative Index.



To use the Vegetative Index, you must select the layers to assign Near Infrared Layer status and Visible Red Layer status. The result is displayed as a theme.

Image Analyst provides default layers for data obtained from TM and SPOT and AVHRR. You can change the layers to be compared if you wish. Once you have selected the layers to be considered for your vegetative index, Image Analyst calculates the NDVI and produces a new grayscale theme which highlights the areas of vegetation as depicted below. Like other Image Analyst themes, you can alter the lookup tables to change how the image is displayed.



The image above clearly depicts the areas of vegetation as bright values.

From this example, you can see that dense vegetation is depicted as brighter. From this result, you may elect to perform a classification to further refine or categorize the data.

Note For information on Classifying data, see Chapter 8, 'Image classification and post classification analysis.'

C H A P T E R 7

Feature extraction

An important part of the image analysis process is picking out certain features which mean the most to you. Feature extraction ranges from identifying ground features to defining a GIS theme for further analysis. The tools for feature extraction in the Image Analyst extension include Seed tool and Find Like Areas. Initially, the Seed tool may be used to identify a feature of special interest. Then, the Find Like Areas tool is used to find additional areas within the image with the same characteristics.

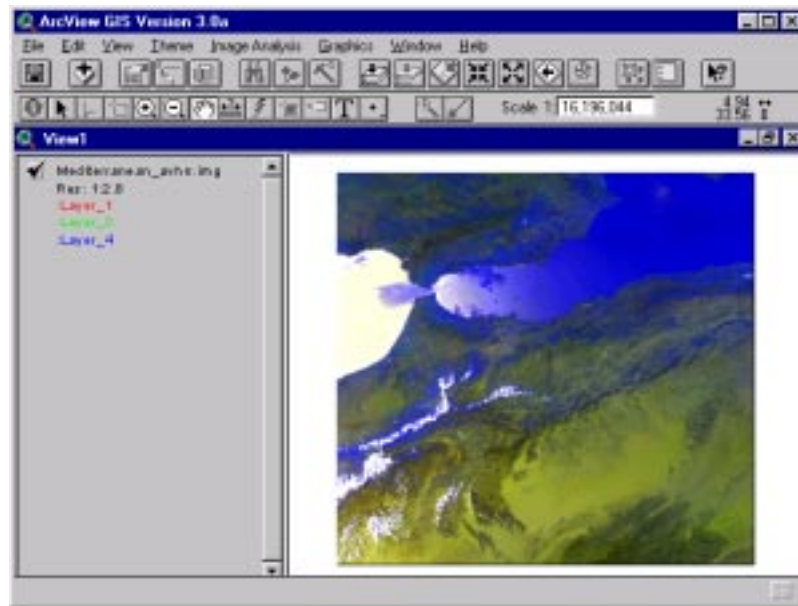
In this chapter you will learn:

How to use the Seed tool.

How to find like areas in an image.

Use the Seed tool to define an area

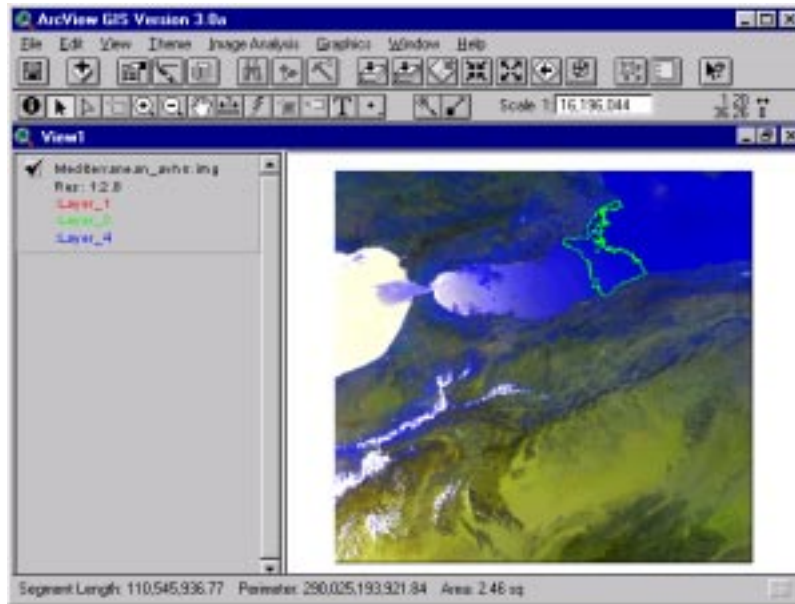
Consider the image of the Mediterranean Sea and surrounding land mass below. In this example, you will see how the Seed tool is applied to the image to quickly highlight areas with the same characteristics. The Seed tool saves you the time of identifying areas of interest on a pixel by pixel basis.



This image of the Mediterranean Sea and surrounding land mass is an excellent candidate for application of the Seed tool and the Find Like Areas tool.

Use the Seed tool in an image

1. Make the theme active in the view.
2. From the ArcView tool bar, click on the Seed tool .
3. Move your mouse (which has changed to a cross-hair) into the view and click to select an area of interest.



As the above picture illustrates, using the Seed tool returns a polygon which contains pixels of the same range.

As the picture above illustrates, you use the Seed tool, located on the ArcView tool bar, to grow a polygon around selected pixels. In order to use the Seed tool, only one Image Analyst theme must be active in the View. By using the Seed tool, all points both similar and contiguous to the designated pixels are selected until no pixels meet the required criteria.

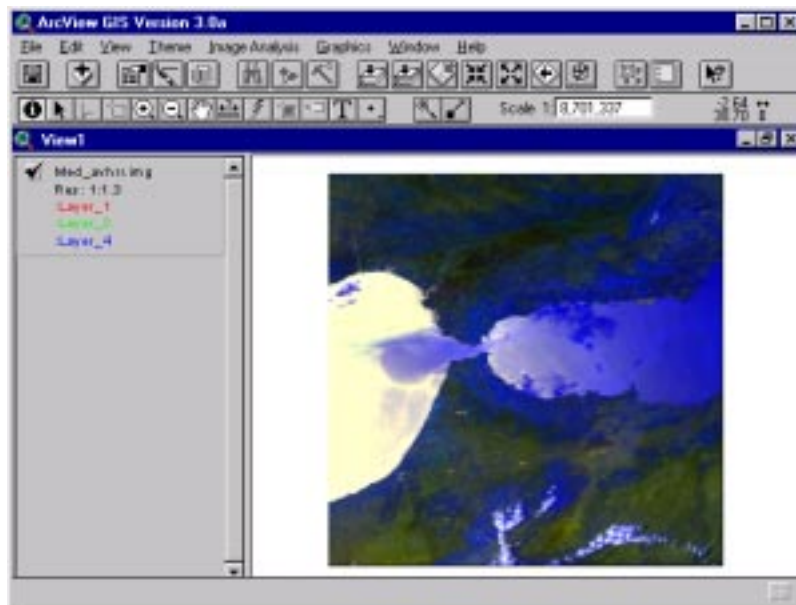
The band or bands used in growing the polygon is controlled by the current visible layers as set in the legend editor. The use of the Seed tool returns a polygonal shape. If a polygonal shapefile is being edited, a polygon defined using the Seed tool added to the shapefile. Otherwise, the polygon is generated in ArcView's graphic acetate layer. The resulting polygon appears on top of the image and is selected.

Specify seed radius

The Seed tool is controlled by Seed Radius. You can change the properties of the Seed Radius by selecting the Image Analysis menu, then choosing Seed Tool Properties. The Seed Properties dialog states the name of the View you are working with in the title bar. From this dialog, you select your Seed Radius in terms of pixels. All subsequent applications of the Seed tool use this set radius.

Change the Seed Radius

1. From the Image Analysis menu, choose Seed Tool Properties.
2. In the Seed Properties dialog box, change the Seed Radius to a new value.

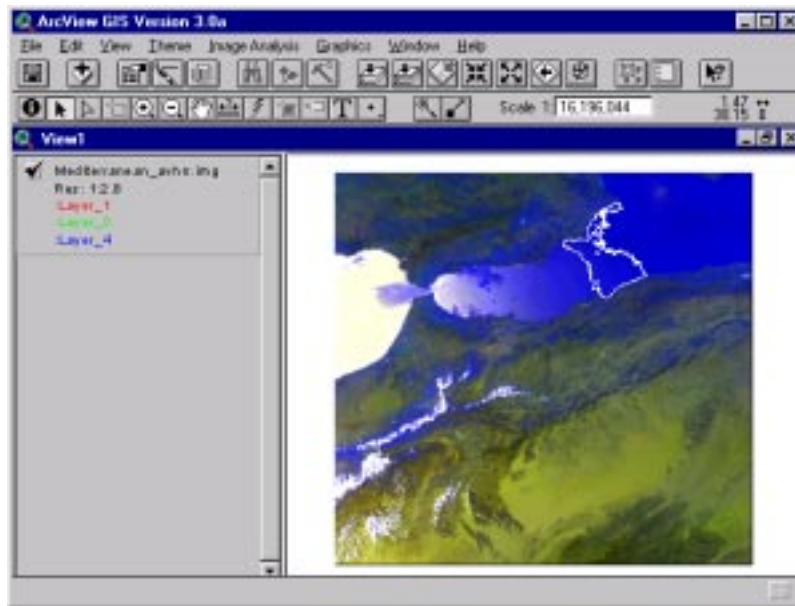


The Seed Diameter can be set every time you use the Seed tool, or you can set a predefined value. Simply access the Seed Tool Properties and change the Seed Diameter.

The Seed Diameter determines how selective the Seed tool is when selecting contiguous pixels. A larger Seed Diameter, or radius, includes more pixels when calculating the range of pixel values used to grow the polygon, and thus, a larger polygon is produced. A smaller Seed Diameter uses fewer pixels to determine the same range. For example, if you select a Seed Diameter of one, then the Seed tool only grows to include pixels in the image which have the same exact value of the pixel you select.

Changing the polygon's color

You can further refine the polygon produced by using the Seed tool by changing its color. To change the color of the polygon, you use the Pointer tool to select the polygon you wish to change. Next, select Graphics, then Properties. From the Color dropdown list, you can choose Outline and make your polygon a standard or custom color. Avenue users can change the default color in the Avenue script.



This example demonstrates how you can change a polygon's color.

Find like areas in an image

The Seed tool is good for selecting single areas of interest to you. There may, however, be other areas in the image with those same characteristics which you need to know about. The Find Like Areas tool finds areas in the image with similar characteristics which are not necessarily contiguous to the selected area.

Consider the same image of the Mediterranean Sea and surrounding land mass. Once you have defined an area which interests you using the Seed tool, you can then use the Find Like Areas tool to isolate all similar areas within an image.

Using the Find Like Areas tool

1. Make the theme active in the view.
2. From the Image Analysis menu, choose Find Like Areas.

Screen Capture

The Find Like Areas dialog box uses an existing image to select common areas and output to a new or existing theme with the information.

- 3.

Screen Capture of results

This picture shows how the Find Like Areas tool creates a new class.

The Find Like Areas process is completed using a parallelepiped classifier. As you saw in the example, the results are shown in a separate Output Image Theme which can either be pre-existing, or you can create it. This depends on the Class Name field. If the class name does not exist in the output image theme, a new class is created. If the class already exists, then additional areas are added to the existing class.

What is a parallelepiped classifier?

A parallelepiped classifier is a classification decision rule in which the data file values of the candidate pixel are compared to the upper and lower limits in each band or layer of interest. It is also defined as the limits of a parallelepiped classification, especially when graphed as rectangles.

In cases where an area can fall into more than one category, Image Analyst assigns that value to the last class calculated. A good example of this type of classification is a swamp – which could fall into either a water or vegetation class.

CHAPTER 8

Image classification and post classification analysis

Image Analyst provides you with an easy method of classifying your data, an unsupervised classification. All you have to do is supply the number of classes you would like your data divided into. The result is a separate theme containing thematic data. This data can then be used in other ways, such as change detection.

After you have classified your data, it may be desirable to perform post classification analysis. Post classification analysis visually improves the quality of your data and allows for GIS analysis within ArcView. The two methods of post classification are focal majority (or smooth) and convert to shapes.

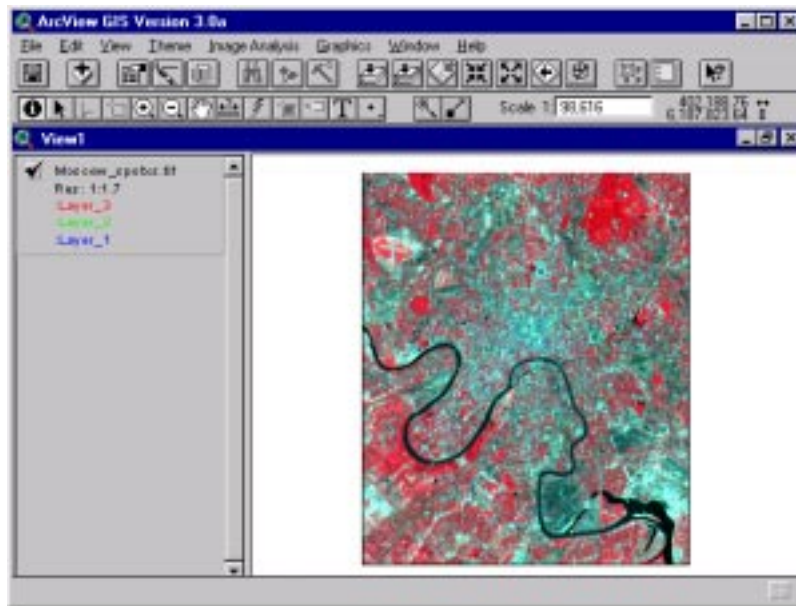
In this chapter you will learn:

How to classify an image.

How to perform post classification analysis of an image.

Classify an image

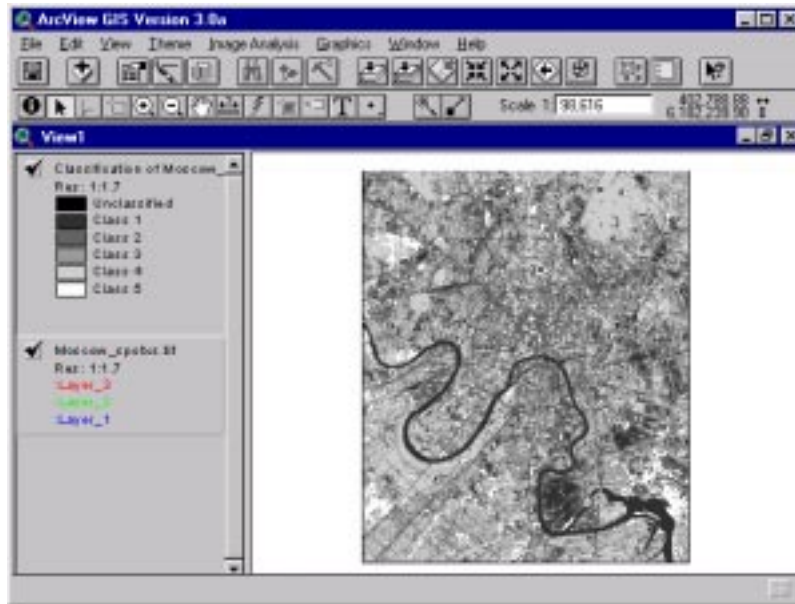
The image of Moscow below has a lot of detail. So much detail, in fact, that it may be difficult to isolate similar areas of the image. In cases such as this, it is helpful to perform an unsupervised classification of your image.



This is an image of Moscow exactly as it was drawn in the view.

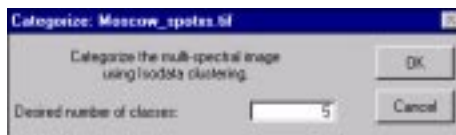
Perform an unsupervised classification

1. Make the theme active in the view.
2. From the Image Analysis menu, choose Categorize.
3. In the Categorize, type '5.' Click OK.
4. Click the check box Classification of moscow_spotxs.tif to make it active.



This picture shows the result of performing an unsupervised classification of an image.

Classification of an image defines certain characteristics and assigns them symbols, values, and labels. If you wish, you can perform an unsupervised classification and simply designate the number of classes you want your data divided into by selecting the Categorize option from the Image Analysis menu. This method assigns data into certain categories based on the properties of the data alone. Unsupervised classification is particularly useful when you are unfamiliar with the data. The unsupervised classification works by using the ISODATA technique.



The Categorize dialog box allows you to type in the number of classes you want and then performs an unsupervised classification.

ISODATA

The *Iterative Self-Organizing Technique (ISODATA)* performs an entire classification (outputting a thematic raster layer) and recalculates statistics. The technique is self-organizing because clusters of data are created without input from you. The advantage to the ISODATA method is that it does not favor values at the extremes of the spectrum.

Perform post classification analysis of an image

Post classification analysis is a type of iterative process which enables you to refine the display of classes of data. Two of the most common methods of post classification are focal majority and convert to shapes.

Applying focal majority (or Smooth) to an image

In Image Analyst, the focal majority is known as the Smooth option. The Smooth option, accessible from the Image Analysis menu, uses a three by three convolution kernel of all ones, which is normalized before application. To achieve the effect of a larger kernel, the Smooth option can be repeated.

The choice is only active when the image is zoomed at least to the resolution of the image. The theme legend displays the resolution of the image in a ratio format. The ratio x:x indicates screen pixels:image pixels. To ensure that the image is zoomed to the proper extent, choose Zoom to Image Resolution from the View menu. Alternately, you can also choose the Zoom to Image Resolution button which is located on the ArcView button bar. The Smooth option can be used on either continuous or thematic data. With thematic data, a focal majority is performed instead of convolution filtering.

Some areas in an image may look very noisy. The Smooth option evens those areas out. In the following example, the Smooth option was applied to the image of Moscow. The resulting theme removes the noisy effect.

Smooth an image

1. Make the theme active in the view.
2. From the View menu, select Zoom to Image Resolution.
3. From the Image Analysis menu, select Smooth.

This picture illustrates the use of a Smooth filter. Features are less defined and the image has an overall fuzzy look.

CHAPTER 9

Using the Image Analyst through Avenue

Like other extensions to ArcView, the Image Analyst extension can be manipulated through the use of the Avenue script. This development environment is defined by an object-oriented programming language and a graphical interface for customization. The Avenue script can be used to edit controls in ArcView, simply by accessing the Script Editor.

Object model for the Image Analyst

This diagram shows the objects that make up the Image Analyst and their relationship to each other.

Object relationships

As in all ArcView applications, objects are managed by requests. A full list of objects and the requests which can be applied to them can be found in the on-line help system.

An *object* is defined as “an entity that represents something you work with in (Image Analyst). Objects are interface elements such as controls and document windows, or they can be project components like views or layouts, or they can be basic elements of Avenue like numbers, dates, Booleans, and strings, or they can be graphic primitives like points, lines, or other shapes” .

A *request* “lets you create, manage, manipulate, or retrieve information about objects” .

Loading and unloading the Image Analyst extension

You can load the Image Analyst extension using Avenue alone.

```
TheIAExt = Extension.Open("AVEXT/image.avx".AsFileName)
```

Accessing an Image Analyst object

Adding an Image Analyst object to a view

Querying the Image Analyst theme

Projections and the Image Analyst

Error checking

APPENDIX A

Functional overview of the Image Analyst class

This appendix provides information regarding the instance and class requests of the Image Analyst class. For a complete list and description of input parameters, consult the on-line help.

Image Analyst class requests

Setting the analysis environment

Managing Image Analyst themes and Image Analyst data sets

Creating and importing Image Analyst data sets

Image Analyst instance requests

Mathematical operators

Arithmetic

Boolean

Logical

Bitwise

Focal and block statistics

Reclassification

Hydrologic functions

APPENDIX B

Functional overview of the IATheme class

This appendix provides you with the instance and class requests specific to the IATheme class. Many requests include input parameters. A complete list of input parameters can be found in the on-line help with descriptions of each.

IA Theme class requests

Making IA themes

IATheme instance requests

Checking capabilities of an IATheme

Querying an IATheme

Editing an IATheme's legend

Generic object requests

Refreshing and updating an IATheme

Supporting identify

