



VISUAL LEARNING
SYSTEMS

Using Feature Analyst™ for Land Cover and Land Use Mapping

A Visual Learning Systems, Inc. White Paper
April 2004

Visual Learning Systems, Inc.
We put the information in GISsm

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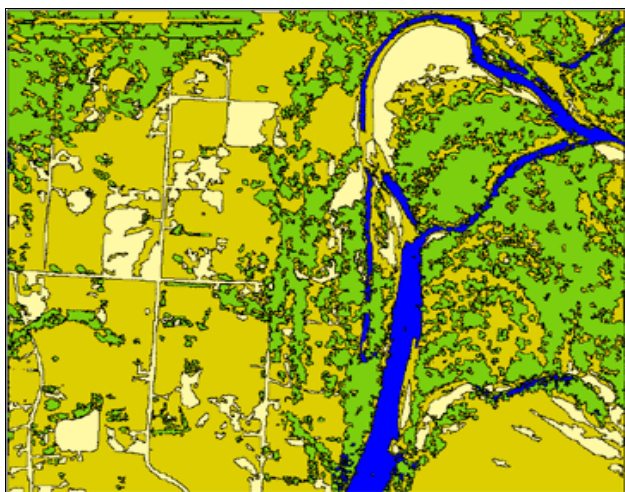
INTRODUCTION

The mapping and updating of land cover data is important to many organizations. From fire burn severity in our forests, to land use on our farms, timely accurate GIS data is necessary in order to make educated policy decisions and to guide organizational strategies. Feature Analyst® for ArcGIS 8.x, ArcView 3.x, and ERDAS IMAGINE® 8.x provides a simple, powerful, and cost-effective solution for creating new land cover maps and updating older data. Renown for its ability to capture small features such as swimming pools, cars, and buildings, Feature Analyst may prove more valuable for mapping land cover features.

The goal of this white paper is to educate on the topic of land cover mapping utilizing different types of imagery and leveraging the revolutionary feature extraction capabilities of Feature Analyst.



The Feature Analyst works with satellite and aerial pan-chromatic, color composite, multi-band, and radar imagery...



...and can perform land cover classifications fast and accurately.

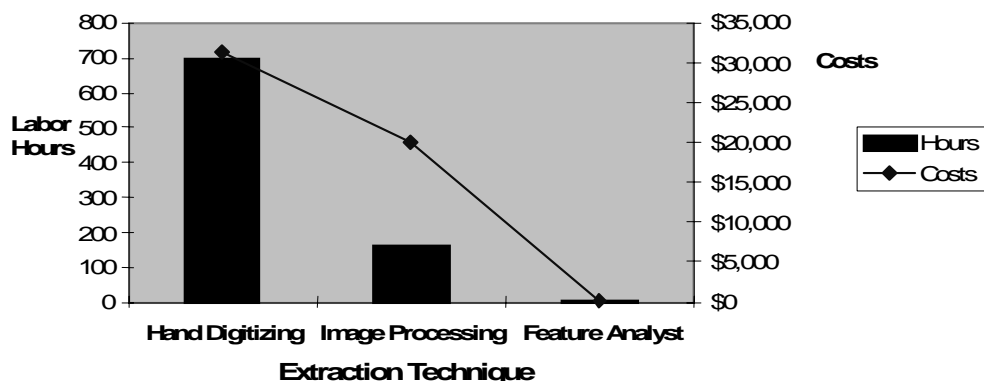
ABOUT VISUAL LEARNING SYSTEMS AND FEATURE ANALYST

Visual Learning Systems, Inc. (VLS) is a machine learning research and software development company creating 21st century information technology tools for the geographic information systems (GIS) industry. The flagship product of VLS is Feature Analyst. With research funded through NIMA (now the NGA) of the Department of Defense as well as NASA, VLS built Feature Analyst into the premiere feature extraction tool on the market. Along with software, VLS provides custom feature extraction work, as well as professional training, both at VLS Headquarters in Missoula, Montana, and on site with clients.

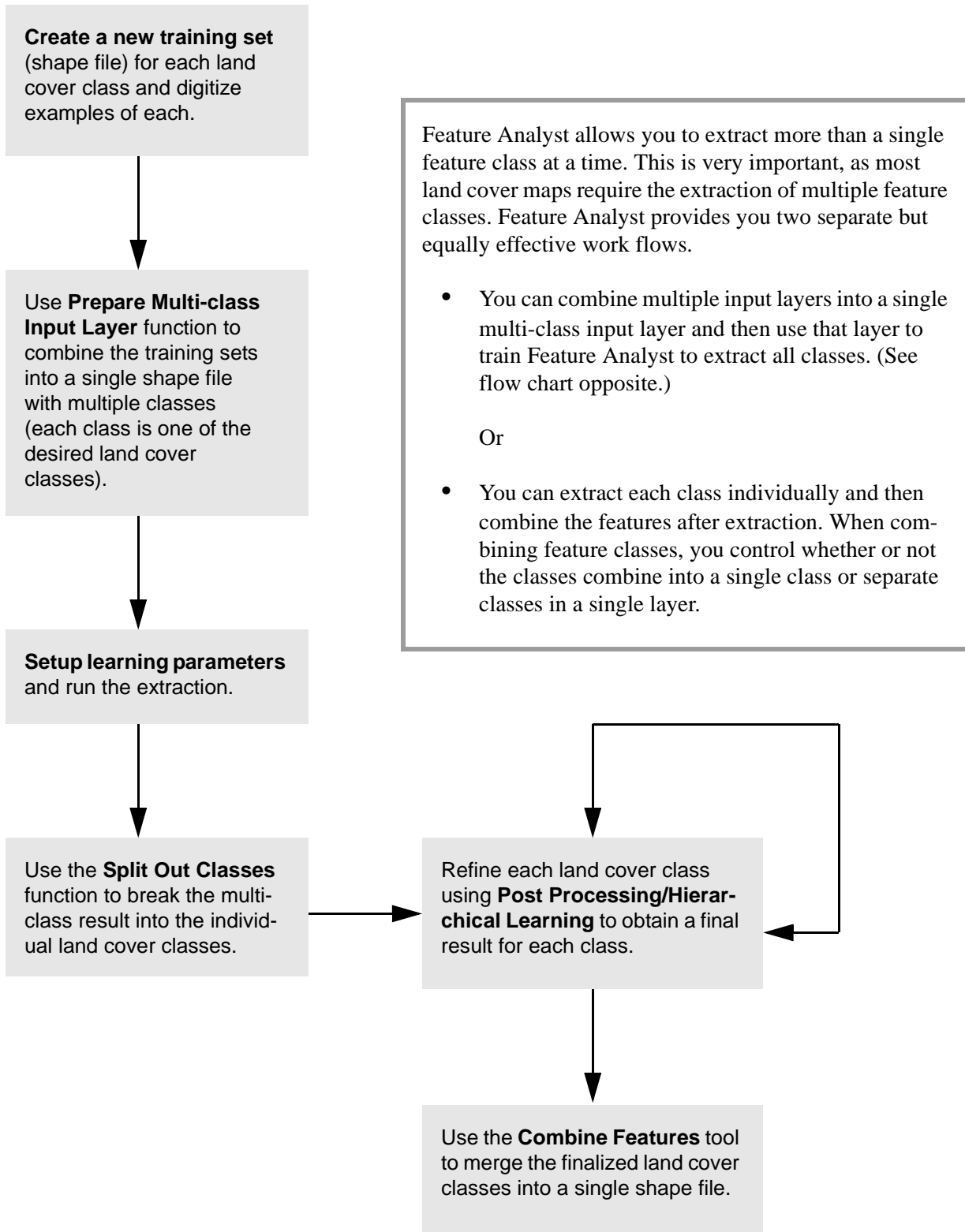
Feature Analyst’s machine learning approach to automated feature extraction incorporates software agent technology which *learns* to find features like hydrology, vegetation, and other land cover feature based on user-specified examples. The software provides *object-specific* feature capture technology using spatial context and advanced machine learning techniques that allow you to control the feature extraction process rather than using hard-coded rule bases. Built as an extension to ESRI’s ArcView 3.x, ArcGIS 8.x, and ERDAS IMAGINE® 8.x, VLS designed Feature Analyst for GIS Analysts and technicians with minimal knowledge of image process technology and yet it is powerful enough for expert image analysts. It integrates advanced image processing transformations, such as Spectral Mixture Analysis into the feature extraction process.

Benefits:	Solutions For:
Automation: Reduces the labor costs of updating GIS databases.	Forestry: land cover, land use, roads, species identification, trails, trees, burn areas, fuels loads, and water.
Accuracy: More accurate than hand digitizing on many features. More accurate than image processing on almost all features.	State/Local Gov’t.: buildings, roads, impervious and pervious surfaces, paint on pavement, weeds, and riparian zones.
Simplicity: User-friendly interface allows for unparalleled ease-of-use. Absolutely no image processing expertise required.	Natural Resources: wetlands, soil classification, hydrology, shorelines, vegetation, and weeds.
Innovation: Department of Defense and NASA machine learning research producing spatial context, clutter removal, intelligent agent, & more.	Small Feature Capture: manhole covers, swimming pools, telephone poles, guardrails, and cars.

Cost-Benefit Analysis for Feature Extraction Techniques for the 1999 Multi-Modality Image Fusion Project



Suggested Land Cover Mapping Workflow



PERFORMING A LAND COVER CLASSIFICATION

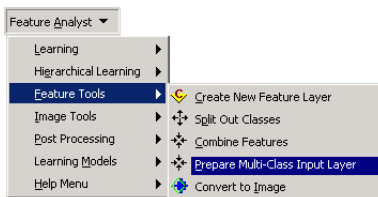
These instructions are for performing a multi-class feature extraction using the method recommended on page 3.

Creating the Training Set

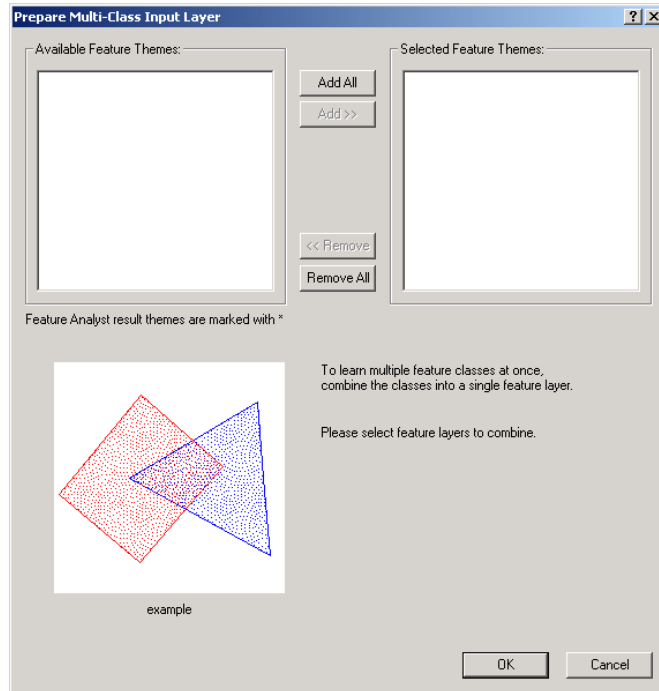


- 1 Using the Create New Theme tool, create a **new shape file** for each target feature type.
- 2 Select the **feature type** (polygon, line, or point) and location for each file.
- 3 Begin **editing each shape file** and specifying examples of the target feature. Make sure you include examples that demonstrate the variety of spectral signatures in the feature class.
- 4 When finished digitizing feature, select **Stop Editing** from the Editor drop-down menu.

Preparing the Training Set



- 1 Highlight the newly created feature layers in the Table of Contents.
- 2 Select **Feature Analyst** on the menu bar and select **Feature Tools** on the drop menu.
- 3 Select **Prepare Multi-Class Input Layer** on the Feature Tools menu.
- 4 Verify that the correct feature layers appear in the Selected Feature Themes list.



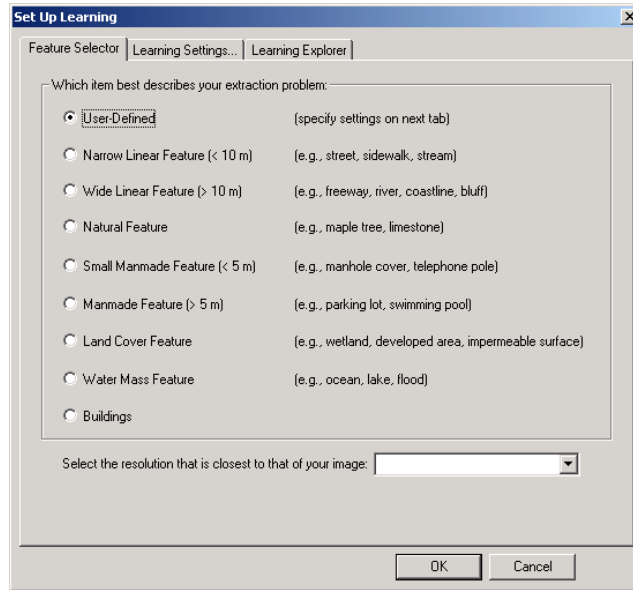
- 5 Click **OK**.
- 6 Name and enter a path for the new layer.

The multi-class shape file appears in the Table of Contents.

Setting up the Learning Parameters



- 1 Highlight the newly created multi-class shape file and click the **Set Up Learning** button.



The Set Up Learning dialog box opens.

- There are two methods for setting up parameters for a land cover extraction. Choose one method below:

Quick Setup:	Fine-tuned setup:
Choose Feature Selector tab on the Set Up Learning dialog box.	Choose Learning Settings tab on the Set Up Learning dialog box.
Select the Land Cover Feature option.	Verify that the correct image appears in the Active Image field and that the correct bands are selected in the Bands Selected scroll box.
Enter the image resolution in the <i>Select the resolution closest to that of your image</i> field.	Choose the Input Representation tab and select the input representation you want to use. We recommend Manhattan for Land Cover extractions.
Choose OK .	Set the Input Pattern to 3 or 5 .
	If necessary, specify the masking type.
	Choose the Learning tab and specify your aggregation size .
	Select the Wall-to-wall Classification option.
	Choose OK .

The Set Up Learning dialog box closes.

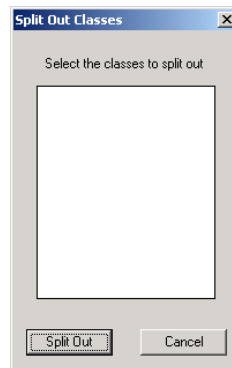


- 3 Choose **One Button Learning** on the tool bar.

Splitting Out the Target Feature Class

Once the Feature Analyst has finished learning, a result theme will be loaded into the TOC. Each pixel in the image will have been classified as one of the target classes. To clean up the results, split out each feature class from the multi-class result.

- 1 Choose **Feature Analyst** on the tool bar and then select **Feature Tools** on the Feature Analyst menu.
- 2 Select **Split Out Classes** from the Feature Tools menu.



The Split Out Classes list box opens.

- 3 Highlight the target feature class and click **OK**.

If you want to refine all classes, you can highlight each class in the list box. The system will ask you to save and name a each new layer.

The Feature Analyst Save As dialog box opens, asking you to name the new layer and select a path.

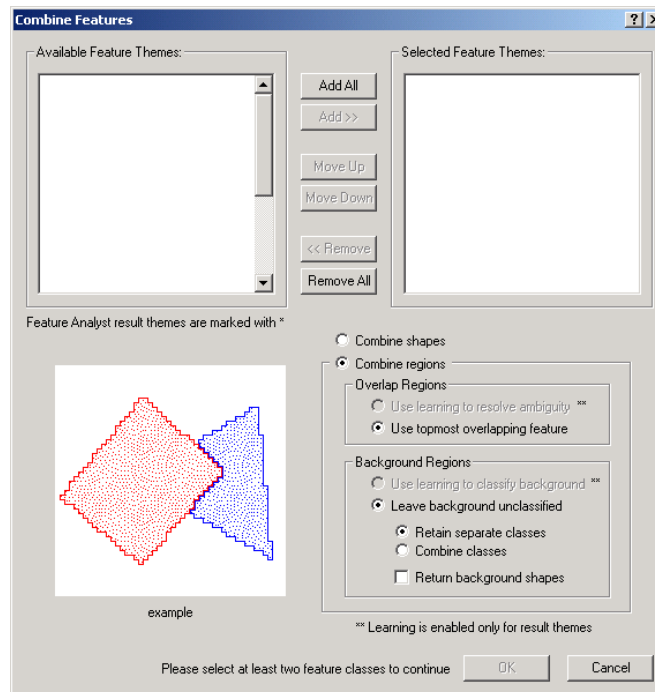
- 4 **Name** and **save** each new layer.

At this point, any you may wish to perform some additional post processing or cleanup using either ArcMap editing tools or Feature Analyst's Hierarchical Learning.

Finalizing the results

Once the final results for each feature class have been obtained, they must then be recombined into a single shape file to achieve the final wall-to-wall land cover classification.

- 1 Highlight each final result and select **Combine Feature** from the Feature Analyst Feature Tools menu.



The Combine Features dialog box opens.

- 2 Verify that the correct feature layers appear in the Selected Feature Themes list. Highlight the layers you want and select Add to move them to the Selected Feature Themes scroll box.

The Combine Features tools allows you to reclassify any empty regions as one of the input feature types, as well as the ability to resolve any overlapping feature types.

- 3 Select the **Combine Regions** option to enable the different combine options.
- 4 To ensure that there is no overlap between the target feature classes, select **Use Learning To Resolve Ambiguity** under the Overlap Regions section.
- 5 In order to obtain a complete land cover classification of the entire image, select **Use Learning To Classify Background** under the Background Regions section.

COMMENTS FROM THE REAL WORLD

The following are some comments from our clients using Feature Analyst to extract land cover and land use features and their reviews of the software's performance.

"The software does very detailed and accurate work of separating forest from non-forest areas as well as separating conifer from hardwood tree species."

From Vanderzanden, D. and Morrison, M. "High Resolution Image Classification: A Forest Service Test of Visual Learning System's Feature Analyst."

"The timing comparisons indicate that Feature Analyst reduces extraction time by a factor of 5 to 10 over small areas. By using Feature Analyst to develop automated classification models over a small training set and extrapolating to larger areas, extraction times could be reduced by several orders of magnitude over large areas."

O'Brien, M., and Irvine, J. "Features Extraction with the VLS Feature Analyst System," Submitted to ASPRS. Conference, Anchorage AK, May 2003.

"I would encourage any GIS Project Manager working with high-resolution imagery to take a hard look at this extraordinary new mapping tool (Feature Analyst). I am convinced you will see the difference in the quality of your projects and in your bottom line."

White, C. "Feature Analyst: Finally a Real Solution for GIS Professionals Working with High-Resolution Earth Imagery." Product Review submitted to SpatialNews.

About the Feature Analyst

- Is a machine learning approach to automated feature extraction that incorporates software agent technology, which *learns* to find features like hydrology, vegetation and other land cover features based on user-specified examples (Shape files).
- Provides *object-specific* feature capture technology using spatial context and advanced machine learning techniques that allows a user to control the feature extraction process rather than using hard-coded rule bases.
- Uses *One-Button* techniques to extract features, remove clutter, and add missed objects, which provides a pathway to autonomous feature extraction using the *Learning Explorer*.

- Is object-oriented component software designed to lower the labor rates of maintaining a GIS database by extending existing COTS image processing and GIS software systems.
- Is designed for GIS analysts and technicians with minimal knowledge of image processing technology; yet is a great tool for expert image analyst as it integrates advanced image processing transformations, such as Spectral Mixture Analysis, into the feature extraction process.

SUMMARY

The Feature Analyst was designed to address the labor cost and time issues of maintaining GIS databases using high-resolution imagery. The Feature Analyst extension for ArcView, ArcGIS 8.x, and ERDAS IMAGINE 8.x provides a solution for this business problem by integrating advanced machine learning technology into the GIS workflow process. The software is simple, affordable, accurate, fast, and excels at capturing land cover features using data from high-resolution color and multi-spectral imagery to lower resolution panchromatic data. Feature Analyst is designed for organizations interested in saving time and money by:

- Leveraging the information content of high-resolution imagery with state-of-the-art technology.
- Using ESRI's ArcView and ArcGIS software to manage the workflow of extracting information from high-resolution imagery.
- Extracting geospatial information from imagery to maintain the spatial and temporal content of your enterprise GIS database.
- Minimizing training requirements for GIS analysts and technicians, and/or provide added functionality for advanced image processing analysts.

References and Suggested Reading

Redmond, R. and Winne, C. (2001). Classifying and Mapping Wildfire Severity. *Imaging Notes*, v16(5), pp. 24-25.

Vanderzanden, D. and Morrison, M. (2002). High Resolution Image Classification: A Forest Service Test of Visual Learning Systems's Feature Analyst. USDA Forest Service, Remote Sensing Applications Center, Salt Lake City, UT.

Visual Learning Systems (2002). *User Manual, Feature Analyst Extension for ArcView 3.x/ArcGIS 8.x*, Visual Learning Systems, Inc., Missoula, MT.