



CATALYST
PROFESSIONAL

Satellite Bundle: Description

CATALYST Professional Satellite bundle comes with everything geospatial professionals need to process and analyze optical Earth imagery from satellite platforms. The Satellite bundle is our advanced solution for geospatial professionals to access powerful processing, visualizations, and analytical capabilities to prototype, build and automate workflows for optical satellite imagery.

With CATALYST Professional Satellite bundle, you get more for less:

- High-performance viewer that supports all major satellite sensors and file types
- Advanced photogrammetry and mosaicking workflows for optical satellite imagery
- Object-based Image analysis
- Visualization tools to enhance viewing and data extraction
- Intuitive wizards to accelerate prototyping and interactive workflows
- Access to hundreds of algorithms through python to build and productize automated workflows
- Plus, full customer support

CATALYST is a PCI Geomatics Enterprises Inc. brand, which has been introduced to put our leading-edge technology into the hands of decision makers. CATALYST provides proven algorithms rooted in photogrammetry and remote sensing to offer engineers, environmental management, and geospatial professionals access to leading edge and scalable software solutions and platforms.

Table of Contents

Introduction	1
Supported Satellite Formats.....	1
Satellite Models	5
Ground Control	7
GCP Collection.....	7
Tie Point Collection	7
Residual Report.....	7
Project Tools	8
Orthorectification	9
Mosaicking	9
Mosaic Tool	10
DEM Extraction.....	10
DEM Extraction Methods	11
Epipolar Pairs.....	12
DEM Extraction.....	12
DEM Editing	13
Pan Sharpening	15
Algorithms	15
PANSHARP.....	16
MRAFUSION	17
Pan Sharpening Hints & Tips	17
Atmospheric Correction.....	18
Workflows	18
Supported Sensors.....	20
Focus Atmospheric Correction Workflows.....	21
Object Analyst.....	22
Workflow.....	22
Focus Object Analyst Workflow	23

Satellite Bundle Functions..... 31

Introduction

The Satellite Bundle of CATALYST Professional includes all the capabilities found in the Essential bundle, including state-of-the-art tools for geometric correction, data visualization and editing, image classification, cartographic map production plus a whole lot more, including applications for raster spatial analysis, radar analysis, hyperspectral analysis, along with a comprehensive desktop automation environment.

The additional tools provided in the Satellite bundle include functionality to produce orthorectified satellite images for all supported sensors and also capabilities to turn pixels into meaningful information with advanced image analytics and image classification solutions, supported by machine learning and powerful processing algorithms that get you better results, faster.

Supported Satellite Formats

The Satellite bundle supports a wide range of high and low-resolution optical satellite sensors.

- ALOS:
 - AVNIR-2: Level 1A, 1B1, and 1B2R format
 - PRISM: Level 1A, 1B1 and 1B2R format (1A and 1B1 provide the highest accuracy)
- ASTER:
 - Level 1A and 1B HDF format (1A recommended for the highest accuracy)
- AVHRR
 - Level 1b 8-bit/10-bit/16-bit HRPT/LAC
 - Level 1b 8-bit/10-bit/16-bit GAC
 - Dartcom 16-bit HRPT
 - Satlantic 16-bit HRPT
 - Quorum Qtrack 16-bit HRPT
 - 16-bit HRPT Minor Frame
 - Dundee 16-bit HRPT
 - AVHRR CEOS (Raw AVHRR CCT Image Format)
- CARTOSAT-1:
 - CARTOSAT L1 (radiometrically corrected) format
- CBERS 1 and 2B
 - Level 1A support
- CBERS-4
 - Level 2 IRS, MUX, P5M, P10, and WF1
- DEIMOS-1
 - L1R, L1T, DIMAP format
- DEIMOS-2
 - L1B, DIMAP format
- Disaster Monitoring Constellation (DMC)
 - LOR and L1R TIFF file format

- Dubaisat-2
 - Level 1R data format
- EROS A/B:
 - Level 1A data format
- FASat Charlie
 - Level 1A SSOT format
- FORMOSAT-2
 - Level 1A DIMAP data
- FORMOSAT-5
 - L1A and L4TWD97 data
- Gaofen-1 (GF1)
 - Level 1A standard
- Gaofen-2 (GF2)
 - Level 1A standard
- Gaofen-4 (GF4)
 - Level 1A standard
- Gaofen-6 (GF6)
 - Level 1A standard
- Gaofen-7 (GF7)
- Earth-observation satellite in the Gaofen series of Chinese civilian remote-sensing satellites. The data includes 2.5m resolution multi-spectral and 0.8m stereo panchromatic data.
- GeoEye-1 (TIFF or NITF format)
 - GeoEye-1 Basic
 - GeoEye-1 Geo
- Gokturk-1
 - Level 0, or Level 1 data
- Gokturk-2
 - Level 0, or Level 1 data
- GOSAT
 - Level 1B (First version)
- Huanjing (HJ)
 - 1A-CCD1, 1B-CCD1 Level 1 format
 - 1A-CCD2, 1B-CCD2, 1B-IRS, 1C Level 2 format
- Hyperion
 - Level 1R, 1T and 1GST
- Ikonos
 - IKONOS provides various levels of processing. The following formats are recommended:
 - GEO product in UTM WGS84 GeoTiff format
 - NITF format with or without rational function

- For color data stored in separate files, you can point to any TIFF file. Channels 1, 2, 3, and 4 correspond to red, green (grn), blue (blu), and near infrared (nir) data.
- IRS
 - Level 0 (raw) and Level 1 (radiometrically corrected) Super Structure format (recommended for the highest accuracy)
 - Full-scene data Orbit-oriented or Map-oriented EOSAT format
- Jilin-1
 - Level 1 with RPC data
- Jilin-1 07b
 - Level 1 with RPC data
- Kanopus-V
 - Level 2A and 3A Pan, MS and PSH data
- KazEOSat-1
 - Level 1A, Level 2 with RPC
- KazEOSat-2
 - Level 1G data
- Khalifasat
 - Support added for RADIO and GEO products for this optical sensor which features 3m multi-spectral and 0.7m panchromatic data
- Kompsat-2:
 - Level 1R (highest accuracy)
 - Level 1G
- Kompsat-3/3A:
 - Level 1R (highest accuracy)
 - Level 1G
- LANDSAT 1/2/3/4/5 MSS
 - LMTX Data with .txt and .tif files
- LANDSAT 5 (Brazilian):
 - Full-scene data with level 4 or 5 processing levels
- LANDSAT 5 (EOSAT):
 - LANDSAT 5 image full-scene data
 - ORBIT-ORIENTED or MAP-ORIENTED product
 - SYSTEMATIC geodetic processing
- LANDSAT 5/7 (LSGOWG) Canadian CDs:
 - LANDSAT full-scene or sub-scene image data
 - Level-4 processing (bulk, radiometric, and along-scan-line geometric corrections applied)
 - Level-5 processing (georeferenced) CD
- LANDSAT 5/7 (LSGOWG) ESA CDs:
 - Level 5 full-scene or quad-scene data
- LANDSAT 5 (NLAPS, TIFF):
 - NLAPS full-scene data with level-8 processing levels

- TIFF full-scene data with systematic correction
- LANDSAT 7 (HDF, TIFF, FAST, NLAPS):
 - Full-scene data with 1G processing in HDF, TIFF, FAST, or NLAPS format
 - 0R or 1R is not recommended because of discontinuity on the image
- LANDSAT 8
 - L1GT and L1T products in Geo TIFF format
- MERIS (ENVISAT)
 - 1B format
- MODIS
 - MCD43A2 and MCD43A4 products
- Orbita
 - Level 1B OHS-2A, OHS-2C, and OHS-2D
- OrbView-3:
 - Orbview Basic product
- PeruSat-1
 - Level 2A, Sensor product Level 3, Ortho product
- Pleiades
 - Level 1A and Level 2
- QuickBird
 - Basic 1B TIFF or NITF format
 - Ortho Ready Standard 2A product in Geo TIFF or NITF format
- RapidEye
 - Level 1B Basic
- RASAT
 - Level 1 TIFF format
- Resourcesat-2
 - Level 1G for the following sensors
 - AWIFS
 - LISS-3
 - LISS-4
- Sentinel-2
 - Level L1C format (S2MSI1C products)
- Shijian 9A (SJ-9)
 - Level 1A TIFF format
- Skysat
 - Basic scene products
- SPOT 1 to 3 (LGWOWG) Canadian formats, Level 1
- SPOT 1 to 4 (SPOTIMAGE)
 - Level 0
 - 1A (recommended)
 - 1B
 - Old SPOTIMAGE LGSOWG format and the new CAP-T format
- SPOT 5

- Level 1A and 1B DIMAP and CAP formats
- SPOT 6 (TIFF)
 - Level 1A DIMAP
- SPOT 7 (TIFF)
 - Level 1A DIMAP
- SuperView-1
 - Level 1B or 2A data
- TeLEOS-1
 - Level 1 and 2
- Thaichote (THEOS)
 - Level 1 /1A
- TH-01
 - Level 1A, 1B, 2, 3A, 3B
- TripleSat
 - Level 1B Geo TIFF format
- WorldView-1
 - Basic (1B) TIFF and NITF formats
 - Ortho-ready (2A) Standard GeoTIFF format
- WorldView-2
 - Basic (1B) TIFF and NITF formats
 - Ortho-ready (2A) Standard GeoTIFF format
- Worldview-3
 - System-ready (Basic), Viewready (Standard), or Mapready (Ortho) products
- Worldview-4
 - System-ready (Basic), Viewready (Standard) products
- Yaogan-2, Yaogan-8, Yaogan-14
 - Level 1 Standard Geo TIFF format
- ZY-1-02C
 - TIFF or RPC format
- ZY-3
 - TIFF or RPC format
- ZY3-2
 - TIFF or RPC format

Satellite Models

Two methods of model calculation are included in the Satellite Ortho Suite:

Rigorous Math Model

- Calculate the position and orientation of the sensor when an image is taken
- Accurately account for known distortions in an image
- Use ground control points (GCPs) and tie points (TPs), combined with the knowledge of rigorous geometry of sensors, to calculate best fit for all images in a project

RPC Models

The Rational Function is a simple math model that:

- Builds a correlation between the pixels and their ground locations
- Obtains RPC data with images and imports coefficients automatically
- Calculates the polynomial coefficients from GCPs
- Refines RPC data with one or more GCPs
 - Zero- or first-order GCP refinement available

RPC-based corrections are available for the following types of imagery:

- ALOS
 - AVNIR-2
 - PRISM
- CARTOSAT (completed 6 Level certification by ANTRIX)
- DEIMOS
- DMC
- Dubaisat-2
- EROS
- GeoEye-1
- Gaofen-1 (GF1)
- Gaofen-2 (GF2)
- Gaofen-4 (GF4)
- Gaofen-6 (GF6)
- Gokturk
- IKONOS
- Jilin-1
- Kompsat-2
- Kompsat-3/3A
- NITF
- OrbView-3
- PeruSat-1
- Pleiades
- QuickBird
- RapidEye
- Resourcesat-2
- Shijian-9A (SJ-9)
- SPOT
- SuperView-1
- TeLEOS-1
- TH
- TripleSat
- WorldView-1
- WorldView-2
- WorldView-3

- WorldView-4
- Yaogan-2, Yaogan-8, Yaogan-14
- ZY-1-02C
- ZY-3
- ZY3-2

Ground Control

The satellite models support GCP and tie-point ground controls as follows:

GCP Collection

GCPs can be collected manually, or automatically by using:

- A geocoded image
- Geocoded vectors
- A chip database
- An imported text file

Other features include:

- Stereo (and multi-way) GCP collection
- Conversion of GCPs to check points to exclude them from model calculation
- Display of individual and overall RMS error for GCPs

Depending on the sensor, the following minimum number of GCPs is required:

- SPOT 1-4: 4 per image, depending on GCP quality
- SPOT 5: 6 per image, depending on GCP quality
- IRS, ASTER, EOC: 6 per image (6-8 recommended)
- LANDSAT: 6 per image (10-12 recommended)
- Rational functions computed from GCPs: 5 per image (19 per image is recommended)
- Rational functions extracted from image files: None required (accuracy is improved with 1 or more GCPs)

Tie Point Collection

- Extends ground control over areas without GCPs
- Identifies how images in a project relate to each other
- Ensures the best fit for all the images in the project
- Imports and exports tie point locations
- Allows entry of tie point elevations manually or extracts them from a DEM automatically
- Show individual and overall RMS errors

Residual Report

Using residual reports, you can:

- Show GCP, check-point, tie-point, GPS/IMU and stereo (and multi-way) GCP error information in one report

- Edit points and update bundle adjustments
- View in ground units, photo pixels, or photo microns
- Print the report to a file

Project Tools

Raw Image Summary Table

A summary of information about all of the images in your OrthoEngine project can be viewed in the Raw Image Summary Table window. This window provides information about the following:

- Total number of images in the project
- Total number of ground control points (GCPs), tie points (TPs), and check points (CPs)
- Image-specific information, including image ID, GCPs, TPs, CPs, root mean square (RMS) error, number of overlapping pairs connected by TPs, number of potential overlapping pairs that could be connected by TPs, and the percentage of all overlaps connected by TPs

The Raw Image Summary Table provides you with a dynamic view of your project, allowing you to better target your quality assurance efforts to achieve your desired project requirements.

Image-specific information is displayed in tabular format. The tabular contents can be sorted, making it easier for you to analyze the data in your project and identify areas on which to focus your quality assurance activities.

The Raw Image Summary Table window displays both active and inactive images in your project. You can activate and deactivate one or more of the images in your project using the check box column. An active image is included in any processing you want to do on your project. When you deactivate an image, it is still in your project, but is excluded from processing. You can also activate and deactivate images in the Project Overview window.

Project Overview

The Project Overview window provides a graphical display of the raw images in your project, while the Raw Image Summary Table lists all pertinent information in table format. You can use both windows together to gather relevant information about each image in your project, allowing you to better target your quality control efforts and manage your project.

By default, the Project Overview window displays centers of each raw image in project. You can choose to display image centers, geocoded vector footprints, and/or thumbnails of the imagery. You can also toggle the display of ground control points, tie points, and check points, as well as Image and Point IDs, for all images or for selected images only.

Note: When the Raw Image Summary Table is open, the Project Overview window displays the current image with a yellow border and its image ID.

This viewer helps users to better assess their project using a graphical overview. It also includes some simple tools to assist in project management like:

- Ability to display reference imagery or vectors

- Rotating the kappa of the input imagery
- Measurement tools

Orthorectification

- Can run as a batch process
- Utilizes a DEM for terrain correction
- Can increase the size of the working cache for faster processing
- Can increase the sampling interval for faster processing
- Offers the following resampling methods:
 - Nearest Neighbor
 - Bilinear Interpolation
 - Cubic Convolution
 - 8-pt Sin X/X
 - 16-pt Sin X/X
 - Average filter
 - Median filter
 - Gaussian filter
 - User-defined filter
- Clips the image size upon orthorectification
- Can use a scheduled start time
- Provides approximately one-third of a pixel accuracy for VIR satellite images, and approximately one pixel for radar images when quality ground-control coordinates are used

Mosaicking

Mosaicking is available using the Mosaic Tool. Using this you can:

- Define a mosaic area
- Collect cutlines manually, including:
 - Import and export of cutlines
 - Specified blend width along seams
- Perform manual color balancing:
 - Based on samples identified in overlap between images
 - By using samples (match areas) to compute look-up tables (LUTs) to adjust new images to match an existing mosaic
 - By adjusting the dark end or light end
 - By importing and exporting LUTs for color balancing
- Mosaic unreferenced images

When you initiate mosaicking OrthoEngine opens the Mosaic Tool application, in which you can perform all of the tasks necessary to create the mosaic.

When you initiate the mosaicking process, the Mosaic Tool New Project Wizard will lead you through the setup of a mosaic project.

If the images in your project are orthorectified, the Mosaic Tool New Project Wizard appears, and the images appear in the Source file box on the Source Images page of the wizard; otherwise, a message appears, prompting you to create the orthorectified images.

Mosaic Tool

Mosaic Tool features a wizard to make creating your mosaic project quick and easy. The wizard walks you through the following steps to ensure you have everything set up to create your mosaic:

- Source files to use
- Key details, such as size and extents
- Applying color balancing, normalization, or both to the input images
- Selecting how to create cutlines and mask layers
- Previewing the mosaic

DEM Extraction

The DEM Extraction tools allow you to create Digital Elevation Models (DEMs) from stereo imagery. Image correlation is used to extract matching pixels in two overlapping images and then use the sensor geometry from a computed math model to calculate x, y, and z positions. Automatic DEM extraction allows you to batch epipolar generation, batch the DEM extraction process, geocode DEMs, and create absolute or relative DEMs.

In general terms, DEM extraction should work for any satellite sensor that produces stereo data. The following list shows known sensors that have been tested:

- ALOS PRISM
- ASTER
- Cartosat-1
- DEIMOS-2
- EROS
- Gaofen-7
- GeoEye-1
- Gokturk-1
- IKONOS
- IRS
- Kazeosat-1
- KOMPSAT-2
- KOMPSAT-3

- Landsat-8
- PeruSat-1
- Pleiades
- QuickBird
- SPOT 1-7
- SuperView-1
- WorldView 1, 2, 3, 4
- ZY-3
- ZY3-2

DEM Extraction Methods

Users can choose from one of two methods for extracting their digital elevation model (DEM).

- Normalized cross-correlation (NCC)
- Semi-global matching (SGM)

NCC

Matching points in a left and right input image are found using image correlation. The image disparity for the point pair is computed and this value, combined with the geometric model for each image, is used to compute the scene elevation for the corresponding scene point.

The image correlation is performed on an image pyramid that is constructed for each of the input images. The base level of an image pyramid is the original image, the next highest level is the original image resampled to a coarser spatial resolution, the level after that is the previous level resampled to a coarser spatial resolution, and so on. The location in one image that matches the current point in the other is first found at the coarsest resolution level for both images. This location is then used as the starting point for finding the match at the second coarsest resolution, and so on until the match is found in the original images.

This multi-resolution approach to image matching is faster than searching for matches in only the full-resolution images, and results in fewer false matches.

SGM

The implementation of SGM is done by image-matching along epipolar lines using the SGM method first proposed by Hirschmuller in 2005. The SGM algorithm produces excellent detail and few blunders, or *errors*, even at full resolution. However, the basic algorithm does have some drawbacks, such as higher computation time, very high memory consumption, and sensitivity to variations in local lighting conditions. With each implementation of the SGM algorithm, various approaches have been taken to work around these difficulties with varying degrees of success.

Our implementation of the SGM algorithm was developed in-house. It is proprietary and full details are not available. Our implementation uses a tiled approach based on pyramid resolutions with multiple cost functions (including mutual information) to achieve stability over varying local lighting conditions while retaining the highest possible detail. The

algorithm self-adjusts to compensate for small errors in the epipolar line. Innovative memory-management techniques limit RAM usage to 2 GB or less, even if the disparity in the images is thousands of pixels (which can occur in some satellite scenes of mountain ranges).

Epipolar Pairs

Epipolar pairs increase the correlation process speed and reduce the possibility of incorrect matches. Stereo pairs are reprojected, ensuring that the left and right images have a common orientation, and matching features between the images appear along a common x-axis.

Using epipolar pairs, you can:

- Choose from the following pairs:
 - User Select – selects a pair manually
 - Maximum Overlapping Pairs – selects the pair with the highest amount of overlap
 - Minimum Percentage Overlap – specifies the lowest percentage of acceptable overlap
 - All Overlapping Pairs – selects all pairs that overlap above a minimum percentage
- Limit the amount of memory used to generate epipolar pairs
- Define a Down-sample factor to reduce an epipolar image resolution
- Define a Down-sample filter
- Set up epipolar-pair start times

DEM Extraction

Using DEM extraction, you can:

- Specify the minimum and maximum elevation to estimate a search-area correlation
- Specify a failure value to represent any failed (uncorrelated) pixel values in the resulting DEM
- Specify a background value to represent any 'no-data' pixel values
- Set the DEM detail to high, medium, or low for the needed level of detail
- Select an output DEM channel type to 16-bit signed or 32-bit real
- Specify a pixel sampling interval for the number of image pixels and lines used to extract one DEM pixel
- Use a clip region to process a specific area only
- Fill holes and filter interpolated failed values and filter elevation values automatically
- Create a score channel to represent the correlation score for each DEM pixel

- Delete an epipolar pair after use
- Create a Geocoded DEM by using geocoding stored in the project
- Set up DEM extraction start times

DEM Editing

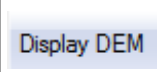
The DEMs may contain pixels with failed or incorrect values. You can edit a DEM to smooth out irregularities and create a more accurate model, and in turn, generate more accurate orthorectified images. For example, areas such as lakes often contain misleading elevation values; setting those areas to a constant value improves the model that will produce a more accurate representation of the lake in the ortho image.




Using the Focus DEM Editing window requires only a DEM; that is, a raster channel in a writable format. To fully use all the functionality available in the DEM Editing window, however, and to produce the best possible DEM, the DEM file should contain additional information. In particular if the DEM file was extracted from epipolar images, you can make use of that imagery to help with your editing.






DEM files created using our technology contain extra information that facilitates DEM editing, including a cutline vector segment and file-level metadata.

The main toolbar on the DEM Editing window provides quick access to several functions that facilitate working with the DEM.

The following table describes the buttons on the DEM Editing toolbar:

Button	Label	Description
	Display DEM	Toggles the display of the digital elevation model layer in the Focus viewer.

Button	Label	Description
	DEM Display Options	<p>Allows you to set display options for the DEM layer. Choose from:</p> <p><i>Grayscale Shaded Relief</i>: displays the DEM using grayscale hill-shading, where a top-left light source and the elevation values are used to cast shadows.</p> <p><i>Color Shaded Relief</i>: displays the DEM using colored hill-shading, where a top-left light source and the elevation values are used to cast shadows.</p> <p><i>Dynamic Color Shade Relief</i>: displays the DEM using colored hill-shading, where a top-left light source and the elevation values are used to cast shadows. This option, the default setting, automatically re-renders the color display of the DEM as you pan or zoom across the viewer so that only the pixels currently being viewed are the basis of the colorization.</p> <p>Typically, editing is most effective when the DEM is displayed as a <i>Dynamic Color Shaded Relief</i>.</p>
	Enhancements	<p>Allows you to apply enhancements to the images automatically loaded in the Focus viewer.</p> <p>Available enhancements are:</p> <ul style="list-style-type: none"> None Linear Root Adaptive Equalize Infrequency Tail Trim (toggle) Exclude Min/Max (toggle) Set Trim % <p>Select the Auto Re-enhance option so that, as you pan across the data, the view is automatically refreshed in the Focus viewer to apply the selected enhancement.</p>
	View DEM Polygons	<p>Toggles the visibility of existing DEM polygons. If a Status layer exists, this option also displays polygons from that layer.</p>

Button	Label	Description
	Set View As Verified	Creates a status polygon using the full extents of the current display area and sets its status to <i>Verified</i> .
	Define Preview Region	Allows you to specify a rectangular region to be displayed in a separate viewer. After you define the preview region, the Full Res. Ortho Preview window opens, displaying a preview of the full-resolution ortho image computed using the modified DEM.
	Open FLY!	Launches CATALYST Professional's FLY! application. FLY! uses the modified DEM and ortho imagery (when available) to allow interactive 3-D display. The FLY! view is centered on the current view, but is restricted to 4096 DEM pixels in x and y.
	Save	Saves the modified DEM and all other associated layers.
	Undo/Redo	Allows you to undo or redo previous actions.

Pan Sharpening

Pan sharpening is the process of automatic image fusion that increases the spatial detail in a lower resolution multispectral (color) image by using a higher resolution panchromatic (black and white) image to produce a high-resolution multispectral image.

Many satellites provide multispectral images at a lower spatial resolution and panchromatic images at a higher spatial resolution. This sharpening process allows you to easily fuse images acquired simultaneously by the same sensor. Alternatively, you can fuse images from different sensors.

Algorithms

The CATALYST Pan sharpening tools include two unique fusion algorithms:

- PANSHARP
- MRAFUSION

Input Images

In both cases the functions require the following input images:

- Multispectral Image Layers:

- Color layers that will be fused with a high-resolution panchromatic image layer
- Reference Multispectral Image Layers:
 - Aid in the pan-sharpening process
 - Span the same frequency range as the panchromatic image layer
 - Varies from sensor to sensor
- Panchromatic Image Layer:
 - The high-resolution grayscale layer used to pan sharpen the multispectral image layers

PANSHARP

The PANSHARP algorithm is based on the least number of squares to an approximate gray-value relationship between the original multispectral image, panchromatic image, and fused image. Using the PANSHARP algorithm, you can:

- Solve color-distortion and operator- or data-dependency problems
- Achieve the best color representation
- Preserve the mean, standard deviation, and histogram shape for each channel
- Fuse all spectral bands of a satellite image with the corresponding panchromatic band at once
- Minimize color distortion, maximize feature detail, and naturally integrate spatial and spectral features of the scene.
- PANSHARP is OpenMP-enabled, which improved the performance of the function

Options

- Enhanced pan sharpening generates a refined pan-sharpened output image:
 - “Yes” option generates a refined pan-sharpened output image (more suitable for visualization or visual interpretation purposes)
 - “No” option generates a standard pan-sharpened output image (more suitable for digital classification purposes)
- No-data image value:
 - Specifies a background value for all layers
- Resampling
 - Specifies the resampling method to use to determine the output pixel values when resampling the input low-resolution data to the higher resolution panchromatic data. (cubic convolution or bilinear interpolation)
- Pyramid options:
 - Specifies the type of resampling to use when computing overview levels (nearest neighbor, average, or model)

NOTE: The Pan Sharpening technique was originally developed by Professor Yun Zhang, from the University of New Brunswick.

MRAFUSION

MRAFUSION, uses advanced wavelet analysis to perform high-quality image pan sharpening while maintaining multispectral consistency.

The A Trous nonorthogonal wavelet transformation is used as the basis for pan sharpening images. The advantage of this type of transformation is that the reconstruction can perfectly recover the original image from decomposed ones regardless of how many decomposition levels have been performed. The transformation can also increase the spatial resolution of the multispectral image to that of the panchromatic while preserving the quality of the spectral information. Because of the multiple levels of decomposition, the transformation tends to provide pansharpened products that have less noise.

Extensive research and analysis has proven that MRAFUSION maintains high spectral fidelity of the multispectral bands. Statistical analysis has been conducted on multiple images, of varying land cover, and of various multispectral bands to verify the algorithm and its ability to preserve radiometric content.

Options

MRAFUSION offers:

- No-data image value:
 - Specifies a background value for all layers or utilizes the values from the source imagery automatically
- Decomposition levels
 - Specify the number of levels to be used for decomposing the image when applying wavelets.
- Output radiometry adaptation
 - User can choose whether to adapt the output radiometry values to those of the input multispectral images.
 - If chosen, the function will try to bring the fused product spectrally closer to the input multispectral data

NOTE: The following paper was used in the development of this functionality: M. Gonzalez-Audicanna, X. Otazy, O. Fors and A. Seco. (2005). "Comparison between Mallat's and the A Trous discrete wavelet transform based algorithm for the fusion of multispectral and panchromatic images". In International Journal of Remote Sensing, Vol. 26, No. 3, pp 595-614.

Pan Sharpening Hints & Tips

When using the pan sharpening algorithms, it is recommended that you:

- Use multispectral-image channels whose wavelengths lie within the frequency range of the panchromatic image channels
- Do not exceed a resolutions ration of 5:1 (e.g. 5m color, 1m panchromatic)

Atmospheric Correction

The data obtained by optical satellite sensors with high spatial resolution has become an invaluable tool for many groups interested in studying, managing, developing, and protecting our population, environment, and resources. Unfortunately, satellite images are often obscured by atmospheric effects like haze as a result of conditions in the atmosphere at the time the image was captured.

The objective of atmospheric correction is the elimination of atmospheric and terrain effects to retrieve physical parameters of the earth's surface, including surface reflectance, ground visibility and temperature. Such correction is especially important in cases where multi-temporal, multi-sensor or multi-condition images are to be compared and analyzed.

Workflows

The Atmospheric Correction module provides several workflows that allow you to perform various types of atmospheric correction and includes ATCOR technology from DLR:

Top-of-the-Atmosphere reflectance

The Top of the Atmosphere Reflectance workflow is the most basic of the atmospheric correction workflows. The workflow converts pixel values to physical reflectance, as measured above the atmosphere. It normalizes images based on radiance values and image acquisition times, using only the required image information.

Haze removal and cloud masking

The Haze Removal workflow allows you to calculate water and cloud masks for the input scene, and remove haze from images before performing atmospheric correction, thematic classification, or creating a mosaic.

This workflow generates an image containing raw DN values (scaled radiance) that have been corrected for haze. The output also includes all the pre-classification masks (haze, cloud, and water).

Ground reflectance atmospheric correction

The ATCOR Ground Reflectance workflow allows you to calculate the reflectance values at ground level to remove atmospheric effects in satellite imagery, preparing the images for analysis under different atmospheric conditions. The workflow generates a reflectance image at ground level, corrected by atmospheric (aerosol type and water vapor) and terrain effects.

When running the ground reflectance workflow, users also have the ability to output value-added products, including:

- Soil-Adjusted Vegetation Index (SAVI): uses the red and near-infrared bands to measure the density and vigor of green vegetation by attempting to eliminate the reflectivity of the ground beneath the canopy
- Leaf-Area Index (LAI): calculates the green-leaf density
- Fraction of Absorbed Radiation (FPAR): calculates the amount of photosynthetically active radiation absorbed by plant canopy
- Surface Albedo: calculates wavelength-integrated surface reflectance
- Absorbed Solar Radiation: calculates the shortwave solar radiation absorbed by the surface

Surface temperature atmospheric correction

The ATCOR Surface Temperature workflow takes an input thermal band in scaled radiance (raw DN values), a DEM and terrain derivatives, and, optionally, a visibility map to generate a surface temperature map of the thermal image. This workflow currently supports only Landsat 4 TM, Landsat 5 TM, and Landsat 7 sensors.

When running the Surface temperature workflow, users have the ability to optionally output the following energy balance components:

- Thermal flux difference: calculates the difference between the emitted atmospheric radiation and the emitted surface radiation
- Ground heat flux: calculates the exchange rate of energy between the Earth's surface and the underground
- Latent heat: calculates the exchange rate of stored heat energy between the air and the Earth's surface. Latent heat flux is measured as the amount of energy needed to change matter from one state to another (from solid to liquid to gas).
- Sensible heat: calculates the exchange rate of excess heat energy between the air and the Earth's surface. Sensible heat flux measures the amount of energy needed to change air temperature.
- Net radiation: calculates the difference between absorbed and emitted shortwave and longwave radiations

Supported Sensors

- ALOS AVNIR-2
- ASTER
- CBERS-4
- DEIMOS-1
- DEIMOS -2
- DMC (Disaster Monitoring Constellation)
- FASat-Charlie
- FORMOSAT-2
- FORMOSAT-5
- Gaofen-1
- Gaofen-2
- Gaofen-4
- Gaofen-6
- Geoeye-1
- Gokturk-1
- IKONOS
- IRS-1A / 1B / 1C / 1D / P6
- Kazeosat-2
- KOMPSAT-2
- KOMPSAT-3 / 3A
- Landsat-4 MSS
- Landsat-5 MSS
- Landsat-4 TM
- Landsat-5 TM
- Landsat-7 ETM+- Data
- Landsat-8
- OrbView-3
- PeruSAT-1
- PlanetScope
- Pléiades
- QuickBird
- RapidEye
- RASAT
- Resourcesat-2
- Sentinel-2
- SPOT-1
- SPOT-2
- SPOT-3
- SPOT-4
- SPOT-5
- SPOT 6
- SPOT 7
- SuperView-1
- Thaichote (THEOS)
- Triplesat
- Worldview-2
- Worldview-3
- Worldview-4
- ZY-3
- ZY3-2

Focus Atmospheric Correction Workflows

The Atmospheric Correction workflows in Focus, accessed from the **Analysis** menu, allow you to perform each of the available operations using the minimum amount of information required. They also allowing you to execute further radiometric corrections, such as calculating ground reflectance or surface temperature. Each workflow runs independently; information provided in one workflow is automatically applied to the other workflows.

The atmospheric correction window provides access to several workflows:

- The TOA Reflectance workflow: computes a Top-of-Atmosphere reflectance image
- The Haze Removal workflow: creates coarse classification masks for cloud and water masking, and performs haze removal
- The ATCOR Ground Reflectance workflow: performs atmospheric correction of satellite images
- The ATCOR Surface Temperature workflow: performs atmospheric correction of thermal images

Focus - Spectra Reflectance Plot

In the Spectra Reflectance Plot window, found under the **Layer** menu in Focus, you can view, analyze, and configure a detailed graph that plots reflectance and wavelength. You can create or import spectra from several sources that include one or more points, lines, or polygons drawn in the view pane or imported from spectra signatures from spectra-library files.

You can also collect and examine both target and reference spectra. The target and reference spectra can be compared from regression statistics to aid in determining the suitability of an atmospheric correction with a known sample in a spectra library or a control dataset. You can zoom in or out on any part of the graph or export the spectra for additional examination in statistical-analysis software or a spreadsheet program.

Spectral plotting with ATCOR

The ATCOR Spectra Plotting window is linked to the image you select in the first step of the ATCOR - Ground Reflectance wizard.

With ATCOR spectra plotting you can apply various atmospheric settings to compare the reflectance signature produced by each variation of the settings for a given spectra. A spectrum can be composed of a single pixel or a weighted average of several pixels. Comparisons of similar features can be made between the target image and library signatures or to a reference reflectance image. By comparing the target image and reference data, you can deduce the most accurate atmospheric model and condition so that you can adjust the atmospheric settings that give the closest match between the image signature and the corresponding library signature or reference reflectance image.

Note: The ATCOR models are incorporated into the CATALYST Professional product under license from Deutsches Zentrum für Luft- und Raumfahrt e.V. (German Aerospace Center). These models are covered by German Patent P 41 02 579.2.

Object Analyst

CATALYST Professional provides Object Analyst tools for segmentation, classification, and feature extraction. Object Analyst includes an all-in-one interface within CATALYST Professional's Focus application that is designed to guide you through segmenting your imagery, extracting features, creating training sites, classification (including creating custom rules for classification), reforming shapes, and performing an accuracy assessment.

Researchers have more recently considered that a pixel is not a true geographical object, and it is not the optimal spatial unit for mapping a landscape. Moreover, the traditional pixel-based image-analysis algorithms showed their inability to cope with high-resolution imagery; that is, imagery with resolution typically finer than 5 meters per pixel. These factors have contributed to the shifting of the model to and the wider use of object-based image analysis (OBIA).

OBIA does not analyze a single pixel, but rather a homogeneous group of pixels — image objects. An object, contrary to a pixel, provides richer information, including spectrum, texture, shape, spatial relationships, and ancillary spatial data. In turn, spatial context can be exploited to emulate a human analyst, who intuitively identifies various objects in an image, rather than individual pixels, by considering various properties, such as size, texture, shape, and the spatial arrangements of these objects to understand the semantics.

The fundamental objective of OBIA, therefore, is to use segmentation to reduce complexity of image data, and to use the extracted image objects and their corresponding attributes (features) to develop strategies for thematic classification. With OBIA, images are segmented to make image objects from various groups of pixels to represent meaningful objects in the scene. Ontologically, this provides more accurate and reliable identification and extraction of real-world features and at more appropriate scales. Moreover, it provides the opportunity to divide map data into homogenous objects of various spatial scales.

Workflow

A simple process flow for object-based image analysis (OBIA) is shown in Figure 1. After preprocessing, a typical OBIA analysis starts with segmenting an image into primitive objects. You then further group the objects together into classes of interest by exploiting their spectral properties, shape measures, context, and so forth.



The preprocessing steps involve operations such as orthorectification, radiometric enhancement, removing shadow, detecting outliers, or creating a new layer(s) such as vegetation indices, texture channels and so forth, so that the data is suitable for image segmentation and feature extraction before classification.

Image segmentation is the first step in OBIA. The objective is to partition an image into statistically homogenous regions or objects (segments) that are more uniform within themselves and differ from their adjacent neighbors. Each segment is characterized by a variety of attributes (features), including spectral properties (band statistics of a segment), shape, texture, context, and so forth. The segments, however, do not have the thematic information at this stage and need classification to assign class (group) membership to each.

Focus Object Analyst Workflow

Object Analyst can be accessed through the **Analysis** menu. The interface includes a Process Canvas, which guides users through process steps that can be run separately or once properly defined, automatically.

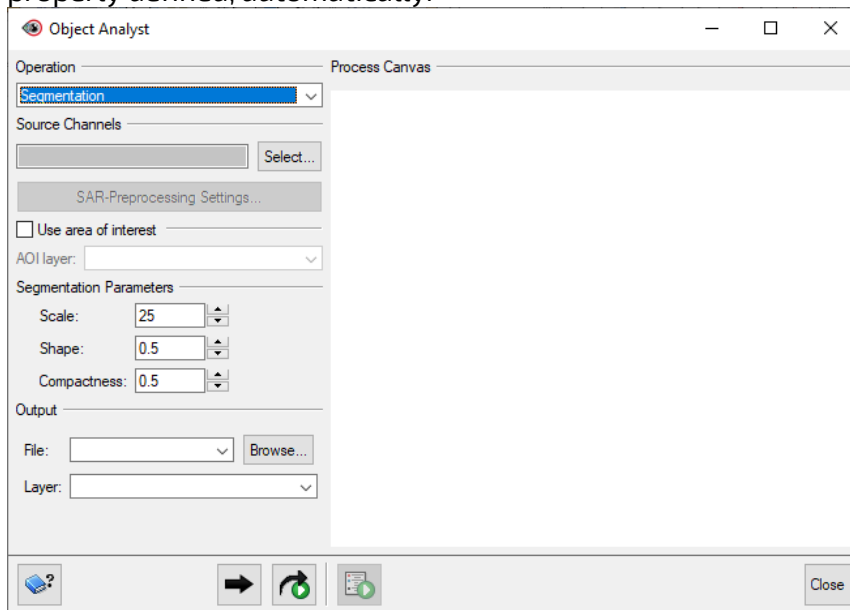


Figure 2: Object Analyst's Process Canvas interface

The process steps are listed here and described below:

- Segmentation
- Attribute Calculation
- Training Site Editing
- Classification
- Rule-based Classification

- Post-classification Editing
- Accuracy Assessment
- Batch Classification

Segmentation

Segmentation is the process of extracting discrete regions of image objects. This is achieved by stratification of an image. These image-objects are used further as the basic unit of analysis for developing image-analysis strategies, including classification and change detection.

The underlying segmentation algorithm in Object Analyst is a hierarchical step-wise region grown by using random "seeds" spread over the entire image. This method can be classified as a "bottom-up" optimization routine that starts with a pixel and ends with segments that are groups of like pixels. The criteria that define the growth of a region can be based on the difference between the pixel intensity and the mean of the region. The algorithm assesses the local homogeneity based on the spectral and spatial characteristics. The size of the object is controlled with the value for scale, which you specify. The larger the scale, the larger will be the output object. Other homogeneity criteria are based on shape and compactness.

The result of the segmentation process is as follows:

- An initial abstraction of the original data
- Creation of a vector (polygon) representation of the image objects

The results of segmentation can be exported as a vector data set and viewed in third-party software.

Constraining segmentation to an area of interest

If necessary, you can constrain segmentation to a specific area of interest (AOI). You do so by selecting a vector file in PCIDSK format you have created that contains only polygons of the AOI you want.

Attribute Calculation

In Object Analyst an attribute represents some information about an image object. Various characteristics of image objects are referred to as attributes of a segment.

You can compute the following types of attributes:

1. Statistical - Statistical attributes are computed based on the image pixels under an object (polygon). Attributes are computed for each of the selected image bands and added to the attribute table of the vector segment layer as new fields. The following attributes can be collected:
 - Minimum value of the pixels beneath an object in a selected band.
 - Maximum value of the pixels beneath an object in a selected band.
 - Mean value of the pixels beneath an object in a selected band.
 - Standard deviation value of the pixels beneath an object in a selected band.

2. Geometric attributes - Geometric attributes are computed by analyzing the polygon boundary created during segmentation, so raster information is not required. Object Analyst computes many commonly used shape descriptors such as:
- Compactness - A measure to indicate how closely packed a shape is. A circle is the most compact.
Compactness = $\text{Sqrt}(4 * A_s / \pi) / O$, where A_s is the area of the object, and O is the perimeter of the object (outer contour).
 - Elongation - The ratio of the height and width of a rotated minimal bounding box. In other words, rotate a rectangle so that it is the smallest rectangle in which the object fits, and then compare its height to its width.
Elongation = Major Axis Length / Minor Axis Length
 - Circularity - The circularity ratio represents how like the object's shape is to a circle. Circularity is the ratio of the area of a shape to the perimeter of the shape's square.
 $C = A_s / O^2$, where A_s is the area of the shape, and O^2 is square of the shape's perimeter.
 - Rectangularity - How rectangular a shape is; that is, how much it fills its minimum bounding rectangle.
 $R = A_s / A_R$, Where A_s is the area of a shape, and A_R is the area of the minimum bounding rectangle.
 - Convexity - The relative amount that an object differs from a convex object. Convexity is calculated by forming the ratio of the perimeter of the convex hull of an object to the perimeter of the object itself.
Convexity = convex-hull perimeter ÷ object perimeter
 - Solidity - The density of an object. Solidity is calculated as the ratio of the area of an object to the area of a convex hull of the object. A value of 1 indicates a solid object, and a value less than 1 indicates an object having an irregular boundary or containing holes.
Solidity = area ÷ convex-hull area
 - Form Factor - The measure that compares the area of a polygon to the square of the perimeter. The form-factor value of a circle is 1, and the value of a square is $\pi \div 4$.
Form factor = $4 \div \pi \div \text{area} \div \text{sqrt}(\text{perimeter})$
 - Major-axis length - The length of the major axis of an oriented bounding box enclosing the polygon.
Values are map units of the pixel size. If the image is not georeferenced, the values are pixels.
 - Minor-axis length - The length of the minor axis of an oriented bounding box enclosing the polygon.

Values are map units of the pixel size. If the image is not georeferenced, the values are pixels.

- Vegetation Indices attributes - You can select from several Vegetation Indices (VI) to perform quantitative and qualitative evaluations of vegetation cover, vigor, growth dynamics, and more.

The following table provides descriptions of each Vegetation Index that can be calculated:

Attribute	Short name	Description
Green/Red Vegetation Index	GRVI	$GRVI = (Green - Red) \div (Green + Red)$
Greenness Index	GI	$GI = ((2.0 \times Green) - (Red + Blue)) \div ((2.0 \times Green) + Red + Blue)$
Vegetation Difference Index	VDI	$VDI = NIR - Red$
Ratio Vegetation Index	RVI	$RVI = NIR \div Red$
Normalized Difference Vegetation	NDVI	$NDVI = (NIR - Red) \div (NIR + Red)$
Transformed Difference Vegetation Index	TDVI	$TDVI = (NIR - Red) \div (NIR + Red) + .5$
Soil Adjusted Vegetation Index	SAVI	$SAVI = ((NIR - Red) \div (NIR + Red + L)) \times (1 + L)$ The L-value is based on the amount of green vegetative cover. L is a default of 0.5, which means, generally, areas of moderate green vegetative cover.
Modified Soil Adjusted Vegetation Index	MSAVI2	$MSAVI2 = (0.5) \times (2(NIR + 1) - \sqrt{((2 \times NIR + 1) - 8(NIR - Red))})$
Global Environmental	GEMI	$GEMI = eta \times (1 - 0.25 \times eta) - ((Red - 0.125) \div (1 - Red))$ Where $eta = (2 \times (NIR - Red) + 1.5 \times NIR + 0.5 \times Red) \div (NIR + Red + 0.5)$

Attribute	Short name	Description
Monitoring Index		
Leaf Area Index	LAI	$LAI = (3.618 \times EVI) - 0.118$ Where EVI (Enhanced Vegetation Index) = $2.5 \times (NIR - Red) \div (1 + NIR + (6 \times Red) - (7.5 \times Blue))$

4. Texture attributes: Texture measures can be calculated for a specific direction or directional invariant for all pixels in an input image. The measures are based on second-order statistics calculated from the gray-level co-occurrence matrices.

Attribute	Description	Algorithm
Mean	Cooccurrence mean	$Mean_i = \sum_{i,j=0,N-1} (i \times P(i,j))$ Average gray-level in the local window.
Standard deviation	Cooccurrence standard deviation	$Var_i = \sum_{i,j=0,N-1} (P(i,j) \times (i - Mean_i)^2)$ $Std. Deviation_i = \sqrt{Var_i}$ Gray-level standard deviation in the local window. High when there is a large gray-level standard deviation in the local region.
Entropy	Cooccurrence entropy	$\sum_{i,j=0,N-1} (-P(i,j) \times \log_2(P(i,j)))$, assuming that $0 \times \log_2(0) = 0$. Entropy is high when the elements of GLCM have relatively equal values. It is low when the elements are close to either 0 or 1 (that is, when the image is uniform in the window).
Angular second moment	Cooccurrence angular second moment	$\sum_{i,j=0,N-1} (P(i,j))^2$ This is the opposite of Entropy. It is high when the GLCM has few entries of large magnitude, low when all entries are almost equal. This is a measure of local homogeneity.
Contrast	Cooccurrence contrast	$\sum_{i,j=0,N-1} (P(i,j) \times (i-j)^2)$ Contrast is the opposite of Homogeneity. It is a measure of the amount of local variation in the image. It is high when the local region has a high contrast in the scale of SPATIAL.

Training Site Editing

Before you can perform a classification or an accuracy assessment, you must have ground-truth data. In remote sensing, ground truth refers to information collected on location. With ground-truth data, image data can be related to real features and materials on the ground. By collecting ground-truth data, remote-sensing data can be calibrated, which aids in the interpretation and analysis of what is being sensed.

With supervised classification, the ground-truth data acts as a training set, which is used by the learning algorithm to generate a classification model.

In Object Analyst, you collect training samples for both the supervised classification and accuracy assessment in the same window. Primarily, you will use on-screen interpretation in the viewer and select segments of various classes.

Classification

Classification is systematic grouping of objects into sets or classes based on their similarities. The goal in Object Analyst is to group extracted image objects or segments into appropriate classes that a human analyst can identify intuitively.

This is achieved through object-based classification. Classification of a segment can be achieved either by labeling a segment as a selected class and assigning a color to it, or by adopting more advanced more advanced computational procedures.

With Object Analyst, you can perform either of two types of classification:

1. Supervised

Supervised classification is a process to find a model, or function, by analyzing the features of a data set of which the class memberships are known. This function is then used to predict the class memberships for target population.

Essentially, supervised classification is a two-step approach.

- The first step is to build a learning model to describe predetermined classes for a data set. The construction of the learning model is based on the analysis of data items or concepts for which class memberships are predetermined or known: data items known collectively as training samples.
- In the second step, the learned model is applied to new (target) data items to predict their class membership. The supervisory component of this procedure is in the training phase, which provides the classifier with a way to assess a dependency measure between features (attributes) and classes.

Users can select between Support Vector Machine (SVM) or Random Trees (Random Forest) algorithms for supervised classification.

Support Vector Machine (SVM)

SVM is a machine-learning methodology that is used for supervised classification of high-dimensional data. With SVM, the objective is to find the optimal separating hyperplane (decision surface, boundaries) by maximizing the margin between classes, which is achieved by analyzing the training samples located at the edge of the potential class.

Random Trees (Random Forest)

Random Trees is an ensemble learning method that has been implemented for image classification. It operates by constructing a multitude of decision trees during training and outputs the class selected by most trees.

2. Unsupervised

Object Analyst provides unsupervised classification based on the k-means clustering algorithm. Clustering algorithms search for generic data patterns among the feature [variable] spaces. No target variable is identified, as such. Clustering algorithms search for patterns among all the input features related to objects and group them into relatively homogeneous clusters.

The goal of clustering is normally descriptive and to discover new categories. Therefore, this strategy learns from observation rather than examples, and hence does not require a prior hypothesis or training set. The core objective is finding the natural boundaries in feature space for the number of clusters you specify.

Rule-based Classification

With Rule-based Classification, you can define a custom classification rule based on a specific property (feature), or properties, of a segment. You can define a rule to either assign a class to segments that meet the requirements of the rule or remove the segments from the class.

Object Analyst provides two methodologies for creating these rules or conditions:

1. Object Analyst Condition Builder window

In this window users can define a condition for rule-based classification. The condition can be based on up to two features (attributes). That is, you can construct a maximum of two conditions per rule. Both conditions can be based on a single attribute, or on two different attributes linked by a logical AND or OR operator.

For example, one could specify a two-part condition where i) classification occurs on an area attribute with a value of greater than 100800 and ii) less than 109800 for the same area attribute.

2. An alternative to creating a condition in the Object Analyst Condition Builder window is to use feature visualization. In the Feature Visualization window, you can dynamically select the vector objects (polygon segments) or update the existing selection in the vector layer based on a given feature (field) and its value range (filter).

You select the field you want, and then define the range. The polygon segments in that range are then selected in the viewer. Changing the range value reapplies the filter and update the selection set. You can immediately see the effects of the selected filter, and experiment to select the one most suitable.

Post-classification Editing

As a post-classification step, users may need to merge two or more polygons or split one or more polygons. You can do so by using either of two methods:

- Reforming shapes by using automatic dissolve
Automatic dissolve, merges two adjacent polygons based on class membership; that is, segments belonging to the same class and that are adjacent to each other are dissolved to create a bigger object. The internal boundaries of such segments are removed. The output will exclude all the attribute fields, except the field that contains the class-membership information. It is this field that is used to dissolve the segments.
- Reforming shapes by using interactive edits
An alternative to reforming shapes with Automatic dissolve is to use Interactive edits. To do so, you must select a layer that contains one or more polygons with class information. Object Analyst provides you with some basic tools to select and edit the polygon data.
- Adding, modifying, and removing classes
You can add, modify, and remove classes, as necessary. You can also assign objects to a class, and change the style of how classes are displayed in the view pane.

Accuracy Assessment

You can evaluate the overall accuracy of a supervised classification by running Accuracy Assessment. This operation compares a reference field, generated by an analyst using training sites editing tool, and a classification field, generated by running a classification.

The reference field and the classification field must be of the same segmentation file. When a segmentation file contains several reference and classification fields, it is a good practice to compare a classification with the reference field used to create it.

This process generates an assessment report that includes:

- Sample Listing – Report includes all assessed samples, described with georeferenced position, image coordinates, classified value/name, and reference value/name are displayed.
- Error (Confusion) Matrix – Matrix of all classes between reference data and classified data is displayed.
- Accuracy Statistics – Various accuracy statistics, such as overall accuracy, kappa coefficient, and their confidence intervals are displayed.

Batch Classification

By running a batch classification, you can run classification simultaneously on a group or collection of images with similar qualities of acquisition. The collection can be any aerial, satellite, or SAR imagery you want classify similarly, such as, but not limited to the following:

- Airphotos (strips or individual images)
- Stack of historical imagery
- Overlapping images
- Contiguous images

You first run classification on an individual image that you want to use as reference for the batch you want to process. After you are satisfied with the results, you can run a batch classification on several images to apply the same classification to each. The batch classification applies a segmentation step, an attribute-calculation step, a classification step (using Support Vector Machine or Random Forest, (based on the training-model file you create from the first individual image you classified), and any number of rule-based classification steps.

Satellite Bundle Functions

In the Satellite bundle the following functions can be executed either independently or sequentially via an EASI™ or Python™ script. They may also be available in the Algorithm Librarian in Focus and Modeler.

- ATCOR – Calculates atmospheric and terrain correction
- ATCOR_T – Atmospheric correction for thermal imagery
- AUTODEM – Generates a digital elevation model from stereo images – OpenMP enabled
- AVMODEL – Calculates model for orthorectifying AVHRR data
- BANDSIM – Combine bands to simulate spectral properties of other bands
- CDCARTOSAT – Reads Cartosat imagery
- CDSPOTRPC – Reads SPOT DIMAP and CAP format data for orthorectification using the Rational Function model
- DEMADJUST – Adjusts (raises/lowers) a raster DEM to elevation points held in a vector layer so that it better fits the elevation points.
- DEMEDPREP – Prepare a DEM for manual editing
- DEMMETA – Adds standard DEM-related metadata tags to an existing DEM raster
- DN2RADIANCE – Conversion from radiometrically calibrated input data to radiance
- DN2REFLECTANCE – Conversion from radiometrically calibrated input data to absolute reflectance

- DN2TOA – Calculates top of atmosphere reflectance
- DSM2DTM – Convert a DSM to DTM
- DSMMERGE – Used to merge (multi-angle) geocoded DSMs that were typically produced by EPIPOLARDSM and geocoded using GEOCODEDEM. Imagery associated with the geocoded DSM can be simultaneously merged at the same time producing a rough ortho image co-registered with the DSM.
- ELEVRMS – Reads elevations from a digital elevation channel and compares the elevations with elevation values from a given GCP (ground control point) segment or from a vector segment
- ELGCPRMS – Generate elevation data RMS report - GCP
- ELVECRMS – Generate elevation data RMS report - vector
- EPIPOLAR – Generates epipolar images from stereo pairs or raw images – OpenMP enabled
- EPIPOLARDSM – Creates a raster digital surface model (DSM) from epipolar stereo pairs using the Semi-Global Matching (SGM) method.
- FPAR – Calculates fraction of absorbed photosynthetically active radiation
- GEOCODEDEM – Geocodes epipolar digital elevation models by reprojecting to the ground coordinate system – OpenMP enabled
- HAZEREM – Removes haze from satellite imagery
- LAI – Calculates leaf area index model value
- MASKING – Creates cloud, haze and water masks from satellite imagery
- MERGEBAND – Merges and recombines multiple bands in separate files into a single file
- MODEL2RPC – Converts a math model to a RPC model
- MRAFUSION – Image fusion using multi-resolution analysis (wavelet decomposition)
- OACALCATT – Calculate object attributes
- OACALCATTSAR – Calculate object attributes for SAR imagery
- OAFLDNMEXP – Export names of attribute fields from vector segment to a text file
- OAGTIMPORT – Import ground-truth points into an existing segmentation
- OARTCLASS – Object-based Random Trees classifier
- OARTTRAIN – Object-based Random Trees training
- OASEG – Segment an image
- OASEGSAR – Segment a SAR image
- OASVMCLASS – Object-based SVM classifier

- OASVMTRAIN – Object-based SVM training
- OARTCLASS – Object-based Random Trees (Forest) classifier
- OARTTRAIN – Object-based Random Trees (Forest) training
- PANSHARP – High-performance image fusion
- QBASMBLE – assembles QuickBird tiles into a single image with the associated RPC model information
- QLTY2MASK – Create an exclusion mask from a quality image
- RFMODEL – Computes the math model of one or more images using the rational function math modeling method
- SATMODEL – Calculates the math model for one or more images using the rigorous math modeling method
- SAVI – Calculates Soil Adjusted Vegetation Index
- SGMMERGE – Merges a nadir-backward and nadir-forward epipolar DSM, created with the EPIPOLARDSM algorithm, into a single, final DSM, and then applies optional filtering.
- SOLVIEWZAZ – Solar and sensor view angles
- SPECLASS – Calculate spectral classification
- STITCH – Merges the different tiles, which are obtained from the same orbit on the same day, into one complete scene
- TERSEUP – Generates terrain derivatives, in preparation for atmospheric correction
- TOPOSOLNORM – Topographic Normalization